মানুষের জ্ঞান ও ভাবকে বইয়ের মধ্যে সঞ্চিত করিবার যে একটা প্রচুর সুবিধা আছে, সে কথা কেহই অস্বীকার করিতে পারে না। কিন্তু সেই সুবিধার দ্বারা মনের স্বাভাবিক শক্তিকে একেবারে আচ্ছন্ন করিয়া ফেলিলে বুদ্ধিকে বাবু করিয়া তোলা হয়।

— রবীন্দ্রনাথ ঠাকুর

"Any system of education which ignores Indian conditions, requirements, history and sociology is too unscientific to commend itself to any rational support".

— Subhas Chandra Bose

ভারতের একটা mission আছে, একটা গৌরবময় ভবিষ্যৎ আছে, সেই ভবিষ্যৎ ভারতের উত্তরাধিকারী আমরাই। নূতন ভারতের মুক্তির ইতিহাস আমরাই রচনা করছি এবং করব। এই বিশ্বাস আছে বলেই আমরা সব দুঃখ কষ্ট সহ্য করতে পারি, অন্ধকারময় বর্তমানকে অগ্রাহ্য করতে পারি, বাস্তবের নিষ্ঠুর সত্যগুলি আদর্শের কঠিন আঘাতে ধূলিসাৎ করতে পারি।

— সুভাষচন্দ্র বসু

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CBCS ● UG ● GEOGRAPHY [HGR] ● GE-GR-41

NETAJI SUBHAS OPEN UNIVERSITY

Under Graduate Degree Programme
Choice Based Credit System (CBCS)

SELF LEARNING MATERIAL

GEOGRAPHY
[HGR]

Disaster Management

GE-GR-41

PREFACE

In a bid to standardise higher education in the country, the University Grants Commission (UGC) has introduced Choice Based Credit System (CBCS) based on five types of courses viz. *core, discipline specific, generic elective, ability* and *skill enhancement* for graduate students of all programmes at Honours level. This brings in the semester pattern, which finds efficacy in sync with credit system, credit transfer, comprehensive continuous assessments and a graded pattern of evaluation. The objective is to offer learners ample flexibility to choose from a wide gamut of courses, as also to provide them lateral mobility between various educational institutions in the country where they can carry acquired credits. I am happy to note that the University has been accredited by NAAC with grade 'A'.

UGC (Open and Distance Learning Programmes and Online Learning Programmes) Regulations, 2020 have mandated compliance with CBCS for U.G. programmes for all the HEIs in this mode. Welcoming this paradigm shift in higher education, Netaji Subhas Open University (NSOU) has resolved to adopt CBCS from the academic session 2021-22 at the Under Graduate Degree Programme level. The present syllabus, framed in the spirit of syllabi recommended by UGC, lays due stress on all aspects envisaged in the curricular framework of the apex body on higher education. It will be imparted to learners over the *six* semesters of the Programme.

Self Learning Materials (SLMs) are the mainstay of Student Support Services (SSS) of an Open University. From a logistic point of view, NSOU has embarked upon CBCS presently with SLMs in English / Bengali. Eventually, the English version SLMs will be translated into Bengali too, for the benefit of learners. As always, all of our teaching faculties contributed in this process. In addition to this we have also requisitioned the services of best academics in each domain in preparation of the new SLMs. I am sure they will be of commendable academic support. We look forward to proactive feedback from all stakeholders who will participate in the teaching-learning based on these study materials. It has been a very challenging task well executed, and I congratulate all concerned in the preparation of these SLMs.

I wish the venture a grand success.

Professor (Dr.) Subha Sankar Sarkar
Vice-Chancellor

Netaji Subhas Open University

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Choice Based Credit System (CBCS)
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UG Geography (HGR)

Course : Disaster Management

Course Code : GE - GR - 41

Unit-1 □ Definition and Concepts of Hazards and Disasters-Risk and Vulnerability; Classification of Hazards

Content Structure

1.1 Learning Objectives

The main objectives are

- To study the concept of hazard and disaster
- To analyse the idea of vulerability and risk.
- To classify different types of hazards and describe the same.

1.2 Introduction

Within nature nothing is constant. Indeed, nature is typified by continual changes, in some cases by predictable evolution or the normal sequence of cyclical events as in seasonal weather. Much of nature, though, is unpredictable. When unpredictable natural events become extreme in their occurrence, they may constitute a danger to humans and to the other members of an evironment. Such an event, then defines a natural hazard.

Another way of conceptualizing natural hazard is an the coexistence of people in a natural environment that may disrupt or threaten their safety, property, or livelihood at an unpredictable time. There are many such natural events that, when experienced in a extreme degree, may become a risk to the inhabitants of an environment. These include avalanche, coastal erosion, drought, earthquake, flood, fog, frost, hail, landslide, lightning snow, tornado, tropical cyclone, volcano, and wind. Some forms of environmental degradation may also contribute to the creation of hazards or be an extension of them, such as deforestation and desertification.

1.3 Definition and Concepts of Hazards and Disasters

Natural hazards such as earthquakes, hurricanes, floods, and droughts spring to mind when the word "Disaster" is mentioned. But a disaster should be defined on the basis of its human consequences, not on the phenomenon that caused it. A disaster is a natural or man-made hazard that has come to fruition, resulting in an event of substantial extent which causes significant physical damage or destruction, loss of life, or drastic change to the environment. Such high intensity phenomenon disruption may be caused by natural phenomena, thus called natural disasters, or by human induced phenomena, thus called man-made disasters. **"The resulting loss depends on the capacity of the population to support or resist the disaster and their resilience" (G. Bankoff, 2003).**

An earthquake, for example, is simply an event in nature. Even a very strong one is not a disaster unless it causes injury or destroys property. Thus an earthquake occurring in an uninhabited area (as do scores of major tremors each month) is only of scientific interest and is not considered a disaster.

A disaster can be more precisely defined as an occurrence of widespread severe damage, injury, or loss of life or property with which a community cannot cope and during which the society undergoes severe disruption.

While some developed nations may be as *prone* to disasters as poor nations, the people of wealthier nations are not as *vulnerable* to disasters, they do not die in as large numbers nor does their environment collapse as easily. Both Tokyo, Japan, and Managua, Nicaragua, are *prone to earthquakes.* But the people of *Tokyo are far less vulnerable* to injury by earthquake because Tokyo has strictly enforced bulding codes, zoning regulations and earthquake training and communications systems. In Managua, there are still many people living in top-heavy mud huses on hillsides. They are vulnerable.

Rapid population growth, urban migration, inequitable patterns of land ownership, lack of education, subsistence agriculture on marginal lands, etc. lead to vulnerable conditions such as unsafe siting of buildings and settlements, unsafe homes, malnutrition, unemployment and underemployment, illiteracy, etc. The poor within the poor countries are the most vulnerrable. Landslides or flooding disasters are closely linked to rapid and unchecked urbanization that forces low-income families to settle on the slopes of steep hillsides or ravines, or along the banks of flood-prone rivers.

Famines can be closely linked to shortages of purchasing power caused by rural unemployment or a sudden influx of fefugees into a country from a strife-torn neighboring country.

High numbers of deaths accompanying earthquakes almost always result from structural collapse of poor, low-cost houses.

In other disasters, such as cyclones and tsunamis, humans can increase their vulnerability by removing bits of their natural environment that may act as *buffers* to these extreme natural forces. Such acts include destroying reefs, cutting natural wind breaks and clearing inland forests.

The poor countries that suffer the worst disasters are the same countries in which environmental dgradation is proceeding most rapidly. Countries with severe deforestation, erosion, over cultivation and overgrazing tend to be hardest hit by disasters.

Therefore, it can be said that nature causes extreme events (called "hazards" when they threaten people), but people create disasters by :

- making faulty assessments of natural hazard risks.
- undermining the resilience of impacted natural and social systems, and
- failing to practice appropriate protective measures.

Natural hazards are agents or trigger mechanisms that can come into contact with a vulnerable human condition to result in a disaster.

In last 1000 years, about 15 million people have died as a result of at least 100000 natural disasters (Munich Re, 1999). In the second half of the twenteth century, about 250 large natural hazards were reported. According to the Natural Hazards Research and Application Information Centre (NHRAIC), U.S.A., within a period of 35 years the most common global natural disaster reported was flood. Floods account for about one third of all natural hazards recorded by the Center for Research on the Elidemiology Disaster (CRED), Belgium, within 1964-1998. About 80 per cent of the deadliest disaster on history occurred as a result of just four hazard types – earthquake, tropical cyclone, flood and drought. Asia Experiences over half of all significant natural disasters. According to information of 'UNDRO' - United Nations Disaster Relief Co-ordination about 90 per cent of all natural hazards and disasters occur in the developing countries. It is because of the fact that most of the developing countries are located in the tropical and sub-tropical regions of the world, where atmospheric processes cause natural hazards and disasters. The CRED conducted 35 year database on the global pattern of natural disaster and revealed that the four most disaster affected countries include China, India, Bangladesh and Philippines. It is due to the fact of their large population, many of whom live in dense clusters in tectonically active zones or near low lying coast subject to cyclones and floods. As per United Nations Development Programme (UNDP) Report, 2001 among the least developed countries, 24 of the 49 countries face high levels of disaster risk, at least 6 of them have been affected by two to eight major disasters per year. In the past 15 years, with long-term consequences on human development.

Again as per International Federation of Red Cross and Red Crescent Socities (IFRC) Report 2001, since 1991, more than 50 percent of all the disasters report occurred in countries with medium levels of human development. However, two thirds of those killed were from low level Human Development Index (HDI) countries. Only 2 percent of deaths came from highly developed countries. So, this proves that the impact of development on disaster results in dramatic. On an average, while 22.5 people die per reported disaster in highly developed countries, 145 die in medium developed countries and 1052 die in countries with lost HDI. As far as International Policy response in concerned, until the 1970s, the International community considered disasters as exceptional circumstances, when local coping capabilities were exhausted from external emergency relief was required.

1.4 Risk and Vulnerability

1.4.1 Vulnerability

It is a concept which describes factors or constraints of an economic, social, physical or geographic nature, which reduce the ability to prepare for and cope with the impact of hazards.

There are different categories of Vulnerability, these are as follows:

1. **Hazard-specific:–** A characteristic which makes the element concerned susceptibel to the force/s or impact of a hazard. The geo-physical and locational attributes of the element/s concerned are considered in this category. Based on the present-knowledge of the distribution and frequency of hazards, a community or country may be threatened by specific hazards.
2. **Setting-specific:–** This is concerned with the prevailing socio-economic arrangement of the are a concerned as to whether it is predominantly rural or urban. There are inherent setting characteristics that may be common to both as well as exclusive to each which contribute to the general susceptibility of the area.
3. **Urban Setting:–** Concentrations and Crowdedness - the three aspects are crowdedness and disease; crowdedness and buildings; crowdedness and resource base.

- **Numbers of Peoples and Activites** – the two aspect of this condition are Technologies and the Management System.
- **Proximity to Man-made Hazards -** the axpects considered are Technological hazards, Economic hazards, and Social Hazards. Major lifelines of the urban area are dependent on each other to function effectively. This interdependency is a factor that may contribute to the area's vulnerability. The existing arrangement of a society regarding relationship of individuals, groups and institutions may create an adverse situations that weakens there element' capabilities to face or withstand hazards and contribute insted to the intensifying of the effects.– The prevalent world view of the society or certain groups within society may contribute to a passive or non-active stance regarding the disaster that beset the area.

1.4.2 Risk

It is the probability that nagative consequences may arise when hazards interact with vaulnerable areas, people, property, and environment RISK is a concept which describes a protential set of consequences that may arise from a given set of circumstances.

The probability that a particular system or population will be affected by hazards is known as the 'risk'. Hence risk is a function of the vulnerability and the hazard, and is expressed as follows:

Risk = Vulnerability x Hazard (Goel, 2006, p6)

Risk is a combination of the interaction of hazard, exposure, and vulnerability, which can be represented by the three sides of a triangle. If any one of these sides increases, the area of the tringle increases, hence the amount of risk also increases. If any one of the sides reduces, the risk reduces. If we can eleminate one side there is no risk.

Parameters of Risk Hazards are the sources of risks Hazards create risks by exposing prepexisting vulnerabilities. The risk that a community faces is mitigated by its level of preparedness, response and recovery or readiness. The following Table No. 1 discusses the possible elements at risk.

Table 1 : Possible Elements at Risk

Consequences	Measure	Tangible	Intangible
Deaths	No. of People	Loss of active individuals.	Social and psychological effects of remaining community.
Injuries	No. of people % disability	Medical Costs loss of productivity Teporary loss of economic activity.	Social and psychological effects of relatives & injured, pain & recovery.
Physical Damage	No of damaged houses, structures etc. agricultural areas. Level of damage%	Replacement costs, rehabilitation & repairs cost.	Cultural losses, Social effects.

Emergency operations	No. of man-days Equipment and resources hours.	Mobilization cost Investment in Preparedness measurers.	Stress & overwork of relief workers,
Disruption of Economy	No. of lost working days, value of prodiction lost.	Cost of lost productivity.	Opportunities competitiveness reputation.
Social Distruption	No. of displaced, No. of homeless.	Cost for temporary housing, relief, health care.	Psycological, social contacts, cohesion morale.
Environmental Impact	Scale & Severity	Maintenance & repair cost.	Helath risks, Future disaster risk.

1.5 Classification of Hazards

A physical event, phenomenon or activity that has the potentially to cause the loss of life or injury, property damage, social and economic distruption or environmenta degradation are called hazrads, e.g. earthquake, flood, drought, tsunami, cyclone etc. Each hazard is characterized by its location, intensity, frequency and probability. The classification of hazard is discussed below:

On the basis of origin of the hazards :

I. Natural Hazards :

1. **Terrestrial Hazards** - Those hazards which originate inside the earth or its atomosphere are called terrestrial hazards.

   a) Endogenic Hazards - Hazards which originate inside the surface of the earth are termed as endogenic hazards, e.g. volcanic eruption Earthquake.

i) **Volcanic Eruption** - Volcanoes can cause widespreads destruction and consequent disaster through several ways. The effects include the volcanic eruption itself that may cause harm following the explosion of the volcano or the fall of rock. Second, lava may be produced during the eruption of a

volcano which destroys any building and plants it ecounters. Third, cool volcanic ash may form a cloud and settle thickly in nearby locations. When it mixed with water this forms a concrete like material. Small quanitities of ash will harm humans if inhaled.

It is believed that ancient Roman Town Pompeii (at present in Italy) was destroyed by a pyroclastic flow (a dense, destructive mass of very hot ash, lava fragments, and gases ejected explosively from a volcano and typically flowing at great speed.) A lahar is volcanic mudflow or landslide. In Armero tragedy (1985), the Armero town of Colombia was buried by lahar and an extimated 23,000 people were killed. A specific type of volcano is the super volcano. According to the Toba catastrophe theory 70 to 75 thousand years ago a super volcanic event at Lake Toba in Sumatra, Indonesia reduced the human population to 10.000 or even 1,000 breeding pairs creating a bottlenock in human evolution. It also killed three quarters of all plant life in the northern hemisphere.

ii) **Earthquake** – an earthquake is a sudden shake of the earth's crust caused by the tectonic plates colliding. The vibration may very in magnitue. Due to earthquake the building collapse, fires, tsuniamis (seismic sea waves) and volcanic eruption may happen. Some of the most significant earthquakes in resent times include:

In 14th July, 2019, a magnitute 7.3 earthquake shook the Moluccas islands, Indonesia. Early reports indicate damage to houses in eastern Indonesia but no injuries or deaths. The world's largest earthquake occurred on May 22, 1960 near Valdivia, in southern Chile. It was assigned a magnitude of 9.5 by the United States Geoliogical Survey. In 2004, the India Ocean Earthquake recorded a magnitude of 9.1 - 9.3 The huge tsunamis triggered by this earthquake cost the lives of at least 229,000 people.

b) **Exo-genic Hazards** – Hazards which orginate above the surface of the earth (in the atomosphere) are called exo-genic hazards. These can be further sub-divided into the following categories :

i) **Atmospheric Hazards** – Natural hazards that originate in the atmosphere of the earth are called atmospheric hazards. These include blizzards, cyclones, tornadoes, droughts, thunderstorms, hailstorms, heat waves, fires.

Blizzards are severe winter storms characterized by low temperature, strong winds (wind speed more than 35 miles per hour), and havy snow. It has a negative impact on local economics and can terminate the visibility in regions where snowfall is rare. Significant blizzards include: The Great Blizzards of 1888, one of the worst blizzards in U.S. history. It dropped 100-130 cm (40-50 inch) of snow and had sustained winds of more than 72 km/h (45 miles per hour) that produced snowdrifts in excess of 15m (50 feet). The Iran Blizzard of February 1972 was the deadliest blizzard in history. A week-long period of low temperatures and severe winter storms, lasting 3–9 February 1972, resulted in the deaths of approximately 4,000 people.

A **Cyclone** is a large scale air mass that rotates around a strong center of low atmospheric pressure. Cyclone, tropical cyclone, hurricane and typhoon are different name of the same phenomenon of a cyclonic storm system that forms over the ocean. The strongest tropical cyclone recorded worldwide, as measured by monimum central pressure, was Typhoon Tip, Which reached a pressure of 870 hPa (25.69 inHg) on October 12, 1979. The 1999 Orissa cyclone is the strongest storm to hit the Indian coast, as well as the strongest in the basin till date, with a minimum central pressure of 912 mbar (26.93 inHg) and Cyclone Nargis is the costliest cyclone with damages almolst $12.1 billion.

A **Drought** is an event of prolonged shortages in the water supply, whether atomospheric (below-average precipitation), surface water or ground water. During 2015–2018, the Cape Town water crisis in South Africa was period of severe water shortage. This likelihood was tripled by climate change. The 2015 drought in Maharashtra affected around 90 lakh farmers, which is close to then population of Sweden.

Hailstorms are rain drops that have formed together into ice. A storm system lasting over a week created severe hail and high wind damage, reaching from Minnesota to Taxas to Virginia to New York. The Minneapolis metro area suffers especially, receiving hail damage to many buildings and vehicles. The total damage was estimated to be over 2.5 billion dollar.

A **Heat Wave** is a period of excessively hot weather, which may be accompanied by high humidity, especially in occeanic climate countries. Heat waves are generally

the result of trapped air. High-pressure systems force air downward. This force prevents air near the ground from rising. The sinking air acts like a cap. It traps warm ground air in place. Starting from 25 June, 2019, very hot air masses from the Sahara desert moved over Europe, leading to heat advisories in several European countries, including France, Germany and the UK. The 2019 Indo-Pakistani heat wave reached a near record high temperature of 50.8° C (123.4° F) in Churu. The Indian and Pakistani media reported dozens of deaths due to the heat wave.

A **Tornado** is a violent, dengerous, rotating column of air that is in contact with the surface of the earth and a cumulonimbus cloud or, in rare cases, the base of cumulous cloud. They come in many shapes adn size but are typically in the from of visible condensation funnel, whose narrow end touches the earth and I soften encircled by a cloud of debris and dust. Most tornadoes have wind speeds less than 110 miles, are aopproximately 250ft across, and travel a few miles before dissipating. The most exterme can attain wind speeds of more than 300 mph, stretch more than 2 miles across, and stay on the ground for dozens of miles. On March 18, 1925, a powerful tornado touched down near Ellington, Missouri, and moved quickly to the northeast, devastating towns in its path. The storm stayed on the ground for three and a half hours, passing into Illinois and Indiana before dissipating. The storm killed 695 people and injured more than 2,000, making it the deadliest tornado in American history. In 30 April, 2019 a rare tornado occurred in Nepal which damaged at least 400 houses.

Fires particulary wildfires are an uncontrolled fire buring in wild land areas. Common causes include lighting and drought but it may start due to human negligence of arson. In 2018, 18,804 structures destroyed 8 confirmed deaths, 2 missing, 17 injured in deadliest and most destructive wildfire in California. In Feburary 2019, massive forest fires broke out in numerous places across the Bandipur National Park of the Karnataka state in India which causes death of slow moving forest animals.

ii) Hydrospheric Hazards

Those natural hazards that are related to water in the atmosphere are termed as hydrospheric hazards. Here, a list of **hydrospheric hazards** is given in detail :

Floods are the result of prolonged rainfall from a strom, including thunderstorms, rapid melting of large amount of snow or rivers which swell from excess precipitation upstream and cause widespread damage to areas downstream or less frequently the bursting of manmade dams or levees. In 1953, the flood in Mississippi River is the largest known meteorological flood caused by rainfall. In 2017, Gujarat flood cause deaths of more than 200 people.

A **limnic eruption,** also termed a lake overturn, is a rate type of natural disaster in which dissolved carbon-di-oxides (CO_2) suddenly erupts from deep lake waters, forming a gas cloud capable of suffocating wildlife, livestock, and humans. A limnic eruption may also cause tsunamis as the rising Co_2 displaces water. Scientists believe earthquakes, volcanic activity, and other explosive events can serve as triggers for limnic eruptions.

A **whirlpool** is a body of rotating water produced by opposing currents or a current running into an obstacle. More powerful ones in seas or oceans may be termed **maelstroms**. In narrow ocean straits with fast flowing water, whirlpools are often caused by tides. Many stories tell of ships being sucked into a maelstrom, although only smaller craft are actually in danger. In 2010, people off the coast of Maine, USA have noted a large whirlpool (250 ft) known as "Old Sow." It's the biggest whirlpool in the western hemisphere, and exhibits a lot of weird behaviors.

A **seiche** is a standing wave in an enclosed or partially enclosed body of water. Seiches and seiche-related phenomena have been observed on lakes, reservoirs, swimming pools, bays, harbours and seas. Seiches are typically caused when strong winds and rapid changes in atmospheric pressure push water from one end of a body of water to the other.

A **tsunami** or **tidal wave** is a series of waves in a water body caused by the displacement of a large volume of water, generally in an ocean or a large lake. Earthquakes, volcanic eruptions and other underwater explosions (including detonations, landslides, glacier claving, meteorite impacts and other disturbances) above or below water all have the potential to generate a tsunami. The term "tsunami" comes from the Japanese word "tsu" meaning harbor and "name" meaning wave so tsunami means "harbor wave". The 2004 Indian Ocean Tsunami is the deadliest tsunami in recorded history, and it caused an extimated $ 14 billion in damages at the time.

iii) Lithospheric Hazards – Lithospheric hazards are those natural hazards that occur near to the surface of the earth. It includes the following hazards: landslides, avalancehes, sink holes.

A **landslide** is defined as the movement of a mass of rock, debris, or earth down a slope. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, and changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors. Earthquake shaking and other factors can also induce landslides underwater. These landslides are called submarine landslides. Submarine landslides sometimes cause tsunamis that damage coastal areas. The 8.5-magnitude Haiyuan Earthquake was the world's second deadliest earthquake of the 20th Century. It generated a series of 675 major loess landslides causing massive destruction to lives and property. The natural calamity which struck the rural district of Haiyuan on the evening of December 16, 1920 claimed over 100,000 lives, and severely damaged an area of approximately 20,000 square kilometers. One of the worst natural disasters in the history of India occurred in June of 2013, when powerful flash floods cause mudslides killed around 5,700 people in the Himalyan state of Uttarakhand.

An **avalanche** (also called a snow-slide) is an event that occurs when a choesive slab of snow lying upon a weaker layer of snow fractures and slides down a steep slope. Avalanches are typically triggered in a starting zone from a mechanical failure in the snowpack (slab avalanche) when the forces of the snow exceed its strength but sometimes only with gradual widening (loose snow avalanche). After initiation, avalanches usually accelerate rapidly and grow in mass and volume as they entrain more snow. If the avalanche moves fast enough, some of the snow may mix with the air forming a powder snow avalanche, which is a type of gravity current. On 31 May 1970, an earthquake off the coast of Peru caused a substantial section of the north slope of Mt. Huascaran to collapse. The avalanche moved down hill at a speed of 1000 MPH with a mass of roughly 80 million cubic feet of ice, mud and rock, It ran nearly 11 miles, burying the towns of Yungay and Ranrahirca in up to 300 feet of rock and debris. Estimates suggest thatr the earthquake killed over 20,000 people. In 2017, avalanches kill 14 Indian soldiers in Kashmir Himalyan Region.

Calcium carbonate inside the surface of the earth is dissolved by the underground running water and taken away with it, creating sink holes. This causes the earth to become **hollow** and eventually the earth above it settles down under load.

c) **Biotic Hazards**– The types of hazards that originate through plants, animals or humans.

   i) **Floral Hazards (Plants)**– The type of hazards that originate from plant life which includes fungal diseases (like Dutch elm disease), infestations (like weeds and water hyacinth), hay fever and poison ivy.

   ii) **Faunal hazards (Animals)**– The type of hazards that originate from plant life which includes bacterial and viral diseases (such as malaria and rabies), infestations (like rabbits and locusts) and venomous animal bites.

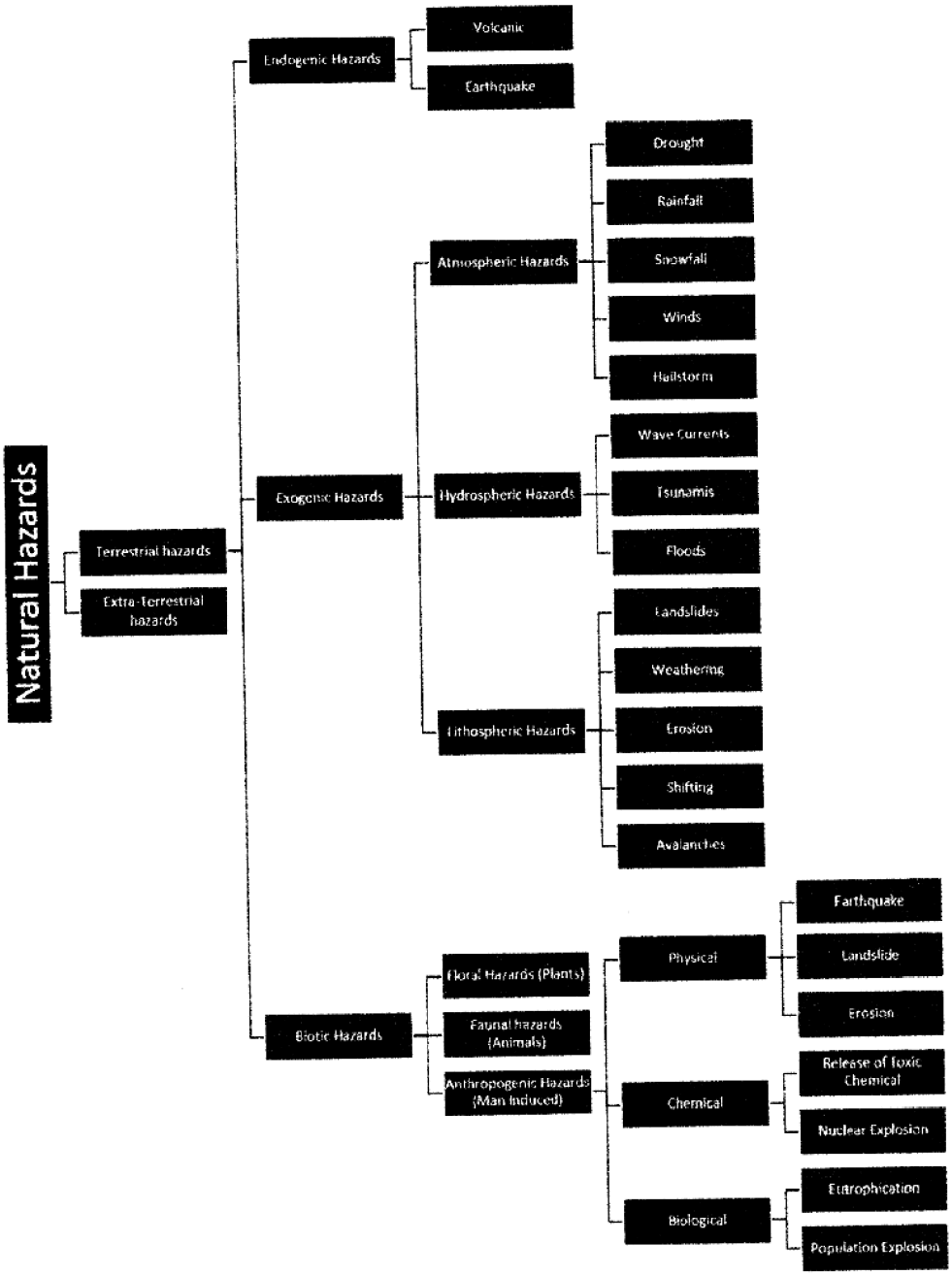
d) **Anthropogenic Hazards (Man induced)**– These are caused by human action or inaction. There are certain societal hazards that can occur by inadvertently overlooking a hazards, a failure to notice or by purposeful intent by human inaction or neglect, consequences as a result of little or no preemptive actions to prevent a hazard from occurring. Although not everything is within the scope of human control, there is anti-social behavior and crimes committed by individuals or groups that can be prevented by reasonable apprehension of injury or death.

Some Physical Hazards like earthquake, landslide, may caused by man then they fall in this group. The release of Toxic Chemical from the industry and Nuclear Explosion can cause chemical hazards which may induced by human being. Eutrophication and population explosion are some biological hazards caused by man.

2. **Extra-Terrestrial Hazards**– The kinds of hazards which originate outside the earth and its atomsphere are called extra-terrestrial hazards. e.g. meteorites and solar flares. A solar flare is a sudden flash of increased brightness on the Sun, usally observed near its surface an in close proximity to a sunspot group. Powerful flares are often, but not always, accompanied by a coronal mass ejection. The most powerful solar flare in the past 500 years is believed to occur in September 1859.

The following Chart No. 1 shows the classification of hazards in Tabular form.

Chart No. 1: Classification of Hazards



1.6 Conclusion

The concept of hazards, risks, and disasters in society requires an understanding of cognition and behavior and would require a cultural shift for much of humankind. Disasters are registering gradual increase. For example natural disasters occurred at the rate of around 120 large disasters annually in the world but in the first decade of 21st Century the number has increased 5 times. The developing countries are most adversely affected. Number of man induced disasters like floods. droughts heat waves, earthquake, landslides, diseases like swine flu, malaria etc., terrorism, atomic, chemical and biological wars are expected to rise in future.

1.7 Summary

In this chapter first the concept and definition of Hazards and Disasters are discused eleborately with example to understand the nature of the both phenomenon. The concept of risks and vulnerability is also highlighted to understand the difference between the two terms. Afterwards a detail classification is given to understand the classification is given to understand the different types of hazards.

1.8 Glossary/Keywords

Disaster–occurrence ofwidespread severe damage, injury, or loss of life or property, with which a community cannot cope and during which the affected society undergoes severe disruption. Disasters may be human-made or have natural causes and may include earthquakes, floods, fires, hurricanes, cyclones, major storms, volcanic eruptions, spills, air crashes, and creeping disasters such as droughts, epidemics or serious food shortages, as well as disasters of civil strife in which many victims may be left homeless as much property is soriously damaged or destoryed.

Major disaster– flood, hurricane, earthquake, drought, volcanic eruption, epidemic, fire or other catastrophe of a severity that causes serious disruption to societal, economic and infrastructure elements. In general, a disaster rating 10 or above on DKM scale.

UNDP– United Nations Development Program. Basic development tool of the U.N. system, with headquarters in New York and resident coordinators in each developing member country. The resident coordinator serves as UNDRO representative for disaster relife and preparedness matters in live of UNDRO presence.

UNDRO– Office of the United Nations Disaster Relief Coordinator: Geneva based organization with responsibility for coordinating disaster prevention, preparedness and relief operations within the U.N. system and among member countries.

Vlunerability– The extent to which a country, area, community or structure risks being damaged by a disaster.

1.9 References and Further Readings

- Beckjord, E.B. Teraniestern, S. Lisa, S. Meregith, L.S. Chandra, A. and Parker, M. (2880). Enhancing, Emergency Preparedness, Response and Recovery Management for Vulnerable Population. RAND's Publication.
- Chakraborty, S.C. (2007). Natural Hazards And Diusaster management. Natural Hazards and Disaster management. Kolkata: Pragatisil Prokashak.
- Cutter, S. L. (2007). Hazards, Vulnerability and Environmental justice. London: Earthacan.
- Dey Mullick, P. Das, A. Chaudhuri, A. (2014). The Meaning and Approaches of Vulnerabilities in Disaster Studies: An Overview. International Journal of Social Science & Interdisciplinary Research, **3(12),** p5-3.
- Earthscan, Natural Disasters: Earthscan Press Briefing Document No. 39, International Institute for Environment and Development, London, 1984.
- Eugene Haas J., Robert W. Kates, Martyn J. Bowden. (1977), Reconstruction Following Disasters, MIT Press, Cambridge, Massachusetts.
- Flanagan, B.E., Gregory, E.W., Hallisey, E.J., Heitgerd, J.L. and Lewis, B. (2011). A Social Vulnerability Index for disaster management, Journal of Homelank Security and Emergency Management, 8(1/3), 1-24. Retrieved on July 11, 2014, from http://www.bepress.com/jhsem/vol8/iss1/3.
- Frederick C Cuny. (1983), Disasters and Development, Oxford University press, new York. Fedrick Krimgold. (1974), The Role of international Aid for Pre-disaster Planning in Developing Countries, audelringen for Arkitektur, KTH Stockholm.
- Goel, S.L. (2006). Encyclopaedia of Disaster Management, Deep & Deep Publications Pvt. Led.
- Govt. Of West Bengal (2006). Bureau of Applied Economics and Statistics, The Office of the Director, District Statistical Hankbook, 19.

- Kumar, N. (2011). Disaster Management. **Disaster Management. New Delhi:** Alfa Publication.
- Mukherjee, D. M. (2010) Natural Disasters. **Natural Disasters.** Kolkata: Arun Banerjee Art Publishing.
- Pan American Health Organization, (1981), A Guide to Emergency Healthe Management after Natural Disaster, Pan American Healthe Organization, Washington, D.C.
- Shagufta. (2012). Disaster And Management. **Disaster And Managemen,** Delhi: APH Publishing Corporation.

1.10 Model Questions

1. Define hazards and disasters? 5
2. What is the difference between hazards and disaster? Discuss with example. 5
3. Define risks and vulnerability? 5
4. Discuss about the possibel elements at risk. 5
5. Discuss the different categories of vulnerability. 5
6. Classify hazards in details. 10
7. Discuss the natural hazards. 10
8. What are endogenic hazards? 10
9. What are exo-genic hazards? 10
10. Discuss the atmospheric hazards in detail. 10
11. What is heat waves? 5
12. Duscuss in brief i) blizzards, ii) cyclone, iii) drought, iv) hailstorms, v) tornado, vi) limnic eruption, vii) whirlpool, vii) seiche, ix) avalanche 5×9
13. What are hydrospheric hazards? Discuss in detail. 10
14. What are lithospheric hazards? Discuss in detail. 10
15. What are biotic hazards? Discuss in detail. 10
16. What are anthropogenic hazards? 10
17. Discuss the extra-terrestrial hazards in detail. 10

Unit-2 □ Causes and Consequences of Hazards : Physical, Economic and Cultural

Content Structure

2.1 Learning Objectives

The main objectives are

i) To identify the causes or preconditions for a hazard.

ii) Discuss the consequences of the hazards.

iii) Generation of awareness to mitigate the hazards.

2.2 Introduction

Hazards is an event or occurrence that has the potential for causing injury to life or damage to property or the environment. The magnitude of the phenomenon, the probability of its occurence and the extent and the severity of the consequences can vary. In many cases, these effects can be antcipated and estimated. Response to the hazards have evolved over time the world over. From a purely humanitarian urge to offer succor to the victims, the response to the challenge of hazards has come to address itself to preparedness, to mitigate their consequemces and reduce their occurrences to sustain the developmental effort.

2.3 Causes of Hazards

The causes of the hazards can broadly be divided into two types :

i) Natural Causes :

a) **Wind** related hazards like strom, cyclone, tornado, hurricane, storm surge, tidal waves.

b) **Water** related hazards like flood, cloud burst, flash flood, excessive rains, drought, and communicable diseases.

c) **Earth movement** related hazards like earthquake, tsunamis, avalanches, landslide, and volcanic eruption.

ii) Man-Made or Anthropogenic Causes :

a) War/battle/hostile enemy actions.

b) Arson/sabotage/internal disturbance/riots.

c) Accidents of vehicle/trains/aircrafts/ships.

d) Industrial accidents/explosions of boilers/gas cylinder or gas chambers/ gas leaks.

e) Fire and forest fire.

f) Nuclear explosion/accidents/radioactive leakages.

g) Deforestation/soil erosion/air/water pollution.

h) HIV/AIDS, life style diseases.

i) Violence.

2.4 Consequence of Hazards

Hazards can happen at any place irrespective of the delveloped, developing or the least developed status of a country. It can cause massine destruction to the lines of the livelihoods of large population and hence, to the national economies. It is experienced that the least developed and developing countries are impacted more severely by large scale natural disasters. The consequences of hazards in term of human and economic losses has risen in recent years and society in general has become more vulnerable. In a matter of minute an entire country can see its infrastructure destroyed, its economy smashed and its people even deprived of their livelihood.

Hazards is an event which causes sudden disruption to the normal life of a society and causes damage to life and property, to such an extent that normal, social and economic mechanisms available to the society are inadequate to restore normalcy and may justify external assistance, in such cases hazards turns into disaster. Viewed in this manner, a host of natural phenomena cause disasters to the society-socially, culturally or economically. So in a nut shell, the consequences of hazards may be as follows:

i) Loss of crops and availability of essential food and agricultural commodities.
ii) Loss of employment opportunities in the area where hazards occur and particularly on rural employment.
iii) Problems of health and diseases arising both from insufficient availability of the basic necessities causing mal-nourishment, hunger, etc. or on the availability of good and hygienic drinking water.
iv) Financial distress caused to the farming community and those dependent on land which affect their ability to withstands hard conditions immediately following the occurrence of the hazards and importantly, their ability to recover well enough before the next cropping season sets in.
v) Agro based Industrial sector in particular may suffer due to shortage of production of raw meterials, reduce generation of power etc. and
vi) Lastly, the cattle wealth may be also badly affected due to hazards.

Human settlements are frequently affected by hazards like earthquake, floods, hurricanes, cyclones and landslides which take a heavy toll on human lives, destroy buildings and infrastructure and have far reaching economic and social consequences on the communities affected by such hazards.

Hazards wipe out years of development and consumer resources that could have been used for development and social welfare of the people. Hazards and poverty compound each other in vicious cycle.

Hazards when coour have a severe consequences on all the sections of the society. But, globally, it is ovserved that it is certain sections who are more susceptible. These vulnerable sections lack resources and are deprived of basic necessities, that expose them to the adverse effects. Preparedness activity, is to be holistic. They need to be integrated in the overall disaster management process.

Natural disaster arrest the process of economic development. Restoration and repair of the damaged/destroyed infrastructure, particullary roads, communication, power, irrigation are undoubtedly a daunting task. It also requires a substanitial

resources. The desirability of integrating restoration work in the development plans of each and every state must be examined and incorporated in the district disaster management manual.

Based on the above discussion the consequences can be grouped into three broad group:

i) Physical consequences

Physical consequences mean the physical impact on the built environment, infrastructure or population. Information on the vulnerability of buildings and infrastruture has been developed in developed countries such as the United States and in Europe.

Hazards can have any number or combination of four effects: destruction and damage to homes and buildings; decreased quantity or quality of water supplies; destruction of crops and/or food stocks; and the presence of unburied human bodies or animal carcassses. These environmental effects vary considerably from disaster to disaster. For example, earthquakes affect buildings but usually not crops, while tropical cyclones may affect both. Closely related to the environmental effects is the impact that disasters have on land tenure are values. These effects also vary with the disaster type; for example, land values after earthquakes will go up in zones that were not havely damaged, but land values go down in zones of active volcanoes.

ii) **Economic consequences**

Three types of cost are observed, these are :

a) Direct Tangible Costs :–

Costs resulting from the impact of the event, such as physical damage to buildings and their contents, which have a market value and so can be easily quantified.

b) Indirect Tangible Costs :–

Costs that result from the flow on effects of a disaster that have a market value, such as business distruption and clean up.

c) Intangible Costs :–

Any direct or indirect cost that does not have a market value, such as death and injury, loss of memorabilia, disruption to social activities or loss of environmetal assets. Intangible costs are difficult to measure and so non-market valuation techniques using proxy values are usually used.

Ideally, an economic assessment of potential or actual losses from a disaster will incorporate all of these loss categories. However direct tangible losses are the simplest to obtain, because they follow more directly from the physical impact, while intangible losses are complex, so many assessments include direct tangible losses only.

Disasters disrupt rather than destroy economies. During an emergency, people must leave their jobs and devote their time to disaster-related activities, such as search and rescue, or to care of survivors. During this period normal economic activities are severely curtailed, even if the sources of employement are unaffected by the disaster. This period is short-lived, however, and in the later phases of a disaster economic activities quickly assume a high priority for both business and victims alike. Whether or not an economy can recover quickly depends on the losses sustained. Physical damage to business and industry may temporarily halt some activities, but most enterprises can operate at reduced levels even with the loss of equipment. Often the workers in a damaged factory can be put to work helping to repair or rebuild the facility. In any case, the loss of jobs is usually only temporary. Of far more concern is the impact of disasters or persons who are participating only marginally in the economy, people such as subsistence farmers, small shopkeepers, and fishermen. After a disaster it is not uncommon for many small enterprises to fail. For the owners, a disaster can wipe out not only their investments but also their savings. Several observers have noted that boom economies often develop after a widespread disaster such as an earthquake or hurricane requiring major physical reconstruction. Long-term effects are not yet known, but at least one study indicates that if low-income victims are given priority in job hiring, boom economies can be a means of adjusting some of the losses.

iii) Cultural or Social Consequences–

Social consequences refer to the factors that influence the way people, households and communities react to a hazard and to the things that influence the losses they experience. Social losses are not always financial; outcomes such as poor health, mental healthe issues, loss of social interactions, loss of identity and family breakdown are all social losses.

Social vulnerability is nested in that the losses of an individual can impact on the whole house hold, and the losses of a household can affect a whole community. Community can been viewed as either a contained geographic area, such as a town or neighbourhood, or a group of spatially dispresed individuals who meet for a collective purpose, such as a sporting team or theatre group.

Social vulnerability is complex-just as people are complex-and ongoing research, usually conducted as post-disaster surveys, tries to understand the interaction of factors that influence social losses. However a number of factors are understood to play a part:

a) **Demographics and Socio-Economic Statistics,** such as age, disability status, income and motor vehicle ownership. These factors are often needed for operational needs in the response phase of disasters and are easily measured quantitatively through the Census and other datasets.

b) **Social Capital :** The social networks and resources that people can call upon to help in times of crisis. Friends, family and neighbours play and important role in all areas of the hazard cycle from warnings, to evacuation, to support in recovery.

c) **Risk Perception :** The household's understanding of whether the hazard will happen to them, and what the impacts of the hazard will be. An appropriate preception of the risk is requried before hauseholds will prepare for and respond to a hazard. Warning will be ignored if the household does not think that the hazard will happen to them personally.

d) **Helth and Mental Health :** People with poor health or mental health issues are at much greater risk of harm or death when a hazard occurs. Conversely, poor health and mental health are common outcomes of disasters in previously healthy people.

Sudden natural disasters are often belived to cause not only widespread death but also massive social disruption and outbreaks of epidemic disease and famine, leaving survivors entirely dependent on outside relife. Systematic observation of the effects of disaster on human health has led to rather different conclusions, both about the effects of disaster on health and about the most effective ways of providing relief. Though all disasters are unique in that they affect areas with differing social, medical, and economic backgrounds, there are still similarities between disasters that, if recognized, can optimize the management of health relief and use of resources. The following point may be noted:

- There is a relationship between the type of disaster and its effect on health. This is particularly true of the immediate impact in causing injuries: earthquakes regularly cause many injuries requiring medical care, while floods, storm surges and seismic sea waves cause relatively few.

- Some effects are a potential rether than an inevitable thereat to health. For example, population movement and other environmental changes may lead to increased risk of disease transmission, although epidemics generally do not result from disasters.
- The actual and potential health risks after disaster do not all occur at the same time. Instead, the tend to arise at different times and to vary in importance within a disaster-affected area. Thus, casualties occur mainly at the time and place of impact and require immediate medical care. The risks of increased disease thansmission take longer to develop and are greatest where there is crowding and reduced standards of sanitation.
- Disaster-created needs for food, shelter, and primary health care are usually not total. Even displaced persons often salvage some of the basic necessities of life. Further, people generally recover quickly from their immediate shock and spontaneously engage in search and rescue, transport of the injured, and other private relief activities.

e) **Administrative and Managerial Consequences :** Administrative problems in disaster are made more difficult by four factors, which increase in importance with the extent of the disaster.

1. Effects on community leadership. The loss of leaders due to death or injury can impair disaster response.
2. Disruption of formal organizations. When a disaster strikes, large formal organizations are most distrupted. Small, community-based organizations are generally better able to function, even with loss of leaders.
3. Damage to cirtical facilities and lifelines. Widespread disasters can destroy or damage facilities that may be critical not only for responding to the disaster but also for maintaining a safe evironment and public order. Among these are communications installations; electrical generating and transmission facilities; water storage, purification, and pumping facilities; sewage treatment facilities; hospitals; police stations; and other private buildings.
4. Disruption of transportation (and isolation of resources). During the initial stages of most types of disasters, almost all surface means of transportation within a community are disrupted. Bridges can be knocked out; roads can be cut by landslides; rubble can block streets and highways.

Prevention, Mitigation and Preparedness

Up until this point, disasters have been discussed in terms of reaction, both by the affected societies and the relife agencies. An underlying theme, however, has been that disasters are not unforeseen events. The techonology now exists to indentify the hazards that threaten a community and to estimate the areas and the settlements that will be affected. One can then take steps to prevent the disaster, or prepare for the disaster and substantially reduce, or mitigate, its impact. These actions are known as pre-disaster planning. Frederick Krimgold pioneered the early conceptualization of pre-disaster planning, which he describes as follows:

"Planning may be difined as the process of preparing a set of decisions for action in the future directed at achieving goals by optimal means. The stated goals of disaster relief are the reduction of human suffering, the improvement of material well-being, and the increase of personal security. It goes without saying that these goals are best served if disaster, in the first place, can be avoided or reduced. Thus, the primary goal of pre-disaster planning may be seen as the prevention or mitigation of disaster. If we refer to the definition of disaster in terms of the need for outside help, we may describe the goal of ore-disaster planning as the creation of self-sufficiency in dealing with natural phenomena, In those cases where prevention is not possibel, the goal must be to plan for the effective application of aid...(1974)".

Disaster prevention and mitigation should be in the fore front of the reader's mind. Indeed, all disaster managers, whether full-time profesionals or part-time volunteers, are challenged to accept disaster prevention and mitigation not only as a role to play but as their responsibility to their society, constituency, or clientele. Individuals working within government will have opportunities to increase their country's safety by promoting several activities. The most appropriate activity well obviously depend on their position in government. For example, a person within a ministry devoted to natural resource development will see the need to conduct hazard mapping of seismic risk areas, flood prone areas, and perhaps zones subject to lankslides. An employee within a ministry in charge of communication will see the need to integrate a complete disaster warning system with the national communication networks and to develop guidelines on communicating disaster emergencies to the central government and the public. An official of a national bank will become aware of the need to include disaster mitigation measures and also criteria for the financing of projects that take into account disaster risks. Non-government organizations including private voluntary organization have other possible opportunities to implement improved disaster management programs. The traditional role of these groups is to

react to disaster in the form of emergency relief and sometimes long term recovery programms. Being able to anticipate their consequences is a prerequisite not only to appropriate action following disaster events but also to prevention of them.

2.5 Conclusion

The causes and consequences of the hazards can be managed by proper management system. Hazards management has to be proper multi-disciplinary and pro-active approach. Besides, various measures for putting in place institutional and policy framework, disaster prevention, mitigation and preparedness enunciated earlier and intiatives being taken by the government, community, civil society organization and media also have a key role to play in achieving our goal of moving together. Therefore, the prime objective is to raise awareness levels, knowledge base of the community to make them alert, self-reliant and cope with the consequences. The communities poses the capacity and the strength arising out of the previous experiences in facing emergencies. This needs to be harnessed. The awareness in required to enable the community understand the consequences of hazards, efforts they need to put to reduce its impact and save their lives and property.

2.6 Summary

This unit highlighted the cause of the hazards and their consequences in detail. It is advised that, the hazards could be managed properly by implementing the awareness programme by the government as well as the community at large.

2.7 Glossary/Keywords

Allessment– Survey of a disaster area to make estimates of damages and recommendations for necessary relife action.

Hazard– Physical forces (hurricane, flood, volcano, etc.) that, when proximity to populations, may cause disasters.

Health resources– Public and private hospitals and clinics, medical personnel, medical and drug supplies, and pharmaceutical distributors.

Malnutrition– The condition of severe shortage of protein and calorie intake to such a degree that wasting and shrinking of muscles occurs and

performance of daly tasks is drastically inhibited. Malnutrition is measured by several indicators, including upper arm circumference, weight/height, and weight/age ratios. These measurements are compared to a standard for a well-nourished individual of the same age.

Trauma– Injury or shock that can result when individuals are suddenly and violently thrust into a disaster situations; may be physical or mental.

2.8 Reference and Further Readings

- A guide to Emergency Health Management after Natural Disaster, (1981). Washington,
- D.C.: Pan American Health Organization.
- Abbott, Partick L., (1996), Natural disasters, Wm. C Brown Publishing Co.
- Chakraborty U.K., (1993), Industrial Disaster Management and Emergency Response.
- Disaster Reduction, Reliance Publishing House, New Delhi,
- Coch, Nicholas K., (1995), Geohazards, Natural and Human. Prentice Hall.
- Frederic C. Cuny. (1983). Disasters and Development. New York: Oxford University Press.
- International Institute for Environment and Development. (1984), Natural disasters: Earthscan Press Briefing Document No. 39, London : Earthscan.
- J. Eugene Hass, R. W. (1977), Reconstruction Following Disasters. Cambridge, Massachusetts : MIT Press,.
- Jaeryl Covington and David M. Simpson Working Paper 06-02. (2006), An Overview of Disaster Preparedness Literature: Building Blocks for an Application Bay Area Template.
- Keller, Edward A., (1985), Environmental Geology, 4th Ed. Charles E. Merril Publishing Co.,
- Mandal, G.S, Natural Krimgold, F. (1974). The Role of International Aid for Pre-disaster Planing in Developing Countries,. Stockholm,
- Prakash, I (1994) Disaster Management, Rashtra Prahari Publishers, Sahibabad, Ghaziabad, India.

- Rudra, K. (2010), Banglar Nadikatha, Sishu Shahitya Sansad Pvt. Ltd., 1(2), 1-117. S.L.Goel. 2007. Disaster Administration and Management. New Delhi: Deep & Deep Publications Pvt. Ltd.
- Sharma, VK. (2005). Natural Disaster Management in India Environment and development view point. P1-24.
- Shrivastava, N.K. (2015). Management of natural disasters an India perspective.
- State Disaster Management Authority. (2015). West BEngal State Disaster Management Policy & Framework, Department of Disaster Management, West Bengal.
- Vaidyanathan. S. (2011). An Introduction to Disaster Management-Natural and Man Made Hazards, 10.

2.9 Model Questions

1. What are the main causes of hazards? 10
2. Discuss in detail the natural and man-made causes of hazards. 10
3. Write a short note on consequences of hazards. 5
4. What are the different measures to understand the cultural consequences? 5
5. What are the different costs associated with economic consequences of hazards? 5
6. Discuss the environmental consequences of hazards. 5
7. Write short note on social vulnerability. 5
8. what are the social consequences of hazards? 5
9. Write a note on administrative and managerial consequences. 5
10. What are the prevention, mitigation and preparedness of the hazards? 5
11. What are the consequences of hazards in the agro based economy? 5
12. How do hazards affect the people of different economic background? 5
13. How do the government can help to prevent the hazards? 5

Unit-3 □ Role of National and International Organizations in Disaster Management

Content Structure

3.1 Learning Objectives

The main objectives are:

- To Clarify the role and responsibilities of relevant institutions both national and international in disaster management during emergency.

3.2 Introduction

Disaster Management can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disaster.

The first people to respond to a disaster are those living in the local community. They are the first to start rescue and relief operations, The Red Cross and Red Crescent National Societies therefore focus on community-based disaster preparedeness, which assists communities to reduce their vulnerability to disasters and strengthen their capacities to resist them.

When the capacity of a community or country to respomd and recover from a disaster is overwhelmed, and upon request from the National Society, the International Federation uses its regional and international networks, assets and resources to bring assistance to the communities and National Red Cross, Red Crescent Society which is assisting them. At an international level the International Federation advocates with Governments, international organization and humanitarian donors for better practice and accountability in disaster management and greater respect of the dignity of the vulnerable people.

Disaster management is a complex process involving international, national and local organizations each with a distinct role to play. To respond to disaster situations a coordinated effort is required.

3.3 Role of National Organizations in Disaster Management

The role of various agencies in disaster management in India are discussed below.

1. **Role of the Union Government:** Although the State Government concerned has the primary responbility for crisis management, the Union Government plays a key supportive role in terms of physical and financial resources and providing complementary measures, such as early warning and co-ordination of efforts of all union ministries, departments and organizations. At the apex level, a Cabinet Committee on Natural Calamities reviews the crisis situation.

   A high level committee of ministres under the chairmanshiop of Minister of Agriculture deals with the issue of financial support to be provided to the State Governments from the National Disaster Response Fund, if the funds available with the State Governments under State Disaster Response Fund are not adequate. Matters relating to nuclear, biological and chemical emergencies are looked after by the Cabinet Committee on Security.

2. **National Crisis Management Committee:** The Cabinate Secretary, as the highest executive officer, heads the National Crisis Management Committee (NCMC). Secretaries of ministries and departments concerned and heads of other organizations are members of NCMC, which reviews and monitors crisis situations on a regular basis and gives directions to the Crisis Management Group, as deemed necessary. The NCMC can give direction to any ministry, department or organization for specific action needed for meeting the crisis situation.

As disaster management is a multi-disciplinary process, all Central Ministries and Departments have a key role in the field of disaster management. In view of the highly technical and specific nature of certain disaster events such as aviation disasters, rail accidents, chemical disasters and biological disasters etc; the ministries dealing with that particular subject have the nodal responsibility for handling that particular type of disaster. Nodal Ministries/Department for Disaster Management at the National Level: i) Droughts–Ministry of Agriculture, ii) Epidemics and Biological Disasters– Ministry of Helath, iii) Chemical or Industrial Chemical Disasters– Ministry of Environment & Forest, iv) Nuclear Accidents– Department of Atomic Energy, v) Railway Accidents– Ministry of Railways, vi) Air Accidents– Ministry of Civil Aviation, vii) Natural Disasters except Drought & Epidemics and Civis Strife– Ministry of Home Affairs.

The Secretaries of the Nodal Ministries and Departments of GOI, i.e. the Ministry of Home Affairs (MHA), Agriculture, Civil Aviation, Environment and Forests, Health, Atomic Energy, Space, Earth Sciences, Water Resources, Mines, Railways etc. are all members of the National Executive Committee (NEC) and function as nodal agencies for specific disasters based on their core competencies or as assigned to them.

The coordination between various nodal ministries/departments is done by NEC, which is headed by Home Secretary. The NEC has to prepare the national plan for disaster management based on the National Disaster Management Policy.

3. **Crisis Management Group:** The Crisis Management Group (CMG) consists of nodal officers from various concerned ministries. Apart from CMG, the National Executive Committee headed by the Home Secretary performs the statutory coordination and functions as per the DM Act, 2005.

The CMG's functions are to review annual contingency plans formulated by various ministries, departments and organizations in their respective sectors, measures required for deling with natural disastres, coordinate the activities of the Union Ministries and State Governments in relation to disaster preparedness and relief, and to obtain information from the nodal officers on all these issues.

In the event of a disaster, the CMG meets freequently to review relief operations and extends all possible assistance required by the affected states to overcome the situation. The Resident Commissioner of the affected state is also associated with such meetings.

4. **Funding Mechanism:** Each state has a cropus of funds, called State Disaster Response Fund, administered by a state level committee headed by the Chief Secretary of the State Government. The Size of the corpus is determined with reference to the expenditure normally incurred by the state on relief and rehabilitation over the past ten years.

In case the funds uncer State Disaster Response Fund are not Sufficient to meet the specific requirments, State Governments can seek assistance from the National Disaster Response Fund–a fund created at Central Government level. Both these funds, as the names suggest, are meant for relief and rehabilitation and do not cover either mitigation or reconstruction works, which have to be funded separately by the State or Union Government.

5. **Role of State Government:** In India, the basic responsibility to undertake rescue, relief and rehabilitation measures in the event of natural disasters rests with the state government. Since the very beginning, the entire structure of crisis administration in the state governments had been oriented towards post disaster relief and rehabilitation.

Most of the states have Relief Commissioners who are in charge of the relief and rehabilitation measures. Most of the states have switched over to Disaster Management Department with the required linkages with the various development and regulatory departments concerned with prevention, mitigation and preparedeness.

Every state has a Crisis Management Committee under the chairpersonship of the Chief Secretary, consisting of secretaries in charge of concerned departments, which reviews crisis situations on a day-to-day basis at the time of crisis, coordinates the activities of all departments and provides decision support system to the district administration. At the ministers' level, a Cabinet Committee on Natural Calamities uncer the chairpersonship of the Chief Minister takes stock of situations and is responsible for all important posicy decisions.

6. **Role of District Administration:** The District Magistrate/Collector has the responsibility for overal management of disasters in the district. He has the authority to mobilise the response machinery and has been given financial powers to draw money under the provisions of the General Financial Rules/ Treasury Codes.

All departments of the State Government, including the police, fire services, public works, irrigation etc., work in a coordinated manner under the leadership of the Collector during a disaster, except in metropolitan areas where the municipal

body plays a major role. The District Collector also enjoys the authority to request for assistance form the Armed Forces if circumstances so demand. NGOs have also been effective in providing relief, rescue and rehabilitation in recent times.

7. **Role of Local Self-Governments:** Local self-Governments, both rural and urban, have emerged as important tiers of governance, after the 73rd and 74th Amendments to the Constitution. For the people, they are also the nearest units of administration and are among the first responders to any crisis besides being closely knit with the communities. These units can thus play an important role in crisis management under the overall leadrship of the District Administration.
8. **Role of Public/NGO/ Civil Society/Media:** The local community is usually the first responder incase of a disaster. Local community also carries traditional knowledge and relevant counter measures regarding disaster management. So the role of local community must be utilized with the help of NGOs and media.

They should be encouraged to play an active role in all three phases of disaster management. District administration should also focus on capacity building, participation and empowerment of these stakeholders in disaster management.

Mobilization of country action supported by local NGO's along with government machinery is a must for quick, efficient and effective respomse. For this, helthy coordination must exist between local administration and local community/NGO's Local NGOs and civil society must work on developing a deep culture of safety and prevention in society.

NGOs, civil society and media also play an active role as pressure groups in a damocracy so that any laxity on part of the government can be traced and fixed, So, the public and the NGOs should keep a close vigil over the functioning of the Government regarding disaster management and render their services as a watchdog.

NGOs with dedicated Field Operations and Resource Backup

NGOs Related with Development Technology are involved in developing and propagating development technologies, such as Sulavh International, which is renowned for its work in low cost sanitation. These NGOs are active in times of peace. They carry out their developmental projects all through the years and could also be called in at the time of emergency arising out of disaster situations. They facilitate the work of infrastructure provision to the affected communities. Even in

non-disaster or normal times, their services are important for retrofiting and using latest building technology, in order to minimize the incidents of death and destruction at the time of disasters such as earthquakes and floods.

Interest Grops are also NGOs, which are multi-purpose in nature having varied interests, such as the Ratary Club. However, such interest groups are very active, and have come forward to help disaster victims in the times of need. They could play a major role in resource mobilisation for relief aid and rehabilitation purposes.

Associations of Local Occupation Groups are formed on the basis of common occupational backgrounds, and could include groups such as doctors' associations, traders' associations and Army wives' associations etc. Such groups, just like other interest groups, could play a major role in resource mobilisation, and provision of specilised services to the victims in any emergency situation.

Local Residents' Associations: These Residents' Welfare Associations (RWAs) are formed by the local residents to look into the interests of these living in their area. These associations are extremely concerned about the welfare of the local community and need to external motivation or resource backup to take active part in disaster reduction. Thus, They could act as a very useful tool for getting across the massage of community participation at the ground level.

Religious Bodies are one of the most important NGO groups that come to the immediate rescue and relief of the disaster victims. These bodies have a large and dedicated following in their communities. They also have control over the local places of worship, which are usually build on high and safe ground, and can serve as ideal shelters for the disaster victims. Besides, they often have infrastructure and resources to feed mass gatherings, which facilitate disaster relief work.

Educational Institutions such as schools and colleges play an important role in disaster management. Their prime resoponsibility is to spread awareness on natural disasters, provide preventive action needed to minimize damage due to disasters as well as ensure immediate relife and rescue. Besides, these institutions have large buildings as local leves, which could be used as shelters for the victims in the times of disasters.

Taking into account all these NGOs and their respective activity areas, it can be stated that the NGOs can facilitate the process of disaster management by contributing towards:

i) Communication with Community – NGO's have a better link with the community and also have a presence in the field of action. This puts them in a better position to asses, decide and implement relief operations at the time of a disaster.

ii) Human Resources – The human help available with NGO's is unlimited. The human resources of NGO's are very prompt and highly mitivated, as they basically comprise volunteers who are involved at: their own initiative. There are no procedural problems such as those of maintaining rolls and handling related legal issues.

iii) Finances and Materials– NGO's have very flexible means of mobilising resources and a number of them specialise in just and fair resource mobilisation to be able to fund the activites of other NGO's working in the field of disasters.

iv) Professional and Technical Services– A number of specialised technical services can be made available to the community by the NGOs, which would otherwise be too expensive and inaccessible to the common folk. Bsed on the indentified types of NGOs and their capabilities, organised action of NGOs can be very useful in the following activities (Table No 1) that need to be attended to at the different stages of disaster management:

Table No 1

Stage	Activities
Pre-Disaster	Awareness and information campaings Training and local volunteers Advocacy and planning
During-Disaster	Immediate rescue and first-aid including psychological aid Supply of food, water, medicines, adn other emergency meterial Ensuring sanitation and hygiene Damage assessment
Post-Disaster	Technical and meterial aid in reconstruction Assistance iin seeking trnancial aid monitoring

Indian Red Cross Society

In India, we have Red Cross Society at the national, state and district levels. This is not just an agency, but also a movement for providing relief to the people when they are in need of it. Since this is an offshoot of an international movement, it is a completely non-political organisation. It is the image of the Red Cross that makes it ine of the most acceptable institutions in the area of providing relief to the people in distress. Till 1995, the Red Cross was working primarly as a relief organisation.

From 1996 onwards, the International Federation of Red Cross has shifted its focus from 'relief' to 'disaster preparedness' and has started developing community-based disaster preparedness plans.

Media

The role of the electronic media has, during recent times, emerged as a major component of disaster management. This role has been amply demonstrated in the aftermath of disaster be in the Gujrat earthquake of 2001 or the Muzzafarabad Earthquake of 2005. At the same time, the role of the print media especially regional press needs to be given due recognition, as this continues to be the only medium accessible to a large section of people in many parts of society, which still remains unreachable by the electronic media. Besides, it is also true that the print media has a major role to play in pre-disaster prevention, mitigation and preparedness activities through generation of appropriate community awareness.

Relevance of Community Participation:

The community, as an institution in itself, is emerging as the most powerful among all the agencies involved in disaster management. In the event of a disaster, the community, if well aware of the preventive actions it is required to take, can substantially reduce the damage caused by the disaster. Education, awareness and training of the community are particularly useful in areas that are prone to frequent disasters.

The World Helth Organisation (WHO) defines the community as a group in face-to-face contact with each other, having harmony of interests and aspirations. It is also bound by common values and objectives. The efforts of the community in certain areas are laudable. At some places, they have formed their own organisations that take the initiative in disaster situations. These Community-Based Organisations (CBOs) are doing a lot of work in the area of disaster management,

The CBOs, it has been pointed out, perform certain pertinent functions. They:

- Offer mutual support and solidarity.
- Strengthen people's ability to face crisis.
- Generate consciousness, awareness and analvsis on issues of common concern.
- Enable people to demand an access to services and information ofered by government agencies (the new Right to Information Act has facilitated this role).

- Organize collective acquisition of skills and knowledge in various spheres.

One impoetant community-based organisation is the Village Task Force. These Task Forces have been formed in villages of Ahdhra Pradesh, followed by similar task forces in villages of Orissa and Gujarat. The volunteers of the Village Task Force are trained in emergency evacuation and relief within the village. Salient features of their training are:

- Orientation training in disaster preparedness for villagers and staff members.
- Discussion on disaster preparedness in general meetings.
- Sponsoring of staff for specialized training.
- Reparation of a handbook for emergencies.

Each community should have its own Disaster Task Force (DTF) comprising 10-12 members.

The following criteria should be followed while selecting the members:

- They must be young and healthy persons.
- They must be members of the gram panchayat.
- They must have acceptability and credibility in the community.
- They should be persons who do not go to distant places for daily work.
- They should have a strong inclination and commitment towards community service and volunteerism.

The People should tlect the Task Force and during disasters, it must serve as the nodal body for disaster management at the village level. It has to mobilise resources for the community and disseminate necessary information passed on by the outside agencies to the villagers. While the community as an effective institution is yet to take shape in developing countries like India with low literacy levels and widespread poverty, considerable efforts are being made to form and strengthen community-based organisations at the grass roots levels.

The significance of community preparedness in handling diasaters has been duly recognized over time. If human interventions can be listed as the cause for increase in the scale of destruction then it is through community preparedness that the scale can be reduced, The Report of the High Powered Committee, set up in 1999, also

emphasises the need to look into community preparedness components and strategies such as nature of hazard assessment, risk analysis, disaster prevention, emergency planning, public information and awareness. Any effort towards strengthening the capacity of CBOs should aim at :

- Enabling them to efficiently and effectively develop, manage and sustain disaster mitigation, preparedness and response programmes.
- Promoting effective coordination between the community organisation. NGOs and governmental agencies in disaster response.
- Developing a forum for exchange of knowledge and experiences in managing disasters.
- Creating a pool of trained disaster management personnel drawn form the community who can act as key resource persons in disaster management.
- Ensuring training of women in order to assess and meet the health and safety needs of other disadvantaged groups.

3.4 Role of International Organizations in Disaster Management

The following are some International organization in disaster management. The activities and role of these organizations are stated below.

1. The United Nations and its Organizations – The Office for the Coordination of Humanitarian Affairs (OCHA) in collaboration with the Inter-Agency Standing Committee (IASC) is the arm of the United Nations (UN) responsible for bringing together national and international humanitarian providers to ensure a coherent response to emergencies. OCHA also ensures that a framework is in place within which each porvider can contribute to the overall response effort. It also advocates for people in need, promotes preparedness and prevention and facilitates sustainable solutions.

The Food and Agriculture Organization or the UN (FAO) Provides early earning of impending food crises, and assesses global food supply problems.

The International Organization for Migration (IOM) is an inter-governmental agency which helps transfer refugees, internally displaced persons and other in need of internal or international migratrion services.

The Office of United Nations High Commissioner for Human Rights (OHCHR) provides assistance and advice to governments and others actors on human rights issues, sets standards and monitors rights violations.

The United Nations Development Programme (UNDP) assists disaster-prone contries in contingency planning and with disaster mitigation, prevention and preparedness measures. **The United Nations High Commission for Refugees (UNHCR)** provides International protection and assistance for refugees, stateless persons and internally displaced persons, praticularly in conflict-related emergencies.

The United Nations Children's Emergency Fund (UNICEF) works to uphold children's rights, survival, development and protection by intervening in health, education, water, sanitation, hygiene and protection.

The World Food Programme (WFP) is the principle supplier of relief food aid.

The World Health Organization (WHO) provides global public health leadership by setting standards, monitoring health trends, and providing direction on emergency health issues. WHO's role is to reduce avoidable loss of life and the burden of disease and disability. A range of technical guidelines for health action in crises and pre-deployment training courses are abailable. A set of technical hazard sheets on earthquakes, drought, floods and landslides, is also available.

2. The International Fedaration of Red Cross and Red Crescent Societies: The International Federation of Red Cross (IFRC) and Red Crescent Societies is the world's largest humanitarian organization made up of 186 member Red Cross and Red Cresent Societies. The International Federation's mission is to improve the lives of vulnerable people by mobilizing the power of humanity.

The IFRC coordinates and directs international asistance to victims of natural and techonological disasters, to refugees and in health emergencies. It combinaes its relief activites with development work to strengthen the capacities of National Societies and through them the capacity of individual people. The IFRC acts as the official representative of its member societies in the international field. It promotes cooperation between National Societies, and works to strengthen their capacity to carry out effective disaster preparedness, health and social programmes.

3. The International Committee of the Red Cross– The International Committee of the Red Cross (ICRC) is a Swiss-based humanitarian organizations and founding member of the international Red Cross and Red Crescent Movement (1863). It is mandated by the international community to be the guardian and promoter of

international humanitarian law, working around the world to provide assistance to poeple affected by violence.

The ICRC provides physical rehabilitation to people injured by explosive weapons or other types of incident. ICRC organizes, in collaboration with WHO, the Health Emergencies in Large Populations (HELP) course to upgrade professionalism in humanitarian assistance programmes.

The ICRC runs programmes to support the development of physical therapy education and welcomes the involvement of individuals or physical therapy institutions in supporting these developments. Opportunities are added to the working and studying abroad page of their website.

The ICRC publication Health care in danger: the responsibilities of health-care personnel working in aimed conficts and other emergencies provides guidance, in simple language, on rights and responsibilities in conflict and other situations of violence for health personel.

4. International Non-Governmental Agencies– Leading international non-governmental agencies work through volunteers to fight proverty in developing countries. Their strong role in development works side by side with the recovery from a disaster and prevention and preparedeness for any future disasters.

CARE (Cooperative for Assistance and Relife Everywhere) is a humanitarian organisation fighting global proverty. Women are at the heart of CARE's community-based efforts to improve basic education, prevent the spread of HIV, increase access to clean water and sanitation, expand economic opportunity and protect natural resources. CARE also delivers emergency aid to survivors of war and natural disasters, and helps people rebuild their lives. CARE works alongside poor women bacause, equipped with the proper resources, women have the power to help whole families and entire communities escape poverty.

Handicap International Works in partnership with local organizations and government institution. It raises awareness of both governments and the general public on disability and landmine issues, mobilizes civil society and implements action in emergency situations.

Health Volunteers Oversease (HVO) is a network of healthe care professionals, organizations, corporations and donors united in a common commitment to improving global health through education. The website includes a volunteer toolkit and an informative newsletter Volunteer Connection.

IMA World Health is an inter-church not-for-profit organization based in the United States of America, which partners with United State Agency for International Development (USAID), the World Bank and many other organizations to build sustatinabel health care systems.

International Rescue Committee (IRC) Offers lifesaving care and life-changing assistance to refugees forced to flee from war or disaster and provides emergency response by experienced personnel for short-term assignments.

Medicines Sans Frontiers (MSF) provides medical services in emervency situatios. It recruits some physical therapists and other health professionals as well as physicians.

Oxiam is an international confederation of 14 organisations working together and with partners ans allies around the world to bring about lasting change. Oxfam works directly with communities ans seeks to influence the powerful to ensure that poor people can improve their lives and livelihoods and have a say in decisions that affect them.

Rehabilitation International (RI) is a global network of expert professionals who work to empower people with disabilities and provide sustainable solution for a more inclusive and accessible society. It avocates for inclusion of people with disabilities in climate change and disaster management planning.

3.5 Conclusion

Every effort to support and assist the emenrgency response activities are mainly done by national and internation organizations. This guidelins comes into effect on the date of promulgation for every relevant institution/organization both inside and outside of the country to adjust themselves to the characteristics and needs. The knowledge and skills of these organizations are very helpful process for reduction of the risk. First, it is necessary to educate the community about the entire disaster risk reduction and even to impart skills and assign specific roles to the members of the community, so that the first response from the community is a well-coordinated one.

3.6 Summary

The proper management of hazards do not degenerate it into disasters. The proper execution of the role of different national and international disaster management organizations help the people to survive.

3.7 Glossary and Keywords

Community Participation – The participation of community in disaster management is very significant, as it is not only the affected party but is also in the know of the problems vis-h-vis the vulnerability conditions and infrastructure facilities. The involvement and participation of the community in the disaster management process makes all traget-oriented programmes change-specific and people-centered.

Comprehansive Disaster Management – Disaster management to be effective has to be a Holistic exercise. It should start with disaster preparedness and mitigation, and move on to rescue and relife. The final stage in disaster management is rehabilitation and reconstruction, whic should ultinmately provide a frame work leads to total recovery and development of the disaster-affected area.

Disaster Area Survey Team (DAST) – a group that is deployed in an area after a disaster to ascertain the extent of damage to population and property and to recommend appropriate responses.

Disaster assistance– provision of measures to prevent, reduce the impact of, and reverse the effects of disasters; phases include relief, rahabilitation, reconstruction and preparedness, and prevention and mitigation.

Disaster plan– the basic principales, policies, responsibilities, preparations, and responses developed to enable a society to meet any kind of emergency or disaster.

Disaster planning strategy– the national strategy of a country for achieving civil and state defense emrgency preparedness, which defines the overall purposes, systems, methods and organisations (public and private), and the ways and means of achieving coordination and prompt response to needs as they arise.

First aid– the immediate but temporary care given to the victims of an accident or sudden illness in order to avert complications, lessen suffering, and sustain life until the services of a physician can be obtained.

Framework for Coordination– There is a systematic structural framework of coordination for disaster management at the central, state and district levels. The organisational structure at these levels facilitates better cooperation for management of disasters.

ICRC – International Committee of Rod Cross.

Life support– food, water, sanitation, shelter, and medical aid during the 60 to 90 days following a disaster.

Mitigation– long-term measures taken to reduce the effects of disaster through alteration of the physical environment, such as floodplain zoning and control, afforsestation, land terracing, torrent control, sand dune stabilization, and planting of shelterbelts or windbreaks.

NGO– Non Govermental Organization.

Preparedness– may be described as actions designed to minimize loss of life and damage, and to organize and facilitate timely and effective rescue, relief and rahabilitation in cases of disaster. Preparedness is concerned with understanding the threat, forecasting and warning; educating and training officials and the population; establishing organization for and management of disaster situations, including preparation of operational plans, training relief groups, stockpiling supplies, and earmarking recessary funds.

Prevention – measures designed to preclude natural phenomena from causing or resulting in disaster or other emergency situations. Prevention concerns the formulation and implementation of long-range policies and programs to eliminate the occurrence of disasters.

Prevention includes legislation and regulatory measures, principally in the fields of physical and urban planning, public works, and building. It also encompasses the manifestation of such plans.

Public awarness – the state of being informed about the actions needed to save lives and property in the event of a disaster. Public awareness may involve public or adult education, radio or television broadcasts, the establishment of emergency centers in convenient locations, and the use of the print media.

Private voluntary organization (PVO) – a group that aids needy people around the world on a regular basis as well as in times of disaster.

Rehabilitation – as used by OFDA, actions taken in the weeks or months immediately following a disaster to restore basic services, construct temporary housing, and allow a population to function at near pre-disaster level.

Relief – the meeting of immediate needs food, clothing, selter and medical care for disaster victims. As used by the OFDA, the assistance given to save lives and alleviate suffering in the days and weeks following a disaster. For creeping disasters the relief period may be months or even years.

Shelter – housing to meent basic needs of disaster victims. Immediate post-disaster needs are met by the use of tents. Alternatives may include polypropylene houses, plastic sheeting, geodesic domes, and other similar types of temporary housing.

3.8 References and Further Readings

- Amin. S and Goldstein M. (2008). Data against natural Disasters Establising Ellective Systems for Relief, Rocovery, and Reconstruction. World Bank Publication.
- Baiju K. Nath (2006) Holistic Approach to Disaster Management for a Sustainable Future.
- Behera A. 2002. Government - NGO Collaboration for Disaster Reduction and Response : The India (Orissa) Experience, paper presented in the Regional Workshop on Networking and Collaboration among NGOs of Asian Countries in Disaster Reduction and Response, 20-22 February 2002, Kobe, Japan.
- Carter, W. Nick, (1999) Disaster Management: A Disaster Manager's Hand Book, Asian Development Bank, Manila.
- Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., Webb, J. (2008). A Place based model for understanding community resilience to natural disasters. Elsevier, Global Environmental Change. 18(4), 598-606.
- GoI. 2009. National Disaster Management Guidelines/Management of Floods. National Disaster Management Authority.
- GOI-UNDP. 2002-2009. Disaster Risk Management Programme, New Delhi.
- GoWB. 2009. Situation report cyclone Aila. Palli Unnayan Samiti, Baruipur. "Aila" Cyclone Report.
- Gupta, Harsh K, (2003), Disaster Management, University Press, Hyderbad.
- Human Development Report, 1999, World Bank, Oxford University Press, Oxford.
- International federation of Red Cross and Red Crescent Socienties (1998), World Disaster Report 1999, Oxford University Press, Oxford.
- International federation of Red Cross and Red Crescent Societies (1999), World Disaster Report 1999, Oxford University Press. Oxford.

- International federation of Red Cross and Red Cresentr Societies (2000), World Disaster Report 2000, Oxford University Press, Oxford.
- Kirschenbaum, A (2004) Measuring the Effectiveness of Disaster Management Organizations, International Journal of Mass Emergencies adn Disasters, *22(I)*, 75-102. Medury, Uma and Alka Dhameja, (2005), "Rehabilitation of Cyclone Affected People" in Amita Singh (Ed.), Aclmirzi stmtive Kgforrtzs: Towards Sustainable practice, Sega, New Delhi.
- Medury, Uma, (2001). "Coping wit11 Disasters: A Community-based Approch" in Pradeep Sahni et nl. (eds.), Disaster Mitigation Experiences and Reflections.
- Sahni, Pradeep and Madhavi Malalgoda Ariyabarldu (Eds.), (2003), Disaster Risk Reduction in Soutlz Asia, Prentice-Hall of India, New Delhi.
- Sahni, Pardeep, Alka Dhameja and Unla Medury (Eds.), (2001), Disaster Mitigation: Experiences and Reflections, Prentice-Hall of India, New Delhi.
- Samantary S K. 2014. Disaster Management : An overview of peoples perception the Journal of Rural and Agricultural Research 14(2).
- State Disaster Management Authority (2005) West Bengal State Disaster Management Policy & Framework; Department of Disaster Management.
- UNISDR. 2007. Disaster Risk Reduction, 2007: Global Review. Geneva: United Nations

3.9 Model Questions

1. Write short note on i) National Crisis Management Committee, ii) Crisis Management Group, iii) The International Committee of the Red Cross, iv) CARE. 5×4
2. NAme the different Nodal Ministries/Department for disaster management at the Indian National Level. 5
3. Who are the members of the National Executive Committee? 5
4. What are the function of the Crisis Management Group? 5
5. State the different role of Union Governmentr and the State Government to manage the disaster. 5
6. What is the function of the Crisis Management Committee? 5

7. What is the role of i) District Administration, ii) Local Self-Governments and iii) NGO in disaster management? 5×3

8. Name the different organizations of the United Nations and state their functions. 5

9. Which is the world's largest humanitarian organization? State their role in this ragard. 10

10. Name the different International Non-Governmental Agencies and state their role in desaster management. 10

11. Explain community participation in detail. 10

12. What is the function of media in disaster management? 10

13. What is the function of NGOs in Field Operations and Resource Backup in disaster management? 5

14. Discuss about the processes that the NGOs can facilitate for disaster management? 5

15. What is the relevance of community participation? 5

Unit-4 □ Causes, Impact and Distribution of Earthquake, Tsunami, Landslides

Content Structure

4.1 Learning Objectives

The main objectives are:

- To understand the geologic hazards by discussing the meaning and concept of earthquake, landslide and tsunami.
- To understand the causes behind their occurrence.

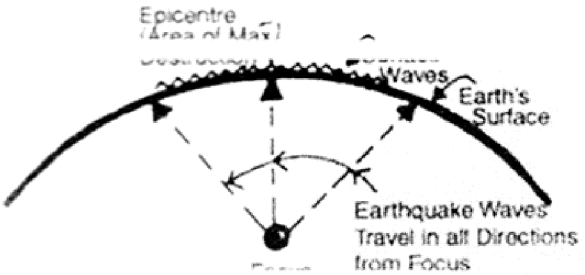
- To describe the disastrous impact of these hazards.
- To describe the geographical distribution of these hazards.

4.1 Introduction

A geologic hazard is an extreme natural events in the crust of the earth that pose a threat to life and property, for example, earthquakes, volcanic eruptions, tsunamis (tidal waves) and landslides. Historically it has brought endless pain to humans leaving many painful memories, so it is the evironmental issues that are of the most concern to people.

4.3 Earthquake

'An earthquake is the motion of the ground surface, ranging from a faint tremor to the wild motion capable of shaking building apart and causing gapping fissures to open in the ground. The earthquake is the form of wave motion transmitted through the surface layer of the earth in widening circles from a point of sudden energy release, the focus' (A.N. Strahler and A.H. Strahler, 1976). Therefore, an earthquake can be defined as a motion or trembling in the earth caused by abrupt release of slowly accumulated strain. The seismic waves of earthquake which originate in the interior of the earth, may give a good shaking to the surface. The place below the earth crust where an earthquake is originated called focus or center. The depth of the focus may vary from place to place and it depends on the structure of the earth's interior. The deepest earthquake may have its focus at a depth of even 700 km below the ground surface. The place on the surface of the earth which is perpendicular to the 'focus' striking first time, is called 'epicenter'. The occurrence of large number of lesser earthquakes in a particular region over an interval of time perhaps several months, without the event of a major earthquake is called earthquake swarm.



Focus and Epicentre of an earthquake.

The magnitude or intensity of energy released by an earthquake is measured by the Richter scale devised by Charles F. Richter in 1935. The number indicating magnitude or intensity on Richter scale ranges from 0 to 9 but in fact the scale has no upper limit of number because it is a logarithmic scale. Another scale of measurement of the degree of destructiveness or intensity of the earthquakes in Mercalli scale. The folliowing Table No 1 shows the comparative picture of Mercalli Intensity Scale and Richter Magnitude Scale.

Table No 1 : Comparative picture of Mercalli and Richter Scales

Mercalli Intensity	**Description and Characteristics Effects**	**Richter Magnitude corresponding to highest intensity reached**
I Instrumental	The tremors of this category of earthquakes are detected only by seismograph	1-3.4
II Feeble	Such earthquakes are noticed by only sensitive people	3.5
III Slight	Like the vibrations caused by passing truck or lorry; felt by people at rest especially in upper floors of the buildings	4.2
IV Moderate	Felt by people while walking; rocking of loose oniects including standing vehicles	4.3
V Rather Strong	Felt generally, most sleeping people are awakend and bells ring	4.8
VI Strong	Trees sway and all suspended objects swing; damage is caused by overturning of vehicles and falling of loose objects	4.9-5.4
VII Very Strong	General alarm, wall crack plaster falls	5.5 – 6.1
VIII Destructive	Vehicles drivers seriously disturbed; masonry constructions are fissured, chimneys fall; poorly constructed buildings damaged	6.2

IX Ruinous	Some houses collapse where ground begins to crack and pipes break open	6.9
X Disastrous	Ground cracks badly; many Bulding destroved and railway lines bent; landslide on steep slope	7-7.4
XI Very Disastrous	Few buildings remain standing; bridges destroyed, all services (railways, pipes and cables) out of action; great landsides and flood	7.4-8.1
XII Catastrophic	Tidal destruction; objects thrown into air ground rises and falls in vaves	Above 8.1

4.3.1 Causes

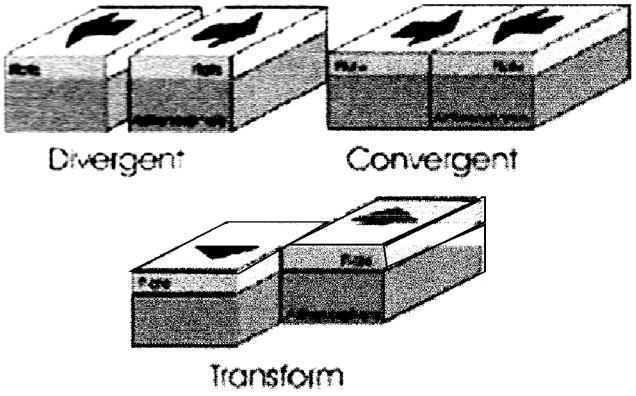
Earthquakes are caused due to disequilibrium in any part of the crust of the earth. There are so many cause responsible for the occurrence of earthquake in the world. Most of the earthquakes happened in the world are caused due to tectonic forces but the rate of occurrence of the earthquakes due to anthropogenic factors are minimum as compared to tectonic forces. These are discussed in detail.

A) Tectonic factors:

i) **Volcanic activity** can significantly cause massive earthquakes. Earthquakes normally accompany escaping magma as it rises to the crust during a volcanic eruption. This is mainly due to the sudden displacement and shaking of underground rocks. It is estimated that about 70% of the world's earthquakes are caused by the volcanic activities. The example may be cited here as violent explosion of Krakatoa volcano in 1883 and Etna volcano in 1968, which were caused severe earthquakes.

ii) **The Plate Tectonic Movement** is explained in the light of the most popular and accpted face of plate tectonic theory. This theory explains that the whole earth is composed by six major and two minor plates which move, due to thermal convectional currents, in different direction in the interior of the earth. During movement at the end of the boundary of the plate many tectonic events may be caused. When two plates move in opposite direction

from the mid oceanic ridges and cause eruption of lava from the mantle and developed submerged ridges in the ocean. Therefore, along the **constructive plate boundary or divergent plate boundary** moderate level of eartrhquake occurred. In case of **destructive plate boundary or convergent plate boundary,** two plates converge and collide against each other and heavier plate is subducted below the lighter plate boudary. Whenver one occanic plate converge with continental plates the brenches, volcanic eruption, faulting are caused to form severe earthquake. When two plates exist closely but move and pass over the other without any collision, are called **conservative plate boundary or transform plate boundary.** Due to this movement, transform fault are formed which cause severe earthquake.



iii) **Due to the formation of fault** dislocation of rocks occurred within the earth which ultimately disturb the isostatic balance within the earth and caused earthquake.

iv) Due to **contraction of earth**, there is accumulation of compressing and tensile forces which results mountain building and ultimately occured earth tremors.

v) Due to continuous erosional works by ground water the **limestone cavroof may collapse** suddenly and cause local earthquake in the karst region.

B) Anthropogenic Factors:

Human activities like pumping of ground water, oil, deep underground mining, blasting of rocks by dynamites for exploring minerals and construction and nuclear explosion etc. caused earthquake in different scales.

4.3.2 Impact

It may be stated that the intensity of the earthquake and their hazardous impacts are determined not on the basis of the magnitude of seismic intensity but are decided on the basis of quantum of damages done by a specific earthquake to human lives and property. Direct and indirect impracts of seismic disasters include following.

1. **Slope Instability and slope Failture and Landslides :** the shocks produced by earthquakes particularly in those hilly and mountainous areas which are composed of weaker lithology and are tectonically sensitive and weak cause slope instability and slope failure and ultimately cause landslides and debris falls which damage settlements and transport system on the lower slope segments. The Chamoli quake followed by a series of seismic events in Uttarakhand, India in 1999 triggered killer Malpa landslides which killed 200 pilgrims on the way to Manasarovar, which were camping in Malpa village in the night.
2. **Damage to Human Settlement:** Earthquake inflict great damage to human structure such as building, roads, rail, factories, bridges, and thus cause heavy loss of human property. May 27, 2006 quake of Java flattened all the buildings and other human structures and rendered millions people homeless.
3. **Damage to Towns and Cities:** the earth tremors at higher magnitude shake the ground to such an extent that the large building collapse and men and women are buried under the large debris and rubbles of collapsed structural materials of buildings, ground water pipes are bent and damaged thus water supply is totally disrupted, electric poles are uprooted, electric and telephone wires and cables are heavily damaged, obstruction and destruction of swear system cause epidemics etc. Kolkata city was severely damaged due to severe earthquake of October 11, 1737.
4. **Loss of Human Life and Property:** the destructiveness on an earthquake is determined on the basis of human casualties in terms of death. From the stand point of human casualties warthquake disasters are divided into 3 categories by Savindra Singh (2013):
    i) **Disastrous earthquake** represents earthquakes which claimed human death toll ranging between 20,000 to 50,000.
    ii) **Highly Disastrous earthquake** causing human death ranging between 51,000 to 1,00,000.
    iii) **Most Disastrous earthquake** are those which are claimed lives more than 1,00,000 persons.

Some example of devastating severe earthquake are given below:

- Earthquake about 7.1 magnitude and subsequent tsunami in Italy's Messina Strait (28 December 1908), badly affecting the cities of Messina and Reggio Calabria. Deaths estimated at 70,000-80,000.
- The Great Kanto earthquake (1 September 1923), with its epicenter just outside Tokyo, claims the lives of 142,800 people in the Japanese capital.
- The Chinese city of Tangshan (28 July 1976), is reduced to rubble in a quake that claims at least 250,000 lives.
- An earthquake measuring 7.6 strikes northern Pakistan and the disputed Kashmir region (8 October 2005), killing more than 73,000 people and leaving millions homeless.
- About 230,000 people die in and around the Haitian capital Port-au-Prince (12 January 2010) as a 7.0-magnitude earthquake strikes the city.
- A magnitude-6.3 earthquake shatters the New Zealand city of Cristchurch (22 February 2011), killing more than 160 people and damaging some 100,000 homes.
- A devastating magnitude-8.9 quake strikes Japan (11 March 2011), leaving more than 20,000 people dead or missing. The tremor generates a massive tsunami along the Japanese coast and triggers the world's biggest nuclear disaster since Chernoby1 in 1986.
- At least 298 people are killed when a magnitude 6 earthquake strikes central Italy (24 August 2016). Worst hit is Amatrice, where many of the town's historic buindings collapse.
- More than 460 people are killed after a 6.9 magnitude earthquake hit the indonesian island of Lombok (5 August 2018). It levelled homes, mosques and businesses, displacing some 350,000 people. An earlier 6.4 magnitude tremor on 29 July killed at least 16, and the region has suffered hundreds of aftershocks.

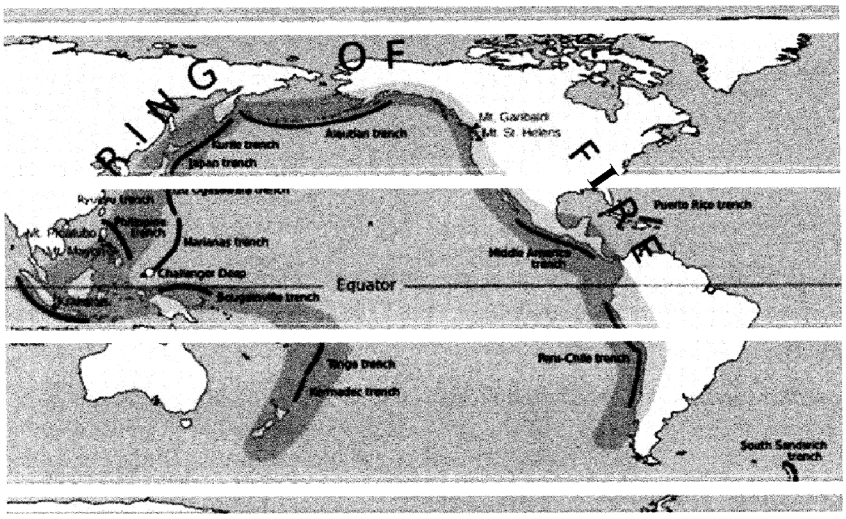
5. **Severe Fire:** The strong vibrations caused by severe earthquakes strongly shake the buildings and thus strong oscillations cause severe fires in houses, mines and factories because of overturnign of cooking gas cylenders, contact of live electrical wires, displacement of other electric and fire related appliances.

6. **Ground Deformation :** Earthquake result in the deformation of ground surface because of the rise and subsidence of ground surface and faulting activity.
7. **Destruction of Dams and Flash Floods :** Strong seismic events results in the damages of dams and cause severe floods.
8. **Tsunami Waves :** Undersea occurrence of earthquake exceeding 7.0 on Richter scale very often generate strong waves, called Tsunami, which cause devastation in the coastal areas.

4.3.2 Distribution

It is true that the earthquakes can happen in any part of the world. But in the areas of faulting and folding or of crustal weaknes, the frequency of earthquakes is more than anywhere else. There are 3 well-marked seismic hazards zones in the world as follows:

1. **Circum-Pacific Eathequake Belt :** This belt includes all the coastal areas around the Vast Pacific Ocean. This belt extends as an isostatically sensitive zone through the coasts of Alaska, Aleutian Islands, Japan, Philippines, New Zealand, North and South America. This zone accounts for 68% of all earthquakes on the surface of the earth. The most talked about earthquake areas in this zone include Japan, Chile, California and Mexico.



2. **Mediterranean-Asia Earthquake Belt :** This belt begins from Alps mountain range and passes through Turkey, Caucasus Range, Iran, Iraq Himalayan Mountains and Tibet to China. One of its branches passes through Mongolia and Lake Baikal and another branch extends to Myanmar. About 31% of world's earthquakes are located in this region.
3. **Mid Atlantic Belt :** There are quite a large number of epicenters on the mid oceanic ridges in the Atlantic Ocean. This belt is generally characterized by moderate and shallow focus earthquakes.

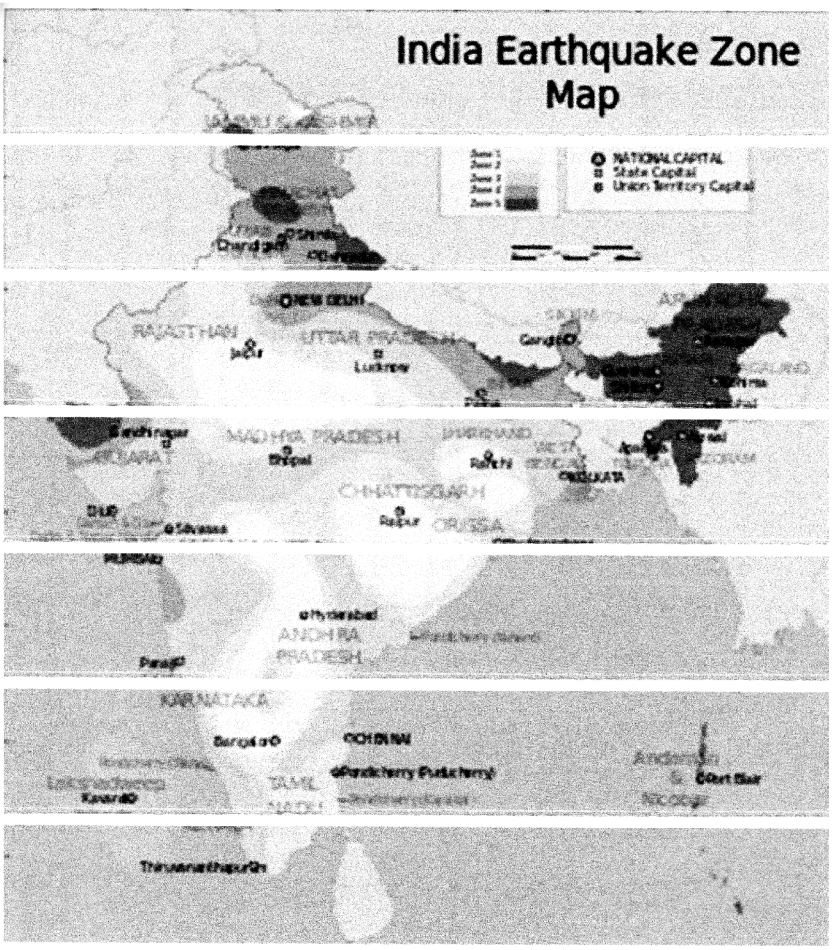
There are some other areas where earthquake occurs, these include Northern Africa and Rift Valley areas of the Red Sea and the Dead Sea. In addition to these, the ocean ridges are also active earthquake Zones.

India being a large landmass is particularly prone to earthquakes. The classification of the zones has been done by the geologist and scientist as early as 1956 when a 3-zone (Severe, Light and Minor hazard) Seismic Zoning Map of India was produced. The severe hazard zone are roughly confined to plate boundary regions, ie, the Himalayan frontal arc in the North, the Chaman fault region in the north-west and the indo Burma region in the north east. The lower hazard zone is confined to Indian shield in the south and then moderate hazard zone confined to the transitional zone in between the two.

The bureau of Indian standards is the official agency for publishing the seismic hazard maps and codes. It has brought out versions of seismic zoning map: a six zone map is currently valid; this map was created based on the values of maximum Modified Mercalli Intensities (MMI) recorded in various parts of the country, in historic times.

Zone V is the most vulnerable to earthquakes, where historically some of the country's most powerful shock have occurred. This region included the Andaman & Nocobar Islands (1941), all of North-Eastern India, parts of north-western Bihar (1934), eastern sections of Uttaranchal (1803), the Kangra Valley in Himachal Pradesh (1905), near the Srinagar area in Jammu & Kashmir (2005) and the Rann of Kutchh in Gujrat (1819). Earthquakes with magnitudes in excess of 7.0 (Richter scale) have occurred in these areas, and have had intensities higher than IX (MMI).

Much of India lies in Zone III, where a maximum intensity of VII can be expected, Mumbai lies in this zone. Other two major metropolitan areas lie in Zone IV, i.e. New Delhi, and Calcutta. Only Chennai lies in Zone II. A large section of south-central India lies in Zone I along with a section stretching from eastern Rajasthan into northern Madhya Pradesh. Some areas of Orissa, Jharkhand and Chhattisgarh also lie in Zone I.



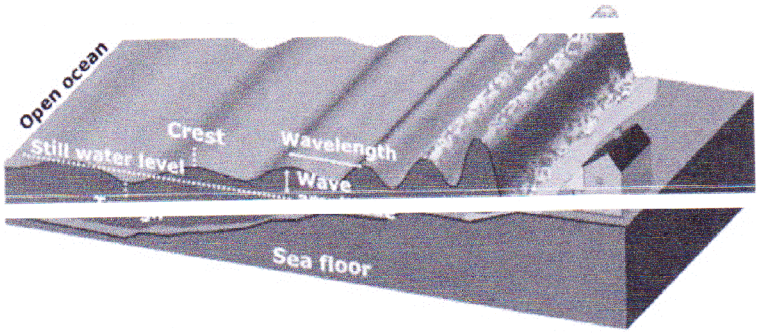
The ten most powerful earthquake of India is given below in a tabular form.

Sr. No.	Place	Deaths	Date, Time, and Year	Magnitude	Epicenter
1	Indian Ocean	> 283,106	08:50, December 26,2004	9.1-9.3	West coast of Sumatra, Indonesia
2	Kshmir	130,000	08:50:38, October 8,2005	7.6	Muzaffarbad, Pakistan administered Kashmir
3.	Bihar and Nepal	> 30,000	14:13, January 15, 1934	8.7	South of Mount Everest
4.	Gujrat	20,000	08:50:00, January 26.2001	7.7	Kutch, Gujrat
5.	Kangra	> 20,000	06:10, April 4, 1905	7.8	Himalayas

6.	Latur	>9,748	22:25, September 30,1993	6.4	Killari, Latur
7.	Assam	1,526	19:39, August 15, 1950	8.6	Rima, Tibet
8.	Assam	1,500	17:11, June 12, 1897	8.1	Exact location not known
9.	Uttarkashi	>1,000	Unknown time October 20,1991	6.8	Garhwal, Uttarkhand
10.	Koynanagar	180	4:21, December 11,1967	6.5	Koyna

4.4 Tsunamis

Tsunamis are ocean waves triggered by large earthquakes that occur near or under the ocean, volcanic eruption, submarine landslides, and by onshore landslides in which large volumes of debris fall into the water. The term "tsunami" is a borrowing from the Japanese word meaning "harbour wave". Tsunami consists of three Japanese words, 'tsu' means harbour and 'noh' and 'me' combinedly means waves. Tsunami waves can travel much farther inland than normal waves. When tsunamis approach shore, they behave like a very fast moving tide that extends far inland. If a tsunami-causing disturbance occurs close to the coastline, a resulting tsunami can reach coastal communities within minutes. A rule of thumb is that if you see the tsunami, it is too late to outrun it. Even small tsunamis (for example, 6 feet in height) are associated with extremely strong currents, capable of knocking someone off their feet. As a result of complex interactions with the coast, tsunami waves can persist for many hours. As with many natural phenomena, tsunamis can range in size from micro-tsunamis detectable only by sensitive instruments on the ocean floor to mega-tsunamis that can affect the coastlines of entire oceans, as with the Indian Ocean tsunami of 2004.



The following are the characteristics of tsunami.

i) The tsunamis are generally classified into two types, example– deep sea tsunami (wave travel speed 500 to 1000 km/hour) and local tsunami (wave travel speed 10 km/hour).

ii) The speed of tsunami increases with the increase of ocean depth.

iii) The hieght of tsunami waves become comparatively low in deep sea water but the hight of all types of waves increase near the coast.

iv) The waves in the tsunami are characterized by two types viz negative wave or retreat rise cycle and positive wave or rise retreat cycle. The tsunami occurs in retreat and rise cycle with a period of 30 minutes between each peak. If the crest of tsunami arrives first, there won't be any recession. The sea level will increase rapidly to inundate everything in the path of the tsunami.

v) Tsunami detection is not ease because while a tsunami is in deep in water it has little height and a network of sensors in needed to degtect it.

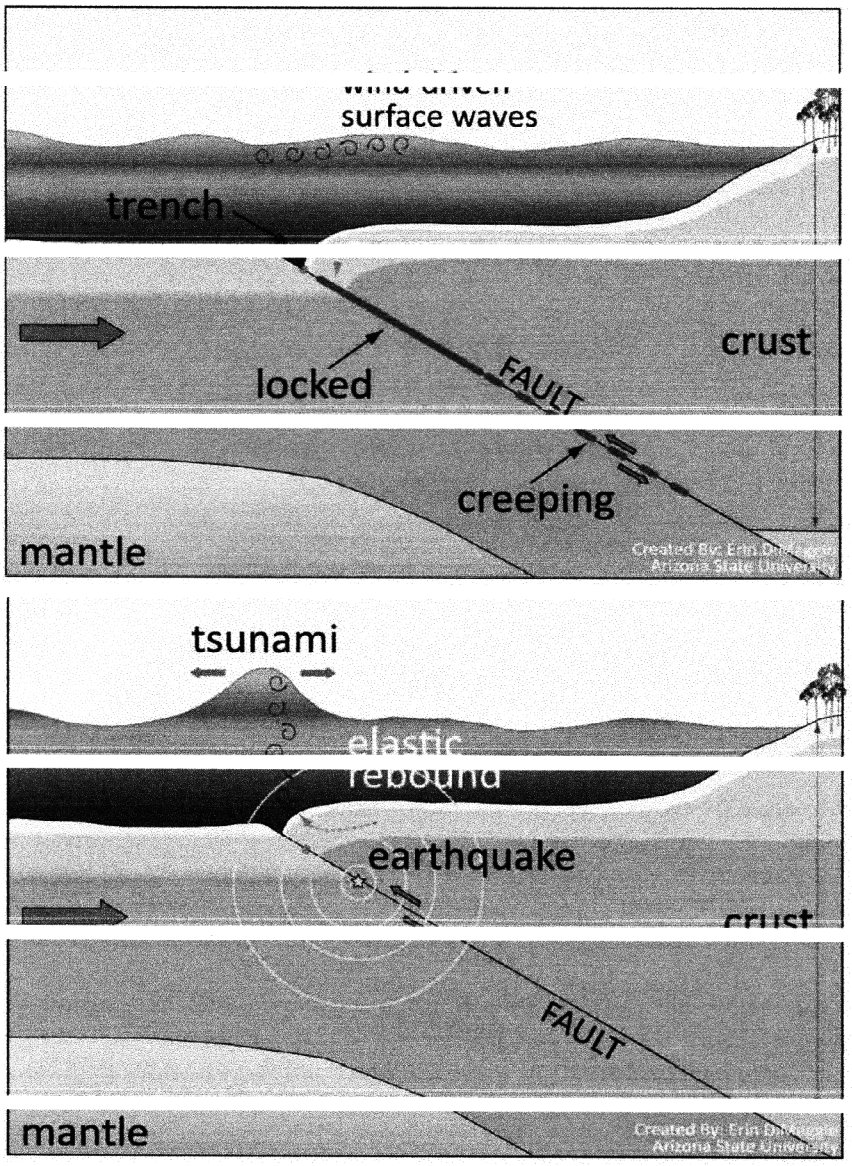
4.4.1 Causes

The important factors for the occurrence of tsunami are discussed below.

(i) Undersea earthquakes :

Most destructive tsunamis are mainly generated by massive undersea earthquakes, occurring at depth less than 50 km with the epicenter or fault line near or on the ocean floor.

How a tsunami is generated by an earthquake at a subducation zone



A strong undersea earthquake with magnitude greater than 7.5 on the Richter scale tilts and deforms large areas of the sea flooor ranging from a few kilometers to 1000 kilometers and even more. As the sea floor is tilted or deformed by the tectonic earthquake (earthquake associated with the earth's crustal deformation), the sea water above is displaced from its equilibrium position.

Waves are formed as the displaced water attempts to regain its equilibrium under the influence of gravity. It is this vertical movement of the entire water column that generates destructive tsunami waves.

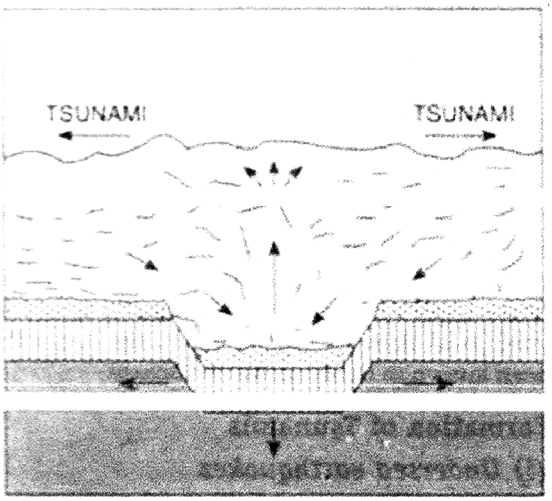


FIG. 8.5. Formation of Tsunami

The displacement of sea floor and occurrence of an earthquake and formation of tsunamis can best be explained on the basis of plate tectonics. When two converging lithospheric plates come closer together heavier plate is thrust under the lighter plate and displacement of the crust takes place at trhe subduction zone. A fault is created and an earthquake occurs, giving rise to tsunamis. According to Law of Conservation of Energy, energy cannot be created or destroyed but can be transeffed from one form to another. Thus the potential energy that results from pushing water above the mean sea level is transferred to kinetic energy that initiates the horizontal propagation of the tsunami waves.

It must be noted that a tsunami is usually not generated it the sea floor movement is horizontal. Besides, not all undersea earthquakes create tsunami, as it depends upon the nature and degree of displacement of seawater column. It is only the vertical displacement of the seawater due to adrupt, jerky movements of fault blocks on seabed that gives birth to tsunamis. Once formed, the monstrous waves soon begin their journey towards the nearest coastline, ringing the bells of doom.

(ii) Landslides :

Tsunamis waves are also generated by displacement of sewater resulting from

landslides as well as rock falls, icefalls etc. Construction work of an airport runway along the coast of Southern France in the 1980s caused an underwater landslide.

(iii) Volcanic Eruption :

Whenever a violent volcanic eruption takes place under the sea, it causes sudden displacement of a large volume of seawater and tsunami waves are formed. Similarly, when the roof of a volcano collaopses that has a large empty magma chamber owing to continuous flow of lava, a crater sometimes as large as one kilometer in diameter is formed. As the seawater gushes into this crater, the water column of the sea is disturbed which gives rise to tsunami waves.

One of the largest and the most destructive tsunami ever recorded was generated on August 26,1883 atter the explosion and collapse of the volcano of Krakatoa in Indonesia. This explosion generated waves with a twoering height of about 40 m, that wreakend havoc on the coastal areas along the Sunda Strait in both the islands of Java and Sumatra killing more than 36,000 people.

(iv) Meteorites and Asteroids:

There is a potential danger of tsunami being fromed by the fall of meteorites and asterolds in the ocean. Although the possibility of such an impact is very remote, the computer model definitely gives the researcher an insight into the destructive power of tsunami caused by near-earth object.

4.4.2 Impact

i) **Environmental Impact** – The environmental impact caused by the tsunami will affect the region for many years to come. It has been assessed that the severe damages has been inflicted on ecosastems such as mangrove, forest, coastal wetlands, coral feefs, sand dunes, plant and animal biodiversity and ground water. Besides these, the spread of solid and liquid waste and industrial chemicals, water pollution and destruction of sewage collectors and treatment plants threaten the environment. The other main effect is being caused by poisoning of the freshwater supplies and the soil by salt water infiltration deposit of a salt layer over arable land.

ii) **Economic Impact** – The major effect on economy consist of fishing activites, industrial infrastructure, ports, tourist sites, drinking water supplies, farm fields etc. Preliminary estimates indicate that 66% of the fishing fleet and industrial infrastructure in coastal regions have been destroyed by the

wave surges, which will have adverse economic effect both at local and national levels.

iii) **Humanitarian Impact** – A great deal of humanitarian aid was needed because of widespread damage of infrastructure, shortage of food, drinking water, medicines etc. There was rapid spread of diseases such as cholera, dysentery, typhoid, which need to be checked quickly so as to avoid epidemic. Besides the ferocity of powerful tsunamis also create social problems such as mental stresses leading to psychological disorder, fear psychosis etc.

4.4.3 Distribution

Most of tsunamis are generated by strong submarine earthquakes and by volcanic eruptions, the areas in the **World** where Tsunami occur are those characterized by a high seismic and tectonic activity. In particular, the Pacific Ocean is the most affected area and the majority of tsunamis are generated along the "Circum-Pacific Belt" (or ring of fire) while other events are located in Indonesia is the indian Ocean side. About 30% of Pasific tsunamis occurs in the region of Japan-Taiwan and the coasts of Japan are particularly prone to tsunami due to the occurrence of a relevant number of submarine earthquakes. Neverthless, both destructive and minor tsunamis occur also in the Indian Ocean, Atlantic Ocean and in the Mediterranean Sea. Over history (1610 BC to AD 2017), there have been over 12,000 confirmed tsunamis, of which 249 have been deadly. 70% occurred in the Pacific Ocean 81% of the tsunami were caused by earthquakes. The strongest earthquakes occurred in the last hundred years generated catestrophic tsunamis. On May 22, 1960 in Chile (Magnitude 9.5) producing a violent tsunami with waves reaching 15-20 m height in the coasts clese to the epicenter. About 15 hours later, waves more than 10 m high invested Hawaii in about 22 hours the tsunami reached the Japanese coasts (about 10.000 km far away) with 6 meters waves. On March 27, 1964 an earthquake (magnitude 9.2) in Alaska produced a violent tsunami with waves that invested Hawaii islands and California coasts reaching 2-6 meters hieght.

India is the third country to be severely affected with tsunami after Sri Lanka and Indonesia. Indian states affected by tsunami were Tamil Nadu, Puducherry, Kerala, Andhra Pradesh, and Andaman and Nocobar Island. The first tsunami to struck India was back in December 31, 1881. However, the government of India indicated that around 11,000 people died and more than 5,000 were missing and were assumed dead by the Home Affairs Ministry. An estimation points out that

about 380,000 Indians displaced by this tsunami. It is expected that reconstruction of these affected places would cost over 1.2 billion dollars from the World Bank. On December 26, 2004, most of the countries located around the Indian Ocean and Bay of Bengal were struck by tsunami. During this time, the Richter scale measured the earthquake at 8.9 with an epicenter near Sumatra's west coast in Indonesia. The Andaman Island was said to be extensively damaged due to this tsunami. The regions affected the most by tsunami were the Andaman and Nicobar Islands and south-eastern coast. Due to this earthquake resulting tsunami, many countries affected Southeast Asia and area beyond. Countries such as Indonesia, Sri Lanka, India, Thailand, the Maldives, Somalia, Myanmar, Malaysia, Seychelles and many others had to go through the devastating calamities.

4.5 Landslides

A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Landslides are a type of "mass wasting," which denotes any down-slope movement of soil and rock under the direct influence of gravity. The term "landslide" encompasses five modes of slope movement: falls, topples, slides, spreadsm and flows.

Fs = Strength or shearing resistance of materials / magnitude of shearing forces.

Where, Fs = Factor Of Safety

When the sefty factor is less than 1.0, materials being to move downslope and thus slides of weathered debris occurs. It is apparent that lavelslides may occur when either shearing forces increase or shearing resistance of materials decreases.

4.5.1 Causes

Landslides are considered as natural disasters but human-induced changes in the environment have recently caused their upsurge.

I. Natural Causes of Landslides

i) **Climate** - Long-term climatic changes can significantly impact soil stability. A general reduction in precipitation leads to lowering of water table and reduction in overall weight of soil mass, reduced solution of materials and less powerful freezethaw activity. A significant upsurge in precipitation or ground saturation would dramatically increase the level of ground water.

When sloped areas are completely saturated with water, landslides can occur. If there is absence of mechanical root support, the soil start to run off.

ii) **Earthquakes** - Seismic activities have, for a long time, contrituted to landslides across the globe. Any moment tectonic plates move, the soil covering them also moves along. When earthquakes strike areas with steep slopes, on numerous occasion, the soil slips leading to landslides. In addition, ashen debris flows instigated by earthquakes could also cause mass soil movement.

iii) **Weathwering** - Weathering is the natural procedure of rock deterioration that leads to weak, landslide-susceptive materials. Weathering is brought about by the chemical action of water, air, plants and bacteria. When the rocks are weak enough, they slip away causing landslides.

iv) **Erosion** - Erosion caused by sporadic running water such as streams, rivers, wind, currents, ice and waves wipes out latend and lateral slope support enabling landslides to occur easily.

v) **Volcanoes** - Volcanic eruptions can trigger landslides. If an eruption occurs in a wet condition, tho soil will strat to move downhill instigating a landslide.

vi) **Forestr fires** - Forest fires instigate soil erosion and bring about floods, which might lead to landslides.

vii) **Gravity** - Steeper slopes coupled with gravitational force can trigger a massive landslide.

II. Human causes of landslides

i) **Mining** - Mining activities that utilize blasting techniques contribute mightily to landslides. Vibrations emanating from the blasts can weaken soils in other areas suceptible to land slides. The weakening of soil means a landslide can occur anytime.

ii) **Clear cutting** - Clear cutting is a technique of timber harvesting that eliminate all old trees from the area. This technique in dangerous sience it decimates the existing mechanical root structure of the area.

4.5.2 Impact

Landslide causes massive destruction in many ways such as,

Loss of lives : Landsliaes and muslides kill between 25 and 50 people every year in the USA along. Globally, it is believed that the number of deaths is highly

underestimated. In total, 2,620 fatal landslides were recorded worldwide during the 2004 and 2010 period of the study, casing a total of 32,322 recorded fatalities.

Destruction of property : In 1980, Mount St Helens in Washington USA erupted and causes a rock debris landslide believed to be the biggest in history. The landslide traveled about 14 miles, wiping away highway bridges, buildings, and roads. It is known that the amount of debris in this avalanche can fill 250 million dump trucks.

Economic costs : Landslides bring huge cost to communities and cities affected, by clean up and rebuilding destroyed infrastructure. In 2005 it cost the USA $3.5 billion in damage rapair.

Destruction natural environment : Debris flows usually uproot trees and wipe out vegetation and wildlife in its path.

4.5.3 Distrubution

The most risky regions from the stand point of land slide occurrence are the Andes mountains region including Columbian hills, parts of Peru, Chili and North Brazil; the areas including parts of Alaska, Mckinely, Seera Nevada and Siera Madre of the Rockies, a few parts of Alps, the northern mountains region of Afganistan, parts of Chattagram region of Bangladesh and Himalayan region including Jammu and Kashmir, Uttarakhand, Sub-Himalayan West Bengal and the North east Hills and Western Ghats and the Nilgiris and in the far east, Phillipines become the most notorious landslide affected country.

The most noticoable landslide occurences in the recent past are summarized here. In 2005, Conchita landslide in Ventura, California causing 10 deaths. The 2009 Peloritani Mountains disaster caused 37 deaths, on October 1. The 2010 Uganda landslide caused over 100 deaths following heavy rain in Bududa region. 2011 Rio de Janeiro landslide in Rio de Janeiro, Brazil on January 11, 2011, causing 610 deaths. On 30 July 2014, a landslide occurred in the village of Malin in the Ambegaon taluka of the Pune district in Maharasthra, India. The landslide, which hit early in the morning while residents were asleep, was believed to have been caused by a burst of heavy rainfall, and killed at least 151 people. 2017 Mocoa landslide, in Mocoa, Colombia killed at least 254 people, injured 352, and 70 people were missing.

4.6 Conclusion

This chapter has provided guidelines on earthquake, tsunami and landslide.

Discuss in details the causes, errect or tense geological hazards. Distribution of tnese hazards in world as well as Indian prespective. Such a catalogue could also include a brief guide on how to use the information in a development planning study. These guides could be prepared cheaply and quickly.

4.7 Summary

Natural hazards can be categorized under two main sections: weather induced hazards and geological hazards. Earthquakes, tsunamis, and landslides are geological hazards. The first one presents the causes and worldwide distribution of earthquakes, together with a presentation of the scales for measuring earthquake magnitude and intensty. One of the major phenomena generated by earthquakes is the tsunami; this phenomenon is described in the latter part of the chapter, together with a presentation of major, worldwide tsunami disasters. The prediction of tsunami incidence in the Pacific region is then discussed. The last paragraph discusses landslides. Land instability is then classified and described under the headings: factors influencing landslides; triggering of landslides; and preventive measure.

4.8 Glossary and Keywords

Accleration – a change in velocity due to gravity; in earthquake hazard analysis, it is expressed as a fraction of gravity pull (g).

Aftershok – a tremor that follows the main shock of an earthquake and originates at or near the focus of the prinmary earthquake. Generally, major earthquakes are followed by a large number of aftershocks that decrease in frequency over time.

Amplitude – the maximum displacement from zero level of any wave as a seismic wave.

Avalanche – the rapid and sudden sliding and flowage of masses of usually incoherent and unsorted mixtures of snow/ice/rock material.

Cyclone – a large-scale closed circulation system in the earth's atomsphere with relatively low barometric pressure and winds that blow counter-clockwise around the center in the northern hemisphere and clockwise in the southern hemisphere. See also hyrricane, typhoon, and tropical cyclone, Called "cyclone" in Indian Occan and South Pacific; "hurricane" in Western Atlantic and Eastern Pacific; "typhoon" in Western Pacific.

Cyclone panel – an element within the typhoon committee with principal interest in the Bey of Bengal/Indian Ocean.

Debris flow – a mass movement involving a rapid flow of debris from various kinds of earth meterial in various conditions. Specifically, a high-density mud flow with abundant coarse grained materials and resulting invariably from an unusually heavy rainfall.

Earth flow – a mass movement of land characterized by downslop translation of soil and weathered rock over a discrete sheer surface (landslide) within well-defined lateral boundaries.

Earthquake – a sudden break in the rock of the earth's crust below or at the surface, which results in the vibration of the ground, and the potential collapse of buildings and possible destruction of life and property if the quake is of sufficient magnitude.

Earthquake forecasting – estimating the probability of the occurrence of an earthquake in relative time, place, and magnitude.

Earthquake swarm – a series of minor earth tremors (none of which may be indentified as the main shock) than occurs within a limited area and time.

Epicenter – that point on the earth's surface directly above the place of origin, focus, or hypocenter of an earthquake.

Eye (of the storm) – the clam center of a tropical cyclone.

Fall – a type of landslide, characterized by a very rapid downward movement of rock mass or earth.

Fault – a planar or gently curved fracture in the earth's crust across which relative displacement has coourred.

Flow – a mass movement of unconsolidated material that exhibits a continuty of motion and plastic or semifluid bahavior, resembling that of a viscous fluid. It may be termed a creep, an earthflow, mudflow, or a debris avalanche. Water is usually required for most types of flow movements.

Focla depth – distance from the earth's surface at which a seismic wave first originates, i.e., at the hypocenter of an earthquake.

Focus – a point beneath the earth's surface where the first motion of an earthquake and its eleastic waves originate.

Foreshock – precursory seismicity that commonly precedes a main shock (earthquake) by anywhere from seconds to weeks and usually originates at or near the focal zone of the main earthquake.

Global/plate tectonics – the concept that the earth's surface is made up of several large plates or crustal slabs that move and are continually altering the crust of the earth.

Hurricane – in the Western Hemisphere, a mojor storm with a wind velocity of 75 miles per hour (120 kilometers per hour) or more. Also called typhoons in the Pacific Ocean, and cyclones in the Indian ocean and South Pacific.

Hypocenter – the location of the focus of an earthquake, calculated by the geographic coordinates and depth from the surface.

Induced Sesmicity – earthquake activity resulting from human-made causes such as liquid intrusion and construction of reservoirs.

Intensity – a subjective measurment of the force of an earthquake at particular place as determined by its effects on persons, structures, and earth materials, Intensity is a measure of effects, while magnitude is a measure of energy. The modified Mercalli scale is the principal intensity scale used in the United States.

Landslide – a rapid or marginally rapid downhill movement of soil and rock.

Magnitude – a measurement of the strength of an earthquake, using a scale graduated by the logarithm of the maximum seismic wave amplitude, as recorded on a seismograph at a specified distance from the earthquake's epicenter. Each magnitude step on the Richter scale represents an increase of 10 times the measured wave amplitude of the earthquake.

Mass wasting – a general term for the dislodging and downslope transport of soil and rock material under the direct application of gravitational body stresses.

Mercalli scale – a scale for rating earthquake intensity as humanly perceived, rated numerically from "I – Not felt except by a very few," to "XII– Damage total." Also is called a modified Mercalli scale or MM scale when used in North America.

MM scale – see Mercalli scale.

Richter scale – a scale, not limited at the top or the bottom, that measures the magnitude of an earthquake from 1 (least) to 10 (greatest), with each magnitude step of the scale representing an increase of 10 times in measured wave amplitude of the earthquake. An incresease of one magnitude step has been found to correspond to an increase of 30 times the amount of energey released as seismic waves.

Rock fall – free-falling or precipitous movement of a newly detached segment of bedrock of any size from a cliff or other very steep slope. A rock fall is the fastest moving landslide and is most frequent in mountain areas during spring and fall when there is repeated freezing and thawing.

Rockslide – a landslide involving a downward, usually sudden and rapid movement of newly detached segments of bedrock over an inclined surface or over pre-existing features. The moving mass is greatly deformed and usually breaks up into many smaller slides. Rockslides frequently occur in the high mountain ranges.

Storm surge – a sudden rise of sea as a result of high winds and low atmospheric pressure; sometimes called a storm tide, storm wave, or tidal wave. Generally affects only coastal areas but may intrude several miles inland.

Tremor – quick vivrating or shaking movement of the ground associated with an earthquake.

Tropical cyclone – a strom originating over tropical seas with winds of up to 200 miles per hour rotating around a low pressure area. Most commonly observed in the Northern Hemisphere from May to November and in the Southern Hemisphere from December to June. In the Northern Hemisphere, winds spin counterclickwise around a warm center core. In the Southern Hemisphere, the rotation is clockwise.

Torpical depression – a definite closed circulation (in the sense of a closed isobar) with a maximum sustained wind speed of below 34 knots.

Tropical distrubance – the formative weather pattern from which a cyclone may develop. It forms only in low latitudes over oceans with a warm surface temperature and is characterized by a slow fall in barometric pressure. Its strongest winds arise to the north and east of the developing center or vortex in the Northern Hemisphere, and to the south and east of the developing center or vortex in the Southern Hemisphere. Surface pressure drops to about 1010 to 1000 mil bars (29.82-29.53 inches).

Tsunami – the preferred Japanese term meaning sea waves generated by sub-marine distrubances.

Typhoon – in the Western Pacific, a violent wind and rain storm that results from the existance of certain conditions (see cyclone, hurricane).

4.9 References and Further Readings

- Alexander, D. (1993), Natural Disasters, UCI Press, London.
- Arya A. S. (1994), 'Action Plan for Earthquake Miligation', in V. K. Sharma (ed.), Disaster Management. liP A, New Delhi.
- Blaikie, P., Cannon, T., Davis, I., and Wisner, B., (1994), At Risk, Natural Hazards, People's Vulnerabilities and Disasters, Routledge. London.
- Bolin, R. and Stanford, L. (1998), The Northridge Earthquake: Community based Approaches to Unmet Recovery Needs, Disasters 22, 1 : 21 - 38. Bradford, M. and Carmichael, R. S. (2001), Natural Disasters, Vol. II, Salem Press Inc., California, pp. 456.
- Chakraborty, S. C. (2007). Natural Hazards And Disaster management. *Natural Hazards And disaster management.* Kolkata: Pragatisil Prokashak.
- Chow, V.T. (1956), Hydrologic Series of Floods in the United States, International Association of Scientific Hydrology, in D. J. Parker (2000) ed., Floods, Routledge, New York.
- Frampton, S., Cheffey, J., Hardwick, J. and Mc. Naught (1996), Natural Hazards, Holdder and Stoughton, London.
- Mukherjee, D. M. (2010). Natural Disasters. *Natural Disasters.* Kolkata : Arun Banerjee Art Publishing.
- Sah, M. P. and Bartarya, S. K. (2004). Landslide Hazards in the Himalaya: Strategy for Their Management, Orient Longman Pvt. Ltd., *1(2),* 165-178.

4.10 Model Questions

1. What is earthquake? 5
2. Define the following term : i) Focus, ii) Epicenter, iii) earthquake swarm 5×3
3. Write the comparison between Mercalli Intensity Scale and Richter Magnitude Scale. 5
4. What are the different causes of earthquake? 10
5. Discuss earthquake in light of Plate Tectonic Theory with suitable diagram. 5

6. Discuss the consequences of the earthquake with example. 10
7. Discuss in detail the seismic hazards zone of the world. 10
8. Write a short note on Seismic Zone of India and show these zone on map. 10
9. What is tsunamis? Write the characteristics of tsunami. 5+5
10. What are the importance factors the occurrence of tsunami? 5
11. Explain how earthquake caused tsunami with suitable diagram. 5
12. Discuss the consequences of tsunami. 5
13. Write the distribution of the tsunami in the world and in India as well. 5
14. Whatr is landslide? What is factor of safety? 5
15. What are the different causes of landslide? 10
16. What is the impact of landslide? 10
17. Write the distribution of the landslide. 10

Unit-5 □ Causes, Impact and Distribution of : Flood and Drought

Content Structure

5.1 Learning Objectives

The main objectives of the chapter are

- To study the reasons behind the occurrence of flood and drought
- To discuss the impact as well as the distribution pattern of the hazards related to flood and drought.

5.2 Introduction

Extreme precipitation, stroms, and heat waves will become more common and severe as the global temperature increases, causing hazards to society such as flooding or drought. Here, focus has been given on understanding the causes, effect and dynamics of extreme events like flood and drought.

These are also called cummulative atomosthric hazards.

5.3 Flood

Flood, a cumulative atmospheric hazard, simply means inundation of extensive area by water for several days at a stretch, or say a flood is a state of high water level along a river channel or on the coast that leads to inundation of land which is not normally submerged. A flood is a discharge that exceeds the channels capacity of the river (it is bigger than the bank full discharge), so it inundates the adjacent floodplain. When this happens the channel and the floodplain together allow passage of floodwaters. In other words it is natural process, over bank flows that may construct a flood plain adjacent to a stream channel or higher than normal levels along a coast that extends inland beyond the beach. Floods is a natural phenomenon and is response to rainfall (important component of hydrological cycle) hazards prespective, high water levels in a stream, lake or ocean that may damage human facilities causes large scale loss of life and property. Flood is also a rise of water levels which is abnormally high inundating neighboring areas of water channels because of havy precipitation, dam failures, rapid snow melts, storm surges, cloud burst etc. Floods can broadly divided into three types-flash-floods, river floods and coastal floods. Most of the floods may result in physical damage, deaths and injuries, problems in availability of drinking water and food shortages. It is usually due to the volume of water within a body of water, such as a river or lake, exceeding the total capacity of the body, and as a result some of the water flows or sits outside of the normal perimeter of the body. It can also occur in rivers, when the strength of the river is so high it flows right out of the river channel, usually at corners or meanders. These of course, are not applicable in such instances as sea flooding. The word comes from the old English word 'flod', a word common to Teutonic languages, compare German Flut, Dutch vloed from the same root as is seen in flow, and float.

5.3.1 Causes

The degree and type of flooding is influenced by many climatologically, hydrological and environmental and local geomorphological factors, such as:

(a) Heavy continued rainfall over a long period is the root cause of river floods as the immense volume of runoff results in overtopping of the river bank;

(b) Large scale deforestation in the upper catchments is the most important anthropogenic factor in river bank;

(c) Bare and open basin accelerates soil erosion thereby increases siltation load in the river channel. This reduce cross sectional area of the channel leading to spill over;

(d) Due to heavy siltation the bed level is elevated, which reduces channels depth causing spill over;

(e) Dams capture steady flow of sediment from the upper catchments reducing the water holding capacity of the reservoir. As a result, excess water due to heavy down pour needs immediate release causing floods in the lower catchments;

(f) Highly sinuous and meandering courses of the river obstruct the normal flow of water resulting in low velocity. With flooding the meandering valleys are immediately overflowed and the meander loops are inundated;

(g) Change of slope is another cause of flood. For example, low slope with flat surface supports oscillating channels, sluggish flow, low bank height and low velocity;

(h) The earthen embankments entropy the river, which disturb its normal behavior and hinder natural lank building processes;

(i) Increasing floodplain encroachment for residential and agricultural purposes increases the flood damage;

(j) Unchecked urbanization increases the frequency and dimension of floods in the rivers, as the concrete ground surface and masonry drains reduce rainwater infiltration rate substantially increase runoff.

5.3.2 Impact

(a) **Primary effects:** Physical damage- Structures such as buildings get damaged due to flood water. Flooding can have any of the following effects on housing or other small buildings.

- House washed away due to the impact of the water under high stream velocity. The houses are commonly destroyed or dislocated to severely that their reconstruction is not feasible.
- Flotation of houses caused by rising waters. This occurs when light-weight, typically wood houses are not securely anchored. They can be removed too far from their foundations for relocation and repair.
- Damage caused by inundation of house. The house may remain intact and on its foundation, but the water damage to materials may be severe. Repair is often feasible but may require special procedures to dry out properly.
- Undercutting of house. The velocity of the water may scour and erode the house's foundation or the earth under the foundation. This may result in the collapse of the house or require substantial repair.
- Damage caused by debris. Massive floating objects such as trees and other houses may impact on standing houses and cause significant damage.

Landslides can also take place.

Casualties – People and livestock die due to drowing. It can also lead to epidemics and waterborne and vector borne diseases.

b) Secondary effects

Water supplies- Contamination of water. Clean drinking water becomes scarce.

Diseases- Unhygienic conditions. Spread of water-borne diseases

Crops and food supplies- Shortage of food crops can be caused due to loss of entire harvest.

c) Tertiary/Long-Term effects

Econimic- In most flood prone countries where economies are based on agriculture, the largest economic flood-related losses are in the agricultural sector. Obviously most losses to agriculture result from the drowing of crops. Susceptibility to drowning depends on the type of crop and duration of flooding. Some are quickly killed by a relatively small amount of superfluous water. Others can resist as much as a few days of submersion. Even crops that thrive on large amounts of standing water will be killed if the water stagnates as in the Bengladesh example. Other

agricultural losses occur in the submersion of crop storage facilities. Grains and other crops will quickly spoil if saturated with water, even for a short time.

An additional negative impact on the agricultural sector is the erosion of topsoil by the floods.

Here the impact is indeed long term, resulting in the reduced productivity of the land and possibly eventural abandonment.

Flooding, however, is not all bad. For some agricultural areas flooding is a positive and necessary event. These lands depend on the periodic silt deposits for added mutrients to the soil. Flooding also serves other advantages including the filtering or dilution of pollutants that enter the waterways, flushing of nutrients in river systems, preserving of wetlands, recharging of groundwater, and maintatining of river ecosystems by providing breeding, nesting, feeding and nursery areas for fish, shell fish, migrating waterfowl, and others.

Widespread floods can have a significant effect on the long-term economic growth of the affected region. Indirect and secondary effects on the local and national ecomomy may include reduction in family income, decline in the production of business and industrial engerprises, inflation, unemployment, increases in income disparities, and decline in national income. In addition, relief and reconstruction efforts often compete with development programs for available funds. In countries where flooding occurs frequently, floods can create an enormous financial burden.

The loss of crops and the need to find alternate sources of income have often caused small scale migrations of farmers and skilled workers from rural areas to cities. Once established in a city, few return to their homes of farms.

Small marginasl farms usually cannot survive economically following a major flood. Farmers are often forced to sell their land because they cannot afford to rehabilitate it. This may result in a substantial increase in the number of people migrating to urban areas, and thus a related housing shortage.

Economic hardship, due to e.g. temporary decline in tourism, rebuilding costs, food shortage leading to price increase etc, especially to the poor.

Psychological- Loss of loved ones etc.

5.3.3 Distribution

Flooding tends to be most frequent during the wet and/ or the melt seasons. In some parts of the world, including Britain, intense convection storms can produce

flooding during the summers. Floods are the most common climate-related disaster in the region and include seasonal floods, flash floods, urban floods due to inadquate drainage facilities and floods associated with tidal events induced by typhoons in coastal areas. In Bangladesh, one of the most flood-prone countries in the region, as many as 80 million people are vulnerable to flooding each year. In India, where a total of 40 million hectares is at risk from flooding each year, the average annual direct damage has been estimated at US$240 million, although this figure can increase to over US$1.5 billion with severe flood events.

Most of the flood affected area lie in the Ganges Basin; the Brahmaputra basin comprising the Barak, the Teesta, the Torsa, the Suban Siri, the Sankosh, the Jaldhaka, the Dibang, the Dihang and the Luhit; the north-western river basin comprising of the Jhelum, the Sutlej, the Beas, the Chenab and the Ravi and the Ghagger; the peninsular river basin comprising the Tapi, and the Narmada, the Mahanadi, the Baitarni, the Godavari and Kashna, the Pennar and the Cauvery and coastal regions of Andhra Pradesh, Tamil Nadu, Orissa and Kerala. The most flood-prone basins are those of Ganges in Uttar Pradesh, Uttarakhand, Bihar and West Bengal, the Brahamaputra in West Bengal and Assam, followd by the Baitarni, the Brahmani and the Subarnarekha basin in Orissa. The floods are also experienced in Andhra Pradesh, Rajasthan, Haryana and Gujrat. The are under chronically flood prone Uttar Pradesh and Bihar in increasing.

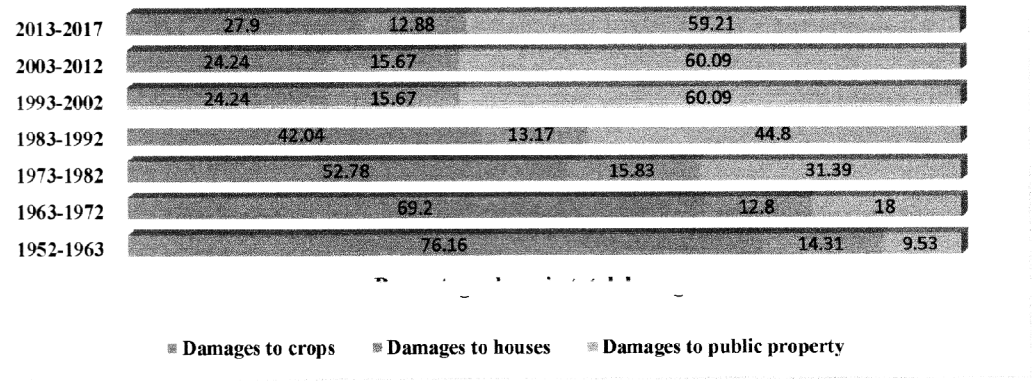
The year-wise damages sufferd in the past 65 year is shown in Chart No 1, the scale of destruction has increased exponentially in the last two decades.

The chast shows that since early 2000s, the overall damages suffered due to floods and heavy rains have increased rapidly-years like 2015, 2017, 2013, 2009, 2006 and 2010 all saw damages exceeding Rs 19,000 crore.

These damages include damage to crops, houses and public properties. Analysing the data, we find that in the past 65 years, the contribution of loses due to damages to crop, houses and public property have changed significantly.

Between 1953 and 1982, the loss suffered due to damaged crop was the biggest contributor to India's flood-related losses. For example, in 1953, damage to crop was extimated at Rs 42.08 crore while tha damage to public property was just Rs 2.9 crore. The damage to public property was even lower than the damage to houses (Rs 7.42 crore).

Chart No. 1 : Flood loss : Damage to crop, houses & public property (in Rs crore) (2953-2017)



Source: Central Water Commission

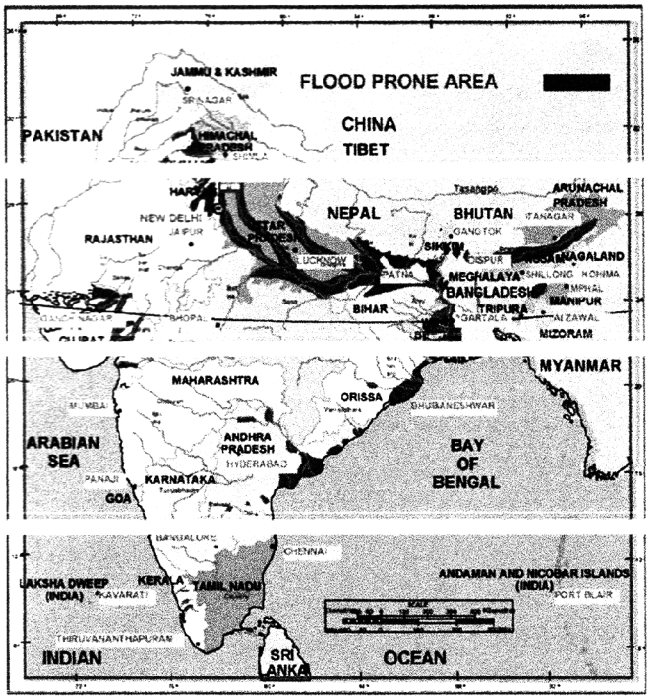
But this changed from the 1980s onwards, when the share of loss due to damaged crop was overtaken by the loss due to damages of public property (see chart-1). Between 1983 and 1992, India's loss due to damaged crop in floods was Rs 11,773.37 crore, but the loss due to damaged public property was Rs 12,546.16 crore.

Over the years, this difference widened and between 2013 and 2017, the loss India suffered due to public property damaged in flood was 112 per cent more than that suffered due to damaged crop.

One of the likely factors responsible for this shift over the years in the urbanisation in India and migration of people from rural areas to urban centers in search of job and better opportunities.

Besides this, as the Indian economy strengthened over the years (resulting in increase in people's incomes and living standards), the size of Indian cities also increased mainfolds. But while cities become larger, the flood management and drainage systems failed to catch up with the need of the hour.

The best examples for this mismatch is the plight of India's four metropolitan cities - New Delhi, Mumbai, Chennai and Kolkata – during monsoon every year most important cities, every year newspapers are splashed with image of these cities heavily flooded during monsoon rains. Deaths, destruction and agony have become the sad reality for these urban giants, despite their corridors of power and lanes of skyscrapers.



5.4 Drought

Generally, drought situation may ne difined as a temporary reduction in water or moisture availability significantly below the normal or excepted amount for a specific period. According to British Rainfall Organization i) Absolute drought is defined when there are at least 15 consecutive days with less than 0.01 inch of rainfall each day, ii) Partial drought is difined when there are at least 29 days having mean rainfall of 0.01 inch or less, iii) Dry Spell means when 15 consecutive days get less than 0.04 inch of rainfall per day. According to IMD a drought is a situation when the deficiency of rainfall is at a meteorological sub-division level. According to the definition of meteorological drought adopted by the Indian Meteorological Department (IMD), a drought is a situation when the deficiency of rainfall at a meteorological sub-division level is 25% more of the long-term average (LTA) of that sub-division for a given period. If the deficiency is between 26% and 50%, the drought is considered 'moderate' and if the deficiency is over 50%, the drought is termed 'severe'.

Droughts are of three broad types– i) Meteorological droughts, ii) Hydrological droughts and iii) Agricultural droughts. i) In metrological terms, a drought is "a

sustained and regionally extensive deficiency in percipitation". The meteorological drought is only a representation of the rainfall distribution pattern and satistics. ii) The hydrological drought is the manifestation of critically low groundwater tables and a marked reduced river and stream flow, causing sever shortage of water for livestock and human needs. iii) An agricultural drought results when soil moistrure and rainfall are inadequate during the crop growing season to support healthy crop growth to maturity.

5.4.1 Causes

i) **Rainfall or Precipitation Deficiency** – Droughts take place whenever there is prolonged periods of rainfall deficiency for a season or more and usually when there is a lack of anticipated rainfall or precipitation. When a region goes for long periods without any rain, especially for more than a season, then the situation leads to dry conditions and water deficiency which qualify as drought. Farmers, for instance, plant in expectation of rain and so when it doesn't rain as expected, drought conditions are experienced. In such cases, it is frequently termed as agricultural drought.

ii) **Human Causes** – Human activities play a relatively significant role in the management of the water cycle. Human acts such as deforestation, construction, and agriculture negatively impact the water cycle. Trees and vagetation cover are essential for the water cycle as it helps to limit evaporation, stores water, and attracts rainfall. In this sense, deforestation– clearing vegetation cover and cutting down trees increases evaporation and lessens the ability of the soil to hold water leading to increased susceptibility of desertification. Deforestation can also influece the occurrence of dry conditions since it reduces forest's watershed potential. Construction and agricultural activities may as well reduce the overall supply quantity of water, resulting in dry spells.

iii) **Drying out of Surface Water Flow** – Lakes, rivers, and streams are the primary suppliers of downstream surface waters in various geographical regions around the globe. In extremely hot seasons or because of certain human activities, these surface water flows may dry out downstream contributing to drought– meaning the demands for water supply become higher than the available water. Irrigation systems and hydroelectric dams are some of the human activities that can significantly diminish the amount of water flowing downstream to other areas.

iv) **Global Warming** – Human actions have contributed to more and more emissions of greenhouse gasses into the atmosphere thus resulting in the continued rise of the earth's average temperatures. Conswquently, evaporation and evapotranspiration levels have risen, and the higher temperatures have led to wildfires and extended dry spell periods. The global warming situation tends to exacerbate the drought conditions. Some of the worst droughts witnessed in sub-Saharan Africa have been associated with global warming and climate change.

5.4.2 Impact

The effects of drought are widespread and have devastating effects on the environment and the society as a whole. Water use is part and parcel of almost every human activity as well as the life of plants and animals. On this basis, extended deficiency of water can affect the society in various ways both directly and indirectly. The effects can therefore generally be categorized as environmental, economic, and social.

i) Environmental Impacts of Droughts

Animal and plants die off as consequence of drought. Mainly, the damages arise out of exclusive destruction of the wild life habitats and reduction in mater quality and quantity. Some plants and animals may completely fail to recover after the drought. The overall climate, the rocks, and soils are also affected, negatively impacting various living and non-living factors.

a) **Drying out of water bodies** – Surface waters such as lakes, rivers, ponds, creeks, streams and lagoons dry out during extended dry conditions which destroy natural havitats. Most especially, aquatic life and other wildlife dependent on these water bodies die or become endangered, destroying the entire food chain and alters the ecosystem.

b) **Reduction in soil quality** – Soil moisture, essential for soil microbial activities, is reduced in drougth conditions. As as result, soil quality is lowered because of minimized organic activity and continued dry spell which kills soil organisms. The end result is dry and cracked soil and it even becomes easier for decertification to occur.

c) **Unsuitable conditions for plant and vegetation survival**– Drought conditions make it unsuitable for plants and vegetation cover to survive.

Besides, fertile lands are lost as a result of drought, and in consequence, desertification sets in. Desertification is whereby the lands become infertile and bare, frequently as a result of overgrazing and is exacerbated by drought which makes it difficult for such lands to recover.

d) **Migration and even death of Animals and Wildife–** Animals and wildlife are forced to migrate in drought conditions since they have to move for long distances to get water and food. The prevaling circumstances during droughts also make it difficult for the survival of the animals. When the wildlife and animals migrate, they end up in new locations where they can be vulnerable, endangered because of new threats. This leads to loss of biodiversity and disruption of the natural ecosystems.

ii) Economic impact of droughts

The economic impacts of drought are realized from monetary and business losses incurred. during droughts by government, business, families and at the individual level. These are some of the examples of economic effects of droughts.

(a) **Increased budgetary spending by farmers** – During droughts, farmers spend more money on crop irrigation so as maintain crop yields. Also, lots of water has to be availed for watering the farm animals to ensure the daily water consumption standards are met. Hence, farmers have to spend more money to buy water or drill wells to keep the crops and livestock nourished with enough water.

b) **Reduced crop yields** – Often, low crop yeilds are experienced during drought periods. Therefore, farmers usually undergo major economic losses because of low crop yields. Thy pay for lots of inputs and labour, but the outcomes are less.

c) **Industrial and governmental losses** – Industries and businesses in farm equipment manufacturing and merchandising respectively loss millions of dollars when farmers lack the money to buy their resources. Governments, on the other hand, have to allocate more money and spend even more for drought mitigation as they have to cushion the farmers and the entire society from the adverse impacts of the droughts. Such governmental monetary spending includes funds for emergency supplies, seed funds, and availing other relevant drought mitigations resources.

d) **Higher energy cost for economies dependent on hydro-power** – Extended dry spells can translate to lowered water levels in rivers and dams used to generate hydro-power. This means higher costs of energy for businesses because the hydro-energy companies are driven to operate below capacity. Businesses at times have to use fuel-powered generators which result in higher business operation costs. At the same time, increased energy demands lead to increased cost of grid energy, which leads to ecomomic losses both for energy industries and businesses.

iii) Social Impacts of Droughts

Social implications are possibly the most felt effects of drought. They are the direct effects to people and communities. They include–

a) **Outbreak of waterborne diseases** – Since water scarcity is high drought conditions, water quality significantly depreciates. This means the availability of clean water for drinking and water for sanitation and cleaning may not ne sufficient. Drought also increase the concentration levels nutrients, chemicals, and solid particles or impurities in surface water. As a result, managing and preventing waterborne diseases such as typhoid and cholera beomes increasingly difficult, especially in poor regions.

b) **Hunger, anemia, malnutrition, and deaths**– Hunger, anemia, malnutrition and deaths of people are often witnessed in drought-stricken areas. Drought is a great causal factor for low food production, thus, when experienced in poorer regions the effects of malnutrition, hunger, anemia and mortalities are compounded since there is little food available for consumption.

Often, it is as a result of lack of sufficient food nutrition that directly contributes of diseases and health vulnerability. Common cases of hunger, anemia, malnutrition, and mortalities are recorded in poorer nations.

c) **Migration of people and anxiety** – People are forced to shift to other places in search for better living conditions during droughts. This contributes to loss of livelihoods and disorients small-scale farmers who are dependent on their farm produce. People forced to migrate also undergo lots of stress, anxiety and are compelled to indulge in strenuous activities to provide for their families. Women, children, and the elderly are the most affected.

5.4.3 Distribution

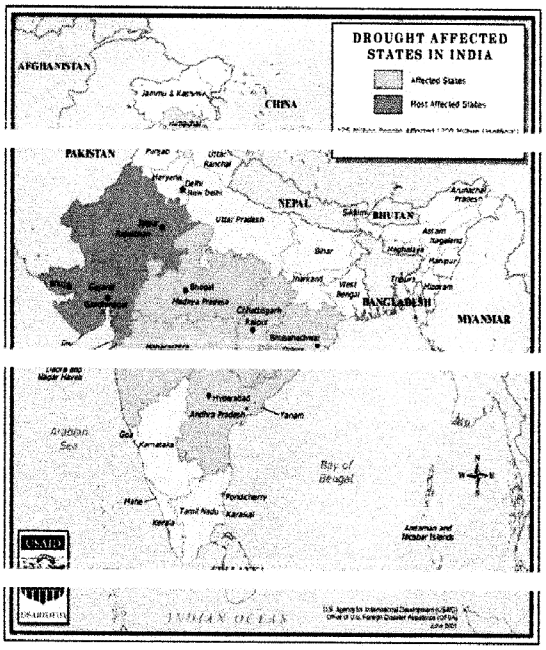
It has been observed that the impact of droughts differs widely between developed and developing countries because of the influence of such factors as water supply and water-use efficiency. The majority of the estimated 500 million rural poor in the Asia-Pacific region are subsistence farmers occupying mainly rain-fed land (*ESCAP, 1995*). The drought-prone countries in this region are Afghanistan, Iran, Myanmar, Pakistan, Nepal, India, Sri Lanka and parts of Bangladesh. In India about 33% of the arable land is considered to be drought-prone (i.e. about 14% of the total land area of the country) and a further 35% can also be affected if rainfall is exceptionally low for extended periods (*ESCAP, 1995*). Nepal has been sunjected to severe droughts in the past. The Philippines, Thailand, Australia and the Pacific islands of Fiji, Vanuatu and Samoa also contain drought-prone areas.

In India, drought remains a recurrent phenomena in spite of its vast water resources. India has several major, medium, and minor rivers. The annual rainfall and snowfall is about 114 cm which creates 4000 cu km of water per annum. Even after evaporation and other losses, about 1860 cu km of water should remain as excess. But, in reality, only 700 cu km surface water reserve remains usable owing to topographical and hydrological bottlenecks. Out of about 6 million villages of India, about 2,31,000 are called 'problem villages'. In these 'problem villages', water is not available within a 1.6 km radius. Almost 68% of the sown area is dependent upon rainfall. Rain fall distribution grossly varies in more than 35 meteorological subdivisions of India. For example, Cherrapunji receives about 118.70 cm of rainfall in comparison to about 10 mm or less rain received in the western part of Rajasthan. The most drought-prone regions is located in West Rajasthan, Gujarat, Saurashtra and Kutch, Maharashtra, Telengana, Rayalaseema, Bihar and some parts of Orissa, such as Kalahandi, Bolangir and Koraput.

The worst drought experienced by India occurred in 1877. The rainfall departure in 1877 was 79%, which had a spread of over 66.8% of the area. In recent times droughts have occurred in 1979, 1982, and as close as 2000. The drought of 1979 had an adverse impact on about 200 million people of Rajasthan, Punjab and Himachal Pradesh. A 'phenomenal' drought took place in 1987 when the departure of rainfall was - 19.3% and the area suffering from deficient rainfall was 64.3%. Among the victims were about 285 million people and 168 million cattle in 15 States and 6 Union Territories. Saurashtra, Kutch, Diu, western part of Rahjasthan, Delhi and Hariyana suffered tremendously. The occurrence of drought does not always have a link with the occurrence of rainfall in a particular region. In recent years, Cherrapunji which receives the highest anound of rainfall in the world was also facing drought conditions due to lack of water harvesting methods.

In the first quarer of 2000, large parts of the country were hit by another drought. Some 14 states reported drought or drought-like conditions of varying magnitude. The worst hit were Rajasthan (in which 26 million people in 23,000 villages in 26 districts were affected), Andhra Pradesh (30 million people in 17,000 villages in 18 districts) and Gujrat (25 million people in 8,000 vilages in 17 districts). Parts of Madhya Pradesh, Orissa, Maharashtra, Manipur, Mizoram and Tripura also came under some stress, as did some districts of Himachal Pradesh, Jammu and Kashmir, Karnataka and West Bengal which reported severe scarcity of water. Over 15% of the Indian population, i.e. 130 million people were affected. Because droughts are a regular feature in India, the Government of India had developed contingency plans. One of its major activities was to establish relief camps where families were provided with work, shelter, food and health care. Protection and care for women and children were a priority. Local and international NGOs were also activly involved in relief programmes.

Whil UNICEF reseased immediate assistance through its state offices, it also decided to focus on long-term assistance to help prevent such situations. The Government of Gujrat requested UNICEF to assist in the development of a White Paper on water management policies. Support was received from Australian Aid (US$ 576,000) and the Dutch Government (US$ 2.8 million) for Gujarat and Rajasthan.



5.5 Conclusion

A hazard only becomes a disaster when it comes in contact with vulnerble population of location. Natural disasters cannot be stopped but with better mitigation we can reduce the loss they incur on life and property and reduce it to bare minimum. Techniques of risk assessment, vulnerability analysis, structural and nonstructural measures including building codes, resistant structures, warning and forecasting etc. can reduce the impact of disaster.

5.6 Summary

A detail discussion has been done on the climatological hazards particularly flood and drought. The main criterion of the difference in rainfall. The cause and effect are discussed elaborately. Moreover the world wide as well as Indian distributions are also highlighted.

5.7 Glossary and Keywords

Agro climatic region – Identification of a region on the basis homogeneous climate, physical features, and crop types; used to determine crop calendars, forecast crop yields, and conduct drought assessments.

Flash flood – a sudden and extreme volume of water that flows rapidly and causes inundation of land areas. It can result in heavy loss of life and destruction of property.

Flood control – the management of water resources through construction of dams, reservoirs, embankments, etc. to aviod floods.

Floodplain – an area adjacent to a river, formed by the repeated overflow of the natural channel bed.

Food shortage – a scarcity of food in a given area which has not yet reached famine proportions. Food shortages usually require some external food assistance but usually do not result in loss of life.

UNIFEF – United Nations Children's fund.

5.8 References and Further Readings

- Abrahams, M. J., Price, J., Whitlock, F. A. and William. G (1976), The Britane Floods, January: Their Impact on Health, Medical Journal of Australia 2.
- Alexander W.J.R. (2000) flood Risk Reduction in Developing Countries in DJ Parker (2000) ed., Floods, Routledge, New York.
- Allen, E. (1994), Political Response to Flood Disaster: The Example of Riode Jeneiro, in Valley, A. (1994), Disaster, Development and Environment, Wiley, Chichester.
- Annual Flood Report, 2013, Irrigation and Waterways Directorate. Govt. of West Bengal, 1-2. Ball, Nicole (1976), "Understanding the Causes of African Famine," Journal of Modern African Studies 14:3, September,
- Biswas, R., Mazumder, A. and Bagchi, S. (1999), ' A Study of Inter-sectoral Coordination in Disaster Management in Flood Prove Districts in West Bengal, in *Journal of Public Health,* Vol. XXXXIII, No. 3, July-September, 1999.
- Brown, Barbara, Jenet C. Tuthill and E. Thomas Rowe (1976), International Disaster Response: The Sahelian Experience, INTERTECT, Dallas, Texas.
- Chakraborty, S. (2015),. Investigating People's Role in Flood Control and Management in West Bengal – A Case Study. American Jarnal of Theoretical and Applied Business, 1 (1), 41-47.
- Chakraborty, S. C. (2007). Natural Hazards And Disaster management. *Natural Hazards and Disaster management.* Kolkata: Pragatisil Prokashak.
- Chapman, G. (2002), *Final Report on Flood Mitigation in West Bengal,* Submitted to DFID, Department of Geography, University of Lancaster, UK.
- Currey, Bruce, Famine (1981) : A First Bibliography, East-West Center, Honolulu, Hawaii.
- Cutter, S. L. (2007) Hazards, Vulnerability, and Environmental Justice. Lonon: Earthscan.
- Dolui, G. and Ghosh, S. (2013). Flood and its Effects : A Case Study of Ghatal Block, Paschim Medinipur, West Bengal. The Global Journals, *2(11),* 248-252.
- Kumar, N. (2011). Disaster Management. *Disaster Management.* New Delhi: Alfa Publication.

- Mirtskhoulava, T.E. (1994), Flood control in former USSR in Roosi, G., Harmancioglu, N. and Yejevich, V. (eds.), *Coping with Floods,* Kluwer Academic Publishers, Dordrecht, 751-758.
- Mukherjee, D. M. (2010), Natural Disasters *Natural Disasters*. Kolkata: Arun Banerjee Art Publishing.
- Pielke, R.A. (2000), Flood impacts on Society- Damaging Floods as Farmework of Assessment, in D.J. Parker (2000) ed., Floods, Routledge, New York.
- Ray, C., (2001), 'The Causes of Flood of September 2000 in West Bengal vis-a-vis the Roles of the Massanger Dam and the Tilpara Barrage, in Sechpatra, Department of Irrigation and Waterways, GoWB, Kolkata, Vol. 1, p.p. 13-32.
- Roth, B.K. (2001), *Lessons from Orissa (Western Orissa, KBK Districts) Draught and its Mitigation by involving PRis, NGOs and* Go, pp 27-29
- Roy, A. (2014). Vaiability of Rainwater Harvesting in Drought Prone Areas of West Bengal: An Empirical Study on Bandu River Basin in Puruliya District. The International Journal of Social Sciences and Humanities Invention, *1(3),* 155-164.
- Vibhas Chandra Jha, V.C. Bairagya, H. (2011). Environmental Impact of Flood and their Sustainable Management in Deltaic Region of West Bengal, India, Caminhos de Geografia, 1*12(39),* 283-296.

5.9 Model Questions

1. How does flood occur?	5
2. What are the different factors that causes flood.	10
3. Discuss the Impact of flood in detail.	10
4. Discuss the impact of flood in detail.	10
5. How does drought occur?	5
6. What are the different factors that causes drought?	10
7. Discuss the impact of drought in detail.	10

Unit-6 □ Causes, Impact and Distribution of : Deforestation, Desertification, Salinization

Content Structure

6.1 Objectives

The main objective is

- To study the reasons behind the occurrence of deforestation, desertification and salinization.

- To analyse the impact as well as the distribution pattern of the above hazards.

6.2 Introduction

Deforestation is the permanent destruction of forests in order to make the land available for other uses. Trees are lost due to deforestation, the result can be a drier climate and desertification or the transformation of the once fertile land to desert. Deserts occur in a variety of types, hot and cold, stony and sandy, but all are characterized by rainfall deficiencies so marked that cultivation or stock-rearing are possible only with special adaptations, as for example, by the development of irrigation. The increase of salt in soil cause salinization. Salinization is the process by which water soluble salts occumulate in the soil. Salinization is a resource concern because excess salts hinder the growth of crops by limiting their ability to take up water.

6.3 Deforestation

Deforestation means cutting down the trees to a large extent be it forests, any barren land or trees. Natural forests are being destructed to use the land for cultivation, building houses, factories and logging, making space for cattle grazing, extraction of oil, minig, and construction of dams or to obtain wood for making furniture and using it as fuel.

Forest wood has been an essential need for us since the time of civilization and still continues to be the main source for many uses in our day to day life. Trees help to maintain the water cycle and give shelter to the organisms. It takes place in an area that is densely populated by trees and is mostly observed in a forest like the Amazon rainforest. Forests cover almost 30% of the earth's land.

The extinction of the forest cover affects the biodiversity which in turn threaten people's lives. Shrinking of the forests cause wide-reaching problems like soil erosion, fewer crops, flooding, water cycle disruption, green house gas emissions, changes in the climatic conditions, and loss of biodiversity.

Conversion of forests to land used for other purposes has a long history. Earth's croplands, which cover about 49 million square km (18.9 million square miles), are mostly deforested land. Most present-day croplands receive enough rain and are warm enough to have once supported forests of one kind or another. Only about 1

million square km (390,000 square miles) of cropland are in areas that would have been cool boreal forests, as in Scandinavia and northern Canada. Much of the remainder was once moist subtropical or tropical forest or, in eastern North America, Western Europe, and eastern China, temperate forest. The extent to which forests have become Earth's grazing lands is much more difficult to assess. Cattle or sheep pastures in North America or Europe are easy to identify, and they support large numbers of animals. At least 2 million square km (772,204 square miles) of such forests have been cleared for grazing lands. Less certain are the humid tropical forests and some drier tropical woodlands that have been cleared for grazing. These often support only very low numbers of domestic grazing animals, but they may still be considered grazing lands by national authorities. Almost half the world is made up of "drylands" – areas too dry to support large numbers of trees– and most are considered grazing lands. There, goats, sheep, and cattle may harm what few trees are able to grow. Although most of the areas cleared for crops and grazing represent permanent and continuing deforestation, deforestation can be transient. About half of eastern North America lay deforested in the 1870s, almost all of it having been deforested at least once since European colonization in the early 1600s. Since the 1870s the region's forest cover has increased, though most of the tgrees are relatively young. Few places exist in eastern North America that retain stands of uncut old-growth forests.

6.3.1 Causes

The causes of deforestation are:

i) **Logging** – Illegal logging activities are very common that destroy the livelihoods of the people depending on forests. Wood-based indultries like paper, match-sticks, furniture need a substantial amount of wood supply. Wood is used as fuel most commonly and so large amount of trees are cut down for fuel supplies. Firewood and charcoal are used as fuel.

ii) **Agricultural Activities** – The conversion of forests into agricultural land is a big reason for deforestation. Due to overgrwoing damand for food products, many trees are chopped down for crops and for cattle grazing. Over 40% of the forests are cleaned to obtain land and meet the needs of agriculture and wood.

iii) **Mining** – Oil and mining of coal require a large amount of forest land. Construction of roads leads to deforestation as they provide the way to remote land. The waste that comes out from mining pollutes the environment and affects the nearby species.

iv) **Urbanization** – As the population grows, the needs of people increases which further leads to deforestation. Forests shrink to a great extent to meet the requirements like for construction of roads, development of houses, mineral exploitation and expansion of industries. Increasing population directly affects forest as with the expansion of cities there is a need for more land for housing and settlements.

v) **Timber Production** – One of the primary cause of deforestation is the production of timber. There is a lot of demand for timber and so deforestation increases. It is a source of raw material which is used for the production of paper and also for construction.

vi) **Forest Fires** – We lose a large number of trees each year due to fires in the forest in various portions worldwide. This happens due toe extrem summers and winters. The fire caused, by man or natrure, results in huge loss of forest cover.

6.3.2 Impact

i) **Climatic Change** – Deforestation is considered to be one of the contributing factors to global climate change. According to Michael Dalet, an associate professor of environmental science at Lasell College in Newton, Massachusetts, the number one problem caused by feforestation is the impact on the global carbon cycle. Gas molecules that absorb thermal infrared ratiation are called greenhouse gass. If greenhouse gases are in large enough quantity, they can force climate change, according to Daley. While oxygen (O_2) is the second most abundant gas in our atomosphere, it does not absorb thermal infrared radiation, as greenhouse gasses do. Carbon dioxide (CO_2) is the most prevalent greenhouse gas. CO_2 accounts for about 82.2 percent of all U.S. greenhouse gas, according to the Environmental Protection Agency (EPA). Trees can help, though. About 300 billion tons of carbon, 40 times the annual greenhouse gas emissions from fossil fuels, is stored in trees, according to Greenpeace.

The deforestation of trees not only lessens the amount of carbon stored, it also releases carbon dioxide into the air. This is because when trees die, they release the stored carbon. According to the 2010 Global Forest Resources Assessment, deforestation releases nearly a billion tons of carbon into the atmosphere per year, though the numbers are not as high as the ones recorded in the previous decade. Deforestation is the second largest anthropogenic (human-caused) source of carbon

dioxide to the atmosphere (after fossil fuel combustion), ranging between 6 percent and 17 percent, according to a study published in 2009 in Nature.

Carbon isn't the only greenhouse gas that is affected by deforestation. Water vapour is also considered a greenhouse gas. "The impact of deforestation on the exchange of water vapor and carbon dioxide between the atmosphere and the terrestrial land surface is the biggest concern with regard to the climate system," said Daley. Changes in their atomospheric concentration will have a direct effect on climate.

Deforestation has decreased global vapur flows from land by 4 percent, according to an article published by the journal National Academy of Sciences. Even this slight change in vapur flows can disrupt natural weather patterns and change current climate models.

Forests are complex ecosystems that affect almost every species on the planet. When they are degraded, it can set off a devastating chain of events both locally and around the world.

ii) **Loss of Species:** Seventy percent of the wrold's plants and animals live in forests and are losing their habitats to deforestation, according to National Geographic. Loss of habitat can lead to species extinction. It also has negative consequences for medicinal research and local populations that rely on the animals and plants in the forests for hunting and medicine.

iii) **Water Cycle:** Trees are important to the water cycle. They absorb rain fall and produce water vapor that is released into the atmosphere. Trees also lessen the pollution in water, according to the North Carolina State University, by stopping polluted runoff. In the Amazon, more than half of the water in the ecosystem is held within the plants, according to the National Geographic Society.

iv) **Soil Erosion:** Tree roots anchor the soil. Without trees, the soil is free to wash or blow away, which can lead to vegetation growth problems. The WWF states that scientists estimate that a third of the world's arable land has been lost to deforestation since 1960. After a clear cutting, cash crops like coffee, soya and palm oil are planted. Planting these types of trees can cause further soil erosion because their roots cannot hold onto the soil. "The situation in Haiti compared to the Dominican Republic is a great example of the important role forests play in the water cycle," Daley said. Both countries share the same island, but Haiti has much less forest cover than the

Dominican Republic. As a result, Haiti has endured more exterme soil erosion, flooding and landslide issues.

v) **Lofe quality :** Soil erosion can also lead to silt entering the lakes, streams and other water sources. This can decrease local water quality and contribute to poor health in polulations in the area.

vi) **The disturbance of Native People :** Many native tribes live in the rainforeset of the world, and their destruction is the destruction of these peoples' homes and way of life. For example, the film "Under the Canopy" takes a look at the Amazon rainforest and the people who live there, including an indigenous guide named Kamanja Panashekung. "Kamanja's community is one of over 350 indigenous communities throughout Amazonia that deoend on the rainforest, as we all do, for the air we breathe and the water we drink," M. Sanjayan, Conservation International's executive vice president and senior scientist, said in a statement.

Many believe that to counter deforestation, people simply need to plant more trees. Though a massive replanting effert would help to alleviate the problems deforestation caused, it would not solve them all.

Reforestation would facilitate the following activities like, a) Restoring the ecosystem services provided by forests including carbon storage, water cycling and wildife havitat, b) Reducing the buildup of carbon dioxide in the atmosphere, c) Rebuilding wildife habitats.

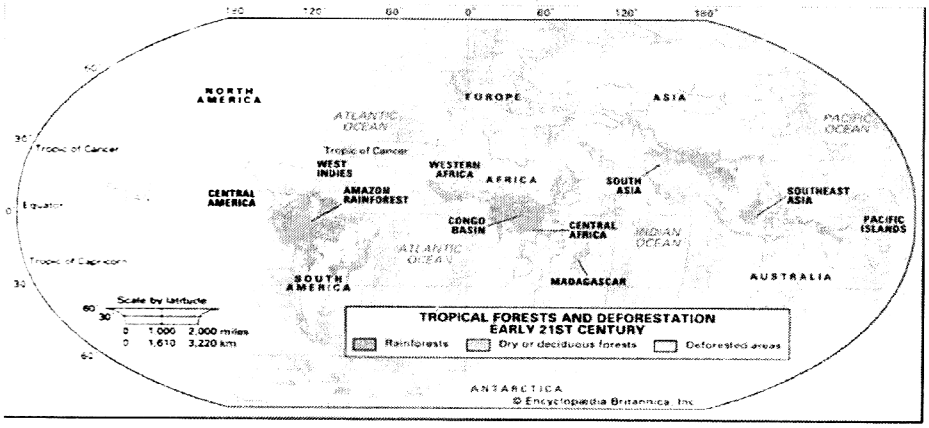
Reforestation won't completely fix the damage, through. For example, Daley points out that forests cannot sequester all of the carbon dioxide humans are emitting to the atmosphere through the burning of fossil fuels and a reduction in fossil fule emissions. It is still necessary to avoid buildup in the atmosphere. Reforestation will not help with extinction due to deforestation, either. "Unfortunately, we have already diminished the population of many species to such an extreme that they might not recover, even with a massive reforestation effort," Daley told Live Science. In addition to reforestation, some other tactice are being taken to counteract or slow deforestation. Some of them include shifting the human population to a plant-based diet. This would lower the need for land to be cleared for raising livestock.

Global Forest Watch has also initiated a project to counteract deforestation through awareness. The organisation uses satellite technology, open date and crowdsourcing to detect and alert others of deforestation. Their online community is

also encouraged to share their personal experiences and the negative effects of deforestation.

6.3.3 Distribution

The United Nations and Agriculture Organization (FAO) extimates that the annual rate of deforestation is about 1.3 million square km per decade, through the rate has slowed in some places in the early 21st century as a result of enhanced forest management practices and the establishment of nature preserves. The greatest deforestation is occurring in the tropics, where a wide variety of forests exists. They range from rainforests that are hot and wet year-round to forests that are merely humid and moist, to those in which trees in varying proportions lose their leaves in the dry season, and to dry open woodlands. Because boundaries between these categories are invitably arbitrary, extimates differ ragarding how much deforestation has occurrd in the tropics. The following map (Map No 1) shows the rainforest and dry deciduous forest cover and the deforested areas.



Map No 1: Rainforest and Dry Deciduous forest and Deforestation in the early 21st century.

A major contributor to tropical deforestation is the practice of slash-and-burn agriculture, or swidden agriculture (*see also* shifting agriculture). Small-scale farmers clear forests by burning them and then grow crops in the soils fertilized by the ashes. Typically, the land produces for only a few years and then must be abandoned and new patches of forest burned. Fire is also commonly used to clear forests in Southeast Asia, tropical Africa, and the Americas for permanent oil palm palntations.

Additional human activities that contribute to tropical deforestation include commercial logging and land clearing for cattle ranches and plantations of rubber trees, oil palm, and other economically valuable trees.

The Amazon Rainforest is the largest remining block of humid tropical forest, and about two thirds of it is in Brazil. (The rest lies along that country's borders to the west and to the north.) Studies in the Amazon reveal that about 5,000 square km (1,931 square miles) are at least partially logged each year. In adition, each year fires burn an area about half as large as the areas that are cleared. Even when the forest is not eantirely cleared, what remains is often a patchwork of forests and fields or, in the event of more intensive deforestation, "islands" of forest surrounded by a "sea" of deforested areas.

Deforested lands are being replanted in some areas. Some of this replanting is done to replenish logging areas for future exploitation, and some replnting is done as a form of ecological restoration, with the reforested areas made into protected land. Additionnaly, significant areas are planted as monotypic plantations for lumber of paper production. These are often plantations of eucalyptus or fast-growing pines– and almost always of species that are not native to the places where they are planted. The FAO estimates that there are approximately 1.3 million squar km (500,000 square miles) of such plantations on Earth.

Many replanting efforts are led and funded by the United Nations and nongovernmental organizations. However, some national governments have also undertaken ambitious replanting projects. For example, starting in 2017, the government of New Zealand south to plant more than 100 million trees per year within borders, but perhaps the most ambitious replanting project took place in India on a single day in 2017, when citizens planted some 66 million trees.

6.4 Desertification

Desertification is difined as a process of land degradation in arid, semi-arid and sub-humid areas due to various factors including climatic variations and human activities. Or, to put it in another way, desrtification results in persistent degradation of dryland and fragile ecosystems due to man-made activities and variations in climate. Desertification, in short, is when land that was originally of another type of biome turns into a desert biome because of changes of all shorts. A huge issue that many countries have is the fact that there are large pockets of land that are going through a process that is known as desertification.

According to UNESCO, one third of world's land surface is threatened by desertification and across the world it affects livelihood of millions of people who depend on the benefits of ecosystems that drylands provides. Desertification is another major enviromental concern and a major barrier to meeting human basic needs in drylands and are being constantly threatened by increases in human pressures and climatic variability. In this article, we're going to give you an idea as to what are the causes of desertification, the effects that desertification has, and what we can do in order to deal with the problem at hand. Let's take a closer look at all of these topics.

According to Wikipedia, *"Desertification is a type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors, such as climate change and human activities. Desertification is a significant global ecological and environmental problem."*

6.4.1 Causes

i) **Overgrazing :** Animal grazing is a huge problem for many areas that are starting to become desert biomes. if there are too many animals that are overgrazing in certain spots, it makes it difficult for the plants to grow back, which hurts the biome and makes it lose its former green glory.

ii) **Deforestation :** When people are looking to move into an area, or they need trees in order to make houses and do other tasks, then they are contributing to the problems related to disertification. Without the plants (especially the trees) around, the rest of the biome cannot thrive.

iii) **Farming Practices :** Some farmers do not know how to use the land effectively. They may essentially strip the land of everything that it has before moving on to another plot of land. By stripping the soil of its nutrients, desertification becomes more and more of a relity for the area that is being used for farming.

iv) **Urbanization and other types of land development.** As mentioned above, development can cause people to go through and kill the plant life. It can also cause issues with the soil due to chemicals and other things that may harm the ground. As areas become more urbanized, there are less places for palnts to grow, thus causing desertification.

v) **Climate Change :** Climate change palys a huge role in desertification. As

the days get warmer and periods of drought become more frequent, desertification becomes more and more eminent. Unless climate change is slowed down, huge areas of land will become desert; some of those areas may even become uninhabitable as time goes on.

vi) **Stripping the land of resources.** If an area of land has natural resources like natural gas, oil, or minarals, people will come in and mine it or take it out. This usually strips the soil of nutrients, which in turn kills the plant life, which in turn starts the process toward becoming a desert biome as time goes on.

vii) **Natural Disasters:** There are some cases where the land gets damaged because of natural disasters, including drought. In those cases, there isn't a lot that people can do except work to try and help rehabilitate the land after it has already been damaged by nature.

6.4.2 Impact

i) **Farming becomes next to impossible.** If an area becomes a desert, then it's almost impossible to grow substantial crops there without special technologies. This can cost a lot of money to try and do, so many farmers will have to sell their land and leave the desert areas.

ii) **Hunger :** Without farms in these areas, the food that those farms produce will become much scarcer, and the people who live in these lecal areas will be a lot more likely to try and deal with hunger problems. Animals will aslo go hungry, which will cause even more of a food shortage.

iii) **Flooding :** Without the plant life in an area, flooding is a lot more eminent. Not all deserts are dry; these that are wet could experience a lot of flooding because there is nothing to stop the water from gathering and going all over the place. Flooding can also negatively affect the water supply, which we will discuss next.

iv) **Poor Water Quality :** If an area becomes a desert, the water quality is going to become a lot worse than it would have been otherwise. This is because the plant life plays a significant role in keeping the water clean and clear; without its presence, it becomes a lot more difficult for you to be able to do that.

v) **Overpopulation:** When areas start to become desert, animals and people will go to other areas where they can actually thirve. This causes crowding and overpopulation, which will, in the long run, end up continuing the cycle of desertification that started this whole thing anyway.

vi) **Poverty:** All of the issues that we've talked about above (related to the problem of desertification) can lead to poverty if it is not kept in check. Without food and water, it becomes harder for people to thrive, and they take a lot of time to try and get the things that they need.

Desertification can be controlled by making different policy related to modernize and technoloty based farming. The following means are implemented to control desertification,

Education : In developing countries, education is an incredibly important tool that needs to be utilized in order to help people to understand the best way to use the land that they are farming on. By educating them on sustainable practices, more land will be saved from becoming desert.

Community participation in lical land management is important to the long-term success of conservation at a regional level. A prevailing notion is that community-based approaches to planning tend to be more effective because they incorporate the relevant knowledge and experience of those affected by land-use decisions (Brandon and Wells, 1992; McNeely, 1993). In this way, participation can help to mitigate potential and existing conflicts and empower the community to take a more active role in exploring management issues and initiating possible responses.

Techonology Advances. In some cases, it is difficult to try and prevent desertification fro happening. In those cases, there is need to apply advanced technology through continuous research which may help in the long run in increasing the productivity of land in use.

Putting Together Rehabilitation Efforts. There are some ways that we can go back and rehabilitate the land that we have already pushed into desertification; it just takes some investment of time and mony. By putting these together, we can prevent the issue from becoming even more widespread in the areas that have already been adversely affected.

Sustainable practices to prevent desertification from happening. There are plenty of sustainable practices that can be applied to these acts that may be causing

desertification. By adding these to what we should be doing with land, we can ensure that we do not turn the entire world into a desert.

Desertification is a huge problem that needs to be addressed accordingly, and if we take the time to do it now, we can prevent other problems from happening with it in the furure. By taking that critical look at desertification, we have the tools that we need in order to get through the processes effectively.

In 1994, the United Nations established the Convention to Combat Desertification (UNCCD) through which 122 countries have committed to land Degradation Neutrality targets, similar to the way countries in the climate Paris Agreement have agreed to targets for reducing carbon pollution. These efforts involve working with farmers to safeguard arable land, repairing degraded land, and managing water supplies more effectively. The UNCCD has also promoted the Great Green Wall Initiative, an effort to restore 386,000 square miles (100 million hectares) across 20 countries in Africa by 2030. A similar efforts is underway in northern China, with the government planting trees along the border of the Gobi desert to prevent it from expanding as farming, livestock grazing, and urbanization, along with climate change, removed buffering vegetation. However, the results form these types of restoration efforts so far have been mixed. One type of mesquite tree planted in East Africa to buffer against desertification has proved to be invasive and problematic. The Great Green Wall initiative in Africa has evolved away fro the idea of simply planting trees and toward the idea of greeting, or supporting small farmers in managing land to maximize water harvesting (via stone barriesrs that devrease water runoff, for example) and natural mentural re-growth of trees and vegetation.

6.4.3 Distribution

Dry-sub humid, semiarid, arid, and hyper arid areas together from the world dry lands, covering as much as 47 percent of the total area. Dry forest, grassland, and shrubland ecosystems are found in drylands except the hyper arid land (the "true desert"), which experiences exterme dry conditions and usually seems lifeless (e.g., central Sahara and Namib desert of Africa, the Hizad on the Arabian Peninsula, the Takla Makan and Turfan depressions in Central Asia, Death Valley in U.S.A.). Desertification occurs primarly in all drylands except hyper arid lands because climatic and ecological conditions make them more susceptible to land degradation than more humid regions. It is hard for hyper arid lands to become more 'desert like". and thus they are usually excluded from the consideration of desertification.

Table 1. Extent and severity of desertification in different regions of the world (from Thomas, 1995).

Region of the Total Dry Land	Area (10^3km^2)	Desertified Area (10^3km^2)		
		Light and Moderate	Strong and Extreme	Total Area of Desertified land
Aisa	16718	3267	437	3704
Africa	12860	2453	740	3193
Europe	2997	946	49	995
Australia	6633	860	16	876
North America	7324	722	71	793
South America	5160	728	63	791
Total	51692	8976	1376	10352

Desertification has been occurring at an astonishing rate over six continents. Most of the desertified lands are found in Asia and Africa, while the problem also has become significant in Europe, Australia, North America, and South America (Table 3). Approximately 25 percent of the irrigated land (3% of the drylands), 50 percent of the rain fed corpland (9% of the drylands) and 75 percent of the rangeland (88% of the drylands) have been desertified at different degrees (Dregne, 1992). Although the accuracy of estimating the exact extent and rate of desertification needs to be improved with the aid of advanced techonologies such as statellite remote sensing and geographic information systems (computer systems for storing, retrieving, and manipulating spatial or goegraphic data), there is little doubt that extensive areas of the world drylands have increasingly experienced some from of chronic land degradation since the early 1900s. Desertification has affected more than one hundred countries and resulted in profound ecological, social, and ecomomic consequences throughout the world. Combating desrtification is an urgent and grand challenge facing humanity today. Global efforts and local solutuins are both needed. Preventive and rehabilitation measures must be undertaken simulataneously based on scientific findings and socioeconomic considerations.

Twenty-five per cent of **India's** total land in undergoing desertification that has affected is productivity, critically affecting the livelihood and food security of millions accross the country. As much as 105.19 million hectares (Mha) of the country's total geographical area of 82.18 Mha is under going desertification. Rajasthan account for the most desertified land (23 Mha), followed by Gujarat,

Maharashtra and Jammu and Kashmir (13 Mha each) and Orissa and Andhra Pradesh (5Mha each). According to the fifth National Report on Desertification, Land Degradation and Drought, 68 per cent of the country is prone to drought, and this will be further heightened because of the impact of climate change, particularly in dry lands.

6.5 Salinization

Soil salinization occurs when water-soluble salts accumulate in the soil to a level that impacts on agricultural prodiction, environmental health, and economics. In the early stages, salinity affects the metabolism of soil organisms and reduces soil productivity, but in advanced stages it destroys all gegetation and other organisms living in the soil, consequently transforming fertile and productive land into barren and desertified lands. The following table (Table 2) lists key indicators of soil salinization, the purpose of the indicator and methods used or measuring or assessing soil salinization.

Table No. 2 : Key Idicators of Soil Salinization, the Purpose and the Methods Used For Measuring or Assessing Soil Salinization

Indicators	Purpose	Methods
Electrical Conductivity (EC)	Assess salt content	Salinity sensors and sampling electromagnetic induction to measure Electrical Conductivity
Exchangeble Sodium Percentage (ESP)	Measure the concetration of sodium relative to the exchangeble cations	ESP=Exchangeable {(Na)/(Ca + Mg + K + Na)} x 100
Sodium Absorption Ratio (SAR)	Measure of the sodicity of soil, as determined from analysis of water exteracted from the soil.	SAR = Exchangeable {(Na)/ Ca+Mg)-0.5}
Salt profile	Assess vertical distribution of salt	Any of the above
Potential salt sources	Measure/estimate EC, SAR, ESP of irrigation water, groundwater and seepage water	Any of the above

Remote sensing indices	Find proxy spectral indicators that can assist in soil salinity mapping	Water absorption bands in the SWIR (short-wave infrared wavelength bands) and NIR (near infrared wavelength bands) 7
Field symptoms	Detect salinity in affected areas visually	Poor condition or absence of vegetation, presence of salt-tolerant weeds, areas that take longer to dry or the presence of unnatural colour soil crusting (white or dark)

There are two main tyoes of salinity:

i) Primary – Naturally Occuring Salinity means Primary salinity occurs naturally in soil and waters. Examples of naturally occurring saline areas include salt lakes, salt pans, salt marshes and salt flats.

ii) Secondary – resulting from human activities means Secondary salinity is salting that results from human activities, usually land development and agriculture.

6.5.1 Causes

The following process are responsible for salinization:

i) **Natural processes-** The accumulation of salt in the soil can occur through natural processes such as physical or chemical weathering and transport from parent material, geological deposits or groundwater. It can also occur due to parent rock constituents, such as carbonate minerals and/or feldspars or as a result of the one-time submergence of soils under seawater. Sea level rise also induces seepage into areas lying below sea level. In arid areas, saline soils are fromed due to evapotranspiration and lack or rainfall to flush the soils. Finally, wind in coastal areas can below moderate amounts of salts inland.

ii) **Human activities-** Human activities can causes salinization through the use of salt-rich irrigation water, which can be exacerbated by overexploitation of coastal groundwater aquifers causing seawater intrusion, or due to other inappropriate irrigation paractices, and/or poor drainage conditions. The excessive use of water for irrigation in dry climates, with heavy soils, causes

salt accumulation because they are not washed out by rainfall. The process occurs in cultivated areas where irrigation is associated with high evaporation rates and a clay texture of the soil. The practice of water-logging without adaquate drainage has also become a serious cause of soil salinization. Water logged soils prevent leaching of the salt imported by the irrigation water.

6.5.2 Impact

As a result of rising water tables in irrigated and non-irrigated areas or the use of saline water supplies–salinity can have significant impacts on the following aspects.

i) **Agricultural production**– Water moves into plant roots by a process known as osmosis, which is controlled by the level of salts in the soil water and in the water contained in the palnt. If the level of salts in the soil water is too high, water may flow from the plant roots back into the soil. This results in dehydration of the plant, causing yield decline or even death of the plant. Crop yield losses may occur even though the effects of salinity may not be obvious. The salt tolerance of a specific crop depends on its ability to extract water from salinized soils. Salinity affects production in crops, pastures and trees by interfering with nitrogen uptake, reducing growth and stopping plant reproduction. Some ions (particularly chloride) are toxic to plants and as the concentration of these ions increases, the plant is poisoned and dies.

ii) **Water quality** – The most significant off-site impact of dryland salinity is the silinization of previously fresh rivers. This affects the quality of water for drinking and irrigation–with serious economic, social and evironmental consecuences for both rural and urban communities. High levels of salts may affect the teste of drinking water. Chloride in particular has a low teste threshold. Sodium and magnesium sulfate levels in drinking water may produce a laxative effect and reduce the suitability of a water supply for grazing animals.

iii) **Ecological health of streams**– Salt interacts with in stream biota (animals and plants). Changing the ecological health of streams and esliaries. The greatest threat to biodiversity is from the loss of habital both on land and in water. Riparian zones are particularly at risk as they occupy the lowest parts of the landscape where much of the saline ground water is realeased to the surface. Salts also help fine materials (such as suspended clay particles) to flocculate, allowing more sunlight to penebiate rivers. This may lead to more harmful algal blooms if there are suitable environmental conditions.

iv) **Terrestrial biodiversity** – Much of the natural vegetation of salt-affected areas has been destroyed or damaged. This has caused major changes to the landscape and biodiversity including the destruction of ramaining natural habitat in many agricultural areas and the fragmentation of many wildlife corridors.

v) **Soil erosion**– Dryland salinity is closely linked to other soil degradation issues, including soil erosion. Salinity is often associated with prolonged wetness and lack of surface cover and therefore increases the vulnerability of soils to erosion.

vi) **Flood risk** – Shallow water tables can increase the risk of flooding. Soils in this situation have limited capacity to absorb rainfall, resulting in high rates of run-off. This can result in damage to roads, fences, dams, agricultural land and wetlands.

vii) **Infrastructure and fixtures** – Impacts include large decreases in the lifespan of road pavements when groundwater levels rise to within 2 meters of the pavement surface. As in other situations, capillary action will assist to draw the salt-laden water to the surface. Salt also corrodes and destroys the properties of bitumen, concerete and brick structures. Damage to infrastructure including houses, roads and playing fields, has been partirualrly high in a number of cities and towns. Salinity damage has also occurred to country roads and farm tracks and buildings.

viii) **Irrigation** – All irrigation water contains some salts, which may remain on the soil surface or on leaves of plants after evaporation. Therefore, any irrigation system has the potential to deliver an increased amount of salt to the soil.

ix) **Social** – Salinity can also affect people directly in a number of ways including:

- Cost to rural communities of declining population
- Loss of business (both existing and potential)
- Cost of rural restructure when farms become unprofitable
- Increased helth problems due to stress on families affected by change.

Salinity may also indirectly affect people by reducing the quality of the natural environment.

6.5.3 Distribution

The following table (Table 3) shows the estimated the area of the continent under salinization as mentioned by FAO.

Table No 3: The Extimated the Area of the Contonent under Salinization

Region	Total Area	Saline Soils	%	Sodic Soils	%
Africa	1899.1	38.7	2.0	33.5	1.8
Asia and the Pacific and Australia	3107.2	195.1	6.3	248.6	8.0
Europe	2010.8	6.7	0.3	72.7	3.6
Latin Amedica	2038.6	60.5	3.0	50.9	2.5
Near East	1801.9	91.5	5.1	14.1	0.8
North America	1923.7	4.6	0.2	14.5	0.8
Total	12781.3	397.1	3.1	434.3	3.4

In case of **India**, saline soils are distributed in the coastal, deltaic plains and mangrove regions in Gujrat, Maharasthra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal and Andaman and Nicobar Islands. The inland saline soils are commonly found in Gujarat and Rajasthan.

6.6 Conclusion

If trees are removed, the area can become much warmer and drier, which may result in desertification, which is a transformation of once fertile land into desert. Deforestation and desertification have many detrimental effect on the environment. One of the most devastating impacts is the loss of biodiversity. Deforestation, desertification and salinization are caused mainly by the people and they have a great effect on them.

6.7 Summary

A detail duscussion has been done on the deforestation, desertification and salinization. They are very much positively interrelated. The different factors of deforestation, desertification and silinization are discussed elaborately. The water level and climatic conditions are important factors for desertification and salinization.

The clamatic conditions are changed due to deforestations. The effect of these are accelerating with davastating consequences for both humans and the environment. The world wide as well as Indian distributions of deforestation, desertification and salinization are also highlighted.

6.8 Glossary and Keywords

Afforestation – establishment of a tree crop in an area where trees have alsays or long been absent.

Deforestation – the clearing of a previously forested area. Though humans are the primary deforesters, natural agents, such as volcanic eruptions, erosion, and landslides may also contribute. Clear cutting, if followed by reforestation, is not an act of deforestation.

Desertification – the process by which an already arid area becomes even more barren, because of prolonged drought, sand drift, or human-made degradation of the environment.

Evalotranspiration – the combined loss of water from a given area, during a specific period of time, by evaporation from the soil and by transpiration from plants.

Forest/grassland fire – fires in forest or brush grasslands that cover extensive areas and usually do extensive damage. They may start by natural causes such as volcanic eruptions or lighting, or they may be caused by arsonists or careless smokers, by those buring wood, or by clearing a forest area.

Forestation– the establishment of a forest, either natural or human-made, on an area that previosly have had none.

Plantation– an artificial forest stand. A human-made forest raised by the sowing of seed or by planting.

Soil moisture– moisture within the zone of aeration of the soil, including water vapor (also part of the soil air) present in the soil pores. In some cases refers strictly to moisture within the root zoone of plants.

6.9 References and Further Readings

- "Sacred Cow Causing Ecological Disaster in C.R. Local Experts Say," Tico Times, San Jose, Costa Rica, Nov 3, 1978.

- Earthscan, Natural Disasters: Earthscan Press Briefing Document No. 39. International Institute for Environment and Development, London, 1984.
- Eckholm, Erik P., "Down to Earth: Environmental and Human Needs," W.W. Norton and Company, New York, 1982.
- Entering the Twenty-first Century: The Global Report to the Presiodent, U.S. Government Printing Offoce, Washington D.C., 1980.
- FAO, Wood : World Trends and Prospects, Rome, 1967.
- Goodland, Robert J.A., "Environmental Ranking of Amazonian Development Projects in Brazil," Environmental Conservation, Spering, 1980.
- Gore, Rick, "An Age-Old Challenge Grows," National Geographic, November 1979.
- INTERTECT, The Poleritial contribution of Peace Corps to Disaster Preparedness in Africal. INTERTECT, Dallas, Taxas, 1983.
- Marchal, J. Y., "The Evolution of Agrarian Systems. The Example of Yatenga (Upper Volta), African Environment: Environmental Studies and Regional Planning Bulletin, Vol.II, 4 and III, 1, November 1977.
- Persson, Reider, World Forest Resources, Stockholm : Royal College of Forestry, 1974.
- Sommer, Adrian, "Attempt at an Assessment of the World's Tropical Forests," Unasylva 28 nos. 112/113, 1976.
- United Nations Conference on Desertification, Secretariat, Desertification: Its Causes and Consequences, Oxford: Pergamon Press, 1977.
- Whitton, S. John, Disasters: The Anatomy of Environmental Hazards, University of Georgia Press, Athens, Gorgia, 1979.

6.10 Model Questions

1. How are deforestation and desertification interrelated ? 5
2. What are the different factors that causes deforestation? 10
3. Discuss the Impact of deforestation in detail. 10
4. Where deforestation is mainly found? 10

5. What do you understand by the term desertification? 5
6. What are the different factors that causes desertification? 10
7. Discuss the impact of desertification in detail. 10
8. Mention the regions where desertification is mainly foud. 10
9. What do you uderstand by the term salinization? How many types of salinity is found? 5+5
10. What are the different factors that causes desertification? 10
11. Discuss the impact of desertification in datail. 10
12. Where salinization is mainly found? 10

Unit-7 □ Response and Mitigation to Disasters: Institutional Set up, NDMA and NIDM

Content Structure

7.1 Learning Objective

This section would help to develop an idea about the concept, approaches and strategies adopted by India to combat and respond to disasters and how they approach towards their mitigation. The organizational structure and institutional set ups regarding the execution of these activities such as NDMA and NIDM would give a vivid description of the processes undertaken by the governmental institutions to combat disasters.

7.2 Introduction

RESPONSE refers to the set of activities implemented after the impact of a disaster in order to assess the needs of the causalties, reduce their suffering, limit further spread and the consequences of the disaster thereby opening the way to rehabilitation. MITIGATION on the other hand refers to the permanent reduction of the risk of a disaster primarily followed by reducing the presence of a potential hazard and its vulnerability. Both response and mitigation to disasters form the two arms of the disaster management cycle. They are discribed below.

7.3 Response to Disasters

Disater response damands restoration of all physical facilities, lost livelihoods, rehabilitation of the affected polulation, and reconstructing efforts to ensure the recovery of the infrastructure lost or damaged. It is one of the important phases of the disaster-management cycle that often attracts the most attention and resources as it entails great impact on the health and well-being of affected communities. There are some important lessons learnt from disaster response retrospectively, as it brings to light the flaws in efforts relating to public policies and planning, location and type of infrastructure and social schemes for improving the social positioning with respect to access to resources of the under priviledged. Response to disaster is the evaluation time after the disaster has struck and hence it depends on the administrative set up of the affected area and hence failure of which would expose the system's weaknesses. Response is therefore largely dependent on the test of previously-planned local and national preparedness and mitigation measures. Disaster management is the ultimate test of administrative efficiency, in the sense of positive impact on the environment, preparedness, procedural simplicity, logistics, speed and expertise. Disaster response is therefore significant as it influences post-disaster recovery and future development possibilities **There are some intrinsic attributes of disaster response that is to be learnt with regard to administrative reforms by way of ensuring policy interventions:**

- Better institutional preparedness
- Opposing contrary pulls such as lack of social cohesion
- Long-term mitigation policy to counter vulnerabilies, structural and non-structural by enabling legal provisions.

7.4 Phases of Disaster Response

Following a disaster. rapid and effective action is needed to save lives, protect health and stabilize the situation, to avoid making the emergency worse. The disaster response is the third phase of the disaster management cycle. The entire purpose of disaster response depends on three phases of assessments: **a)** ***rapid initial assessments,*** (assess nature and scale of the emergency) **b)** ***detailed sectoral assessments*** (to plan, implement and coordinate) **c)** ***continuous assessments*** (monitoring of surveillance). All assessments can be further divided into two types: *acute emergency* and *less acute emergency*. In acute emergencies, intial assessments should be rapid and produce the information required to start an appropriate response. In less acute emergencies, a more detailed assessment is needed to design longer-term measures with adequate provision for monitoring and management.

7.5 Characteristics of Disaster Response

1. Purpose of the emergency situation should be clearly defined and all assessments should be like – an initial decision to be made on whether assistance is needed; a decision to be made on whether local capacity is adequate or external resources are required; priorities for intervention to be established and an intervention strategy indentified; necessary resources to be intensified; base-line data to be collected, to facilitate monitoring; information to be collected for fund-raising and advocacy work (ADAMS 1999).
2. It is important to use standardized processes and standard report formats for assessments, to ensure objectivity and to enable the humanitarian response to be made in proportion to the needs indentified.
3. Checklists should be used with common sense and good judgement to ensure that each emergency is assessed according to its specific characteristics.
4. Assessments should begin with a brief review of information about the area, accurate information on disasters, and organize specific relief to be disbursed.
5. It is most important to work with local partners and government agencies to ensure that proper information and relief is available and is properly disseminated to public.
6. A field assessment, particularly following a large-scale disaster, requires

organization, resource mobilization and disaster management in such a way where teams of people are organized, briefed and often trained before starting the assessment.

7. Evacuation can be an important component of prevention, preparedness and response. It involves the temporary transfer of a population (and to a limited extent, property) from areas at risk of disaster to a safer location.
8. Disaster warnings and emergency instructions in forms of radio and television broadcasting, social media, creates awareness of an impending disaster and ensure their safety and the success of the relief operation.
9. Coordination of emergency response activities must be made at every level for collecting and sharing essential information, and for taking decisions on resource use. Such arrangements can range from a simple committee meeting of community leaders or local administrators, to a complex, preplanned, purpose-built emergency operation centers.
10. Well-trained people are needed at policy-making levels, for technical services, surveys, and overall planning and supervision. They may include managers, engineers, medical doctors, epidemiologists, or environmental scientists, depending on the specific responsibilities concerned.

7.6 Structure of Response Systems for Disaster in India

a) **National Disaster Response Force (NDRF) & State Disaster Response Force (SDRF):** National Disaster Response Force (NDRF) was formed in 2006 as a specialist force to deal with all types of natural and man-made disasters. The headquarters was located at New Delhi and it had 10 battalions spread over the Country by 2012. NDRF was constituted for disaster response with a single chain of command. The State Disaster Response Fund (SDRF) was constituted under Section 48 (1) (a) of the Disaster Management Act, in 2015, for allocating funds available to the different State Governments for responses to notified disasters. Disasters covered under SDRF are cyclone, drought, earthquake, fire, flood, tsunami, hailstorm, landslide, avalanche, cloudburst, pest attack, frost and cold waves.

b) **Regional Response Centre:** The Ministry of Home Affairs in 2004 sanctioned setting up of eight Regional Response Centres (RRCs) and seven Nodal Centres (in high altitude and hilly areas). Three RRCs were set up at

Guwahati, Mundali and Arakkonam and were manned and operated by NDRF. The remaining five were manned and operated by Central Armed Police Forces (CAPFs).

c) **Civil Defense and Fire Service:** In 2009, the Ministry of Home Affairs formulated schemes relating to civil defence and fire services. The Director General of Civil Defence (DGCD) was designated as the implementing authority. The Ministry proposed a scheme for revamping Civil Defence by strengthening it, so that it could play a significant role in disaster management and assist the police in internal security and law and order situations, while retaining its primary role.

d) **Medical Preparedness :** Medical preparedness for disasters was constituted to create an institutional mechanism and systems that would result in the coordinated working of emergency responders, hospital managers and local and regional officials.

e) **Capacity building :** For successful disaster management it is required to have trained manpower to deal with the complex situations and rapidly ruduce the impact of disaster on human life and property. It is therefore necessary to continuously undertake measures to build capacity amongest the people handling with disaster prevention, mitigation, preparedness, response, reconstruction so as to also create awareness amongst the people. In terms of the National Policy 2009, the approach to capacity building includes awareness generation, education, training, research and development.

7.7 Mitigation to Disasters

Mitigation refers to the effort of reducing loss of life and property by lessening the impact of disasters. In fact, mitigation is primarily the permanent reduction of the risk from a disaster and secondarily reduce the effects of the disaster. Mitigation in order to be effective must be addressed before a disaster strikes– to reduce the human and financial consequences later (analyzing risk, reducing risk, and insuring against risk). It is important to know that disasters can happen at any time and any place and if we are not prepared, consequences can be fatal.

Effective mitigation requires knowledge of local risks and aim to invest in longterm community well-being. Without mitigation actions, we jeopardize our safety, financial security and self-reliance. The principal objectives of mitigation are

to save life, reduce economic disruption, decrease vulnerability, increase capacity, decrease chance of disaster occurrence.

7.8 Types of Disaster Mitigation

Disaster mitigation measures may be structural (e.g. flood dikes) or non structural (e.g. land use zoning). Mitigation activities should incorporate the measurement and assessment of the evolving risk environment. Other measures of mitigation include:

- Hazard mapping
- Adoption and enforcement of land use and zoning practices
- Implementing and enforcing building codes
- Floodplain mapping
- Reinforced tornado safe rooms
- Burying of electrical cables to prevent ice build-up
- Raising of homes in flood-prone areas
- Disaster mitigation public awareness programs
- Insurance programs.

7.9 Approaches to Disaster Mitigation

According to Carter (1991) there are two types of disaster mitigation approaches and they are:

- **Structural approach:** This approach refers to both engineered structures and non-engineered structures. Engineered structures are buildings and construction works built after proper planning and designing including buildings, dams, embankments, roads, bridges etc. these structures are built after following proper rules and laws coded for safety of the engineered construction in the specific areas in disaster prone regions. Such works include construction of cyclone shelters, coastal embankments that help to protect coastal landforms from inundation by tidal waves and storm surges. Non-engineered structures are constructed by the local people with the help of local artisans and use locally available raw materials. These structures are considered safer, low of cost and resilient to disasters.

- **Non-structural approach:** Non-structural measures include those actions that are helpful in mitigating disasters by coordinating the effeors of various departments in ensuing the management processes like training of the locals, educating people and community at large, developing insurance schemes, improving the warning system and preparing action plans.

7.10 Strategies of Mitigation Systems for Disasters in India

The stragegies adopted by the Government of India for mitigating disasters are also divided into two sections namely structural strategies and non-structural stragegies. Each strategy shall be discussed below briefly.

Structural strategies: The following are the structural strategies adopted by Government of India for mitigating disasters in India.

a) **Flood Mitigation:** Flood mitigation measures have been in practice since the 1950s, however in order to make it more resilient and effective the Ministry of Home Affairs has initiated measures such as drawing up mitigation plans at the state, district, block and village levels, training the elected representatives and officials for flood management.

b) **Earthquake Risk Mitigation:** For earthquake risk mitigation a comprehensive programme by incorporating the Bureau of Indian Standard (BIS) Codes for maintaining proper building regulations in both the Town and Country Planning Acts of the earthquake prone states of India. An Expert Committee has been appointed by the National Core Group for Earthquake Risk Mitigation, who has submitted a report on the Land-use Zoning Regulation, Development Control Regulations and Building Bye laws to be implemented for the safety aspects in all new constructions and upgrading the strength of existing structurally vulnerable constructions,

c) **Set up Hazard Safety Cells in States:** All the states of India have been advised to constructions and ensure safety on buildings and structures from various hazards.

d) **Reconstruction of Lifeline Buildings:** The reconstruction of lifeline buildings located in seismically vulnerable areas has been entrusted to The Ministries of Civil Aviation, Railways, Telecommunications, Power, Health and Family Welfare and have been advised to comply with BIS norms.

e) **Conventional Mitigations in Rural Development Schemes:** The Ministry of Rural development under the Indira Awaas Yojona (IAY), Sampooran

Grameen Rojgar Yojna (SGRY) are entrusted with the following works like construction of compact housing units, community assets building in form of community centres, recreation centres, anganwadi centres to ensure that the buildings constructed under this scheme are disaster-resistant.

g) **National Cyclone Mitigation Project:** This project is drawn up to plan for mitigation strategies particularly relevant for cyclone-prone states and the plan envisages construction of cyclone shelters, coastal shelter belt plantation or protecting the existing mangrove vegetation, strengthening of warning systems etc.

h) **Landslide Hazard Mitigation:** A National Group has been formed under the Chairmanship of Secretary, Border Management, with the collaboration of Department of Science and Techonology, Road Transport and Highways, Geological Survey of India, National Remote Sensing Agency, to inspect several aspects of landslide mitigation practices.

➢ **Non-Structural Strategies:** The following are the non-structural or non constructional strategies towards disaster mitigation as has been adopted by government of India.

a) **Human Resource Development:** Human resource development is critical for proper management of disasters. The National Centre for Disaster Management (NCDM) at the national level has been disignated as the National Institute of Disaster Management (NIDM) and entrusted with the task of developing training modules at different levels, undertaking training, organising training programmes, developing national level information base on disaster management policies, prevention mechanism and mitigation measures.

b) **Capacity Building of Engineers and Architects for Mitigating Earthquakes:** Seven National Resource Institutions have been designated as National Resource Institutions for imparting traning to faculty of select State Engineering and Architecture colleges. A programme to assist the state union territories in training and certification of rural masons has been formulated in consultation with Housing and Urban Development Corporation (HUDCO) and the Ministry or Rural Development, The curriculum in the vocational training programme of Ministry of Human Resource Development has also been started.The Central Board of Secondary Education (CBSE) is working towards inclusion of Disaster Management in school education in all 39 school boards in the country.

7.11 Institutional Set up : NDMA and NIDM

The National Disaster Management Agency (NDMA) is an organization that was set up with the vision of disaster mitigation and preventing hazards from turning into disasters in India by the Disaster Management Act in 2005. The Prime Minister of India serves as the chairman of the National Disaster Management Authority (NDMA) in India. In 2005, the Disaster Management Act established the NDMA, as well as the organization. India's vision in disaster management focuses on prevention, mitigation, and preparedness.

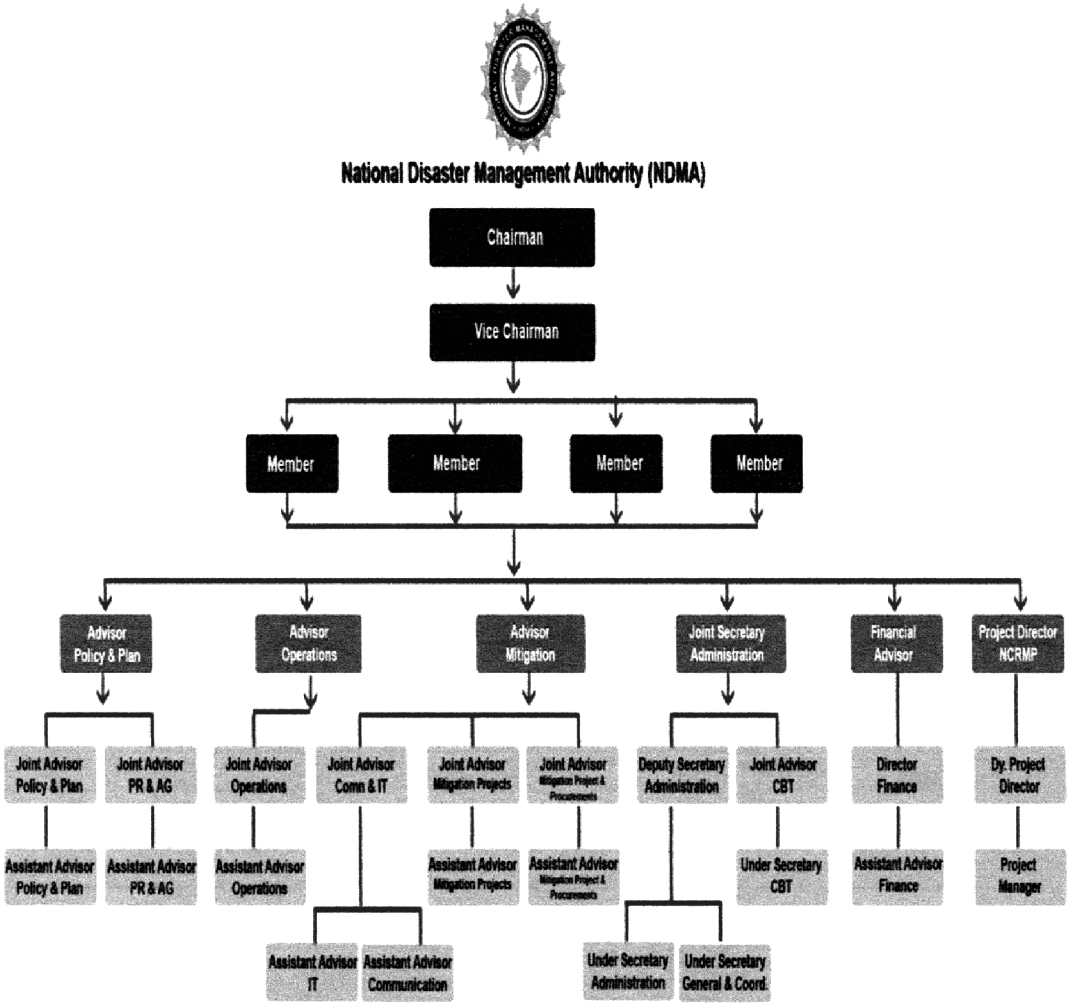


Fig. 7.11.1

The government of India promotes disaster management with the national determination of practicing mitigation by preventing damage and destruction caused by natural and man-made disasters. The government focuses on combining efforts with all Government Agencies, Non-Governmental Organizations (NGOs) and the people's participation. India plans on achieving this by adopting a technology-driven, pro-active, multi hazard, and multi-sectoral strategy, which in turn will create a disaster resilient country. The Vision of the NDMA is "To build a safer and disaster resilient India by a holistic, pro-active, techonology driven and sustainable development strategy that involves all stakeholders and fosters a culture of prevention, preparedness and mitigation." The NDMA is responsible for the policies, plans, and guidelines, as well as to ensure timely and effective response to disasters. Therefore, it has the following responsibilities:

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

7.12 NIDM

The National Institute of Disaster Management (NIDM) under the Ministry of Home Affairs, Government of India, is a primate institute of national level training and capacity developement programmes for managing natural and anthropogenic disasters in India. In the International decade for Natural Disaster Reduction (IDNDR), a National Centre for Disaster Management was established in 1995 by the National Disaster Management Act for managing disaster in the country. The Centre was later upgraded as the National Institute of Disaster management (NIDM) on 6th October 2003, following the transfer of the subject of disaster management to the Ministry of Home Affairs. The Institute was inauguratred by Hon'ble Union Home Minister on 11th August, 2004. The Institute has achived the status of a statutory organization under the National Disaster Management Act 2005, Section 42(8) and is responsible for planning and promoting traning 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.

Objectives of NIDM

NIDM's primary objective is to work as a 'think tank' for the government for providing policy advice and facilitating capacity building services including strategic learning, research, traning, system development and expertise promotion for effective disaster preparedness and mitigation. Other visions enlisted are:

1. As a premier institute of excellence for training and research in disaster risk mitigation and management in the national level it has to strive for getting recognition as one of the leading institutions at the international level in this field.
2. It must strive persistently towards making a disaster free India by developing and promoting a Culture of Prevention and Preparedness at all levels.
3. To facilitate in reducing the impact of disasters through:
    a. Planing and promoting training and capacity building services including strategic learning.
    b. Research, documentation and development of national level information base.

c. System development and expertise promotion for effective disaster preparedness and mitigation.

d. Promoting awareness and enhancing knowledge and skills of all stakeholders.

e. Strengthening institutional mechanisms for training and capacity bulding of all stakeholders.

f. Networking and facilitating exchange of information, experience and expertise.

The following specific functions are enlisted in the Section 42(9) of the Act of the institute:

a. Develop training modules, undertake research and documentation in disaster management and organize training programmes;

b. Formulate and inplement a comprehensive human resource development plan covering all aspects of disaster management;

c. Provide assistance in national level policy formulation;

d. Provide required assistance to the training and research institutes for development of training and research programmes for stakeholders including Government functionaries and undertake training of faculty members of the State level training institutes;

e. Provide assistance to the State Governments and State training institutes in the formulation of State level policies, strategies, disaster management framework and any other assistance as may be required by the State Governments or State training institutes for capacity-building of stakeholders, Government including its functionaries, civil society members, corporate sector and people's elected representatives;

f. Develop educational meterials for disaster management including academic and professional courses;

g. Promote awareness among stakeholders including college or school teachers and students, technical personnel and others associated with multihazard mitigation, preparedness and response measures;

h. Undertake, organize and facilitate study courses, conferences, lectures, seminars within and outside the country to promote the aforesaid objects;

i. Undertake and provide for publication of journals, research papers and books and establish and maintain libraries in furtherance of the afoiresaid objects;

j. Do all such other lawful things as are conductive or incidental to the attainment of the above objects; and

k. Undertake any other function as may be assigned to it by the Central Government.

STRATEGIC PLAN

To build a national hub to share and learn and to create a critical mass of institutions, trainers and trained professionals.

- To undertake quality research covering both natural and human induced disasters, with a multi-hazard approach
- To work as a National Resource Center for the central and state governments in the country through effective knowledge management and sharing of best practices
- To professionalize disaster risk reduction and emergency management in India and other neighboring countries by developing an independent cadre of professionally trained emergency and mitigation managers.
- To promote formal training and education for disaster management in India and in the region
- To build working partnerships with the Government, Universities, NGOs, eminence.
- To link learning and action by building a synergy between institutions and professionnals in the sector.

Organisation Structure of NIDM

Union Home Minister is the President of the Institute and Vice Chairman of the NDMA is its Vice President. Besides the Institute body comprises of 42 Members, which include Secretaries of various nodal Ministries and Departments of Government of India and State Governments and heads of national levels scientific, research and technical organizations, besides eminent scholars, scientists and practitioners.

The Institute has a Governing Body of 14 members chaired by Vice Chairman of National Disaster Management Authority. Union Home Secretary is the Vice Chairman of the Governing Body of the Institute.

The Institute has five Divisions besides a Training Cell. Executive Director of the Institute who is also the Members Secretary of the Institute and its Governing Body runs the day to day administration of the Institute. (Ref diagram below)

Administrative Structure of NIDM

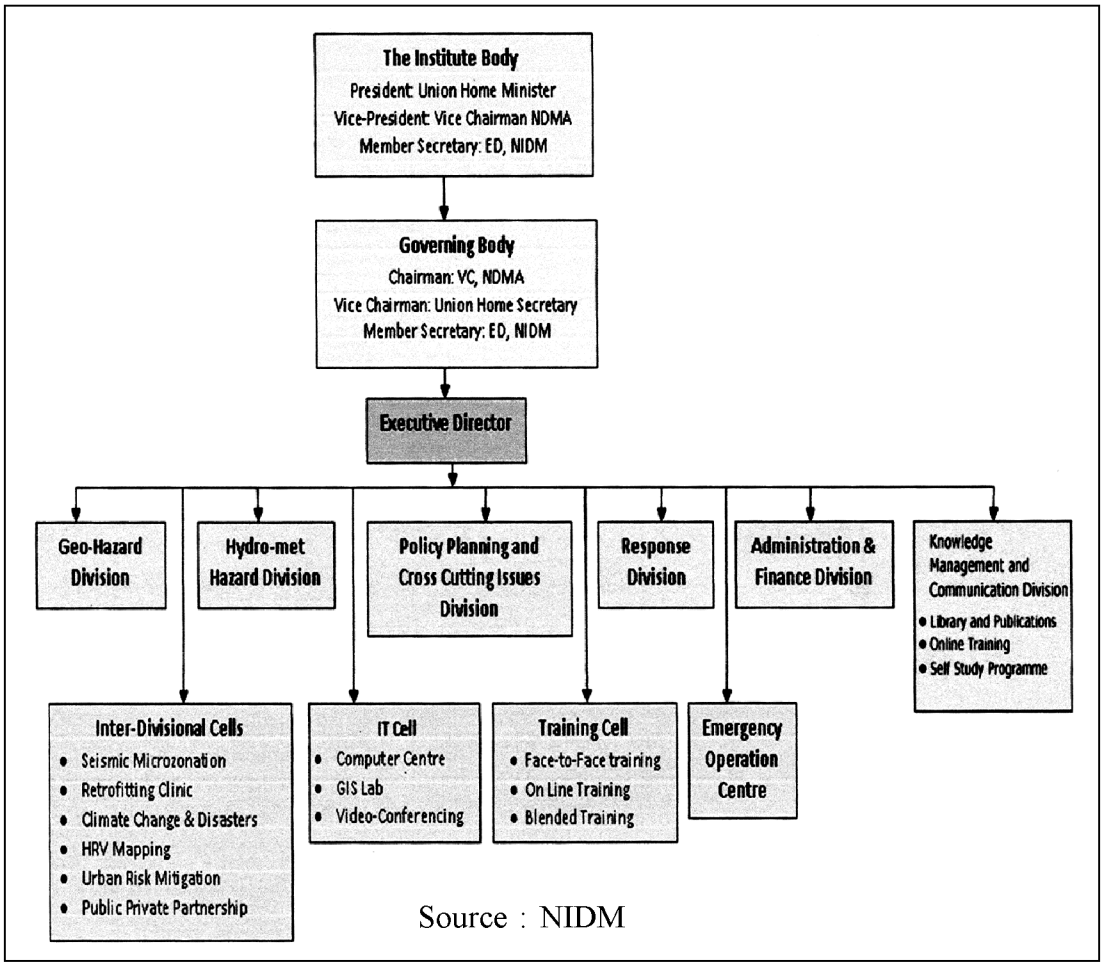


Fig. 7.12.1

Thus the above sections explain the strategies adopted for disaster response and mitigation in India along with the description of NDMA and NIDM the two wings created by the government for the proper execution of the disaster management policies and implementation of the various programmes.

7.13 Summary

A detailed discussion of disaster response and mitigation concepts, mechanisms as well as strategies were made from which it is clearly understood that all disasters can be fought back provided we have enough knowledge to combat it. It is also understood that disasters can only be tried to mitigate but there is no way of completely abolishing it. So mitigation plans must be enumerated properly for potential hazards or disasters. A clear idea about the formation of NDMA and NIDM along with their functions, goals and objectives have also given a vivid knowledge of the two organizations and their functions.

7.14 Glossary and Keywords

1. **Building Code:** A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, meterials, alteration and occupancy of structures that are necessary to ensure human safety and welfare, including resistance to collapse and damage.
2. **Structural Measures:** Any physical construction to reduce or aviod possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems.
3. **Non-structureal Mesures:** Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education.
4. **Recovery:** The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.
5. **Emergency Management:** The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps.

7.15 Assessment Questions

1. What do you understand by response to disasters? Identify the various phases of disaster response in India.

2. What are the various types of disaster mitigations? Discuss the structural and non-structural strategies of disaster mitigation.
3. What are the characteristics of disaster response system? Explain the structure or response systems for disasters in India.
4. What is NDMA? Discuss the organizational structure of NDMA
5. What is NIDM? Explain the objectives and strategic plans of NIDM.

7.16 Further Readings

1. McEntire A David, 2015: Disaster Response and Recovery: Strategies and Tactics for Resilience, second edition, published by John Wiley and Sons, New Jersy Canada.
2. Kapur A, et. al (2005) Disasters in India: Studies of Graim Reality, Rawat Publication, New Delhi.
3. Kumar, K.J.A, Walia, A and Chaturvedi, S, 2012: India Disaster Report, National Institute of Disaster Management (NIDM), June 2012
4. Govt of India, MHA 2009: National Policy of Disaster Management, 2009, National Disaster Management Authority (NDMA)
5. Govt of India, MHA, Disaster Management Division 2010: Standard Operating Procedure for Response to Natural Disasters.
6. Dhameja Pardeep, Sahani Pardeep, Dhameja Alka, Meduri Uma, (2004), Disaster Mitigation: Experiences and Reflections, published by PHI; New title edition
7. Singh B.K (2008), Handbook of Disaster Management: Techniques and Guidelines, Published by Rajat Publications.

Unit-8 □ Indigenous Knowledge and Community based Disaster Management: Do's and Don't's During and Post Disasters

Content Structure

8.1 Learning Objective

Indigenous knowledge is the basis of various communities to cope up and survive from disasters and natural calamities over centuries. The Asia Pacific region is particularly rich in such bodies of knowledge. It is noted from the time of ancient civilizations that frequent disasters of multi hazard categories affected diverse, large and vulnerable geo-cultural communities who depended on scarce resources to deal with such hazards and were bound to have led to the evolution of very low cost ways of combating disasters known as indigenous knowledge. Community based disaster management techniques grew as indigenous knowledge encouraged community participation and empowered communities fo fight reducing disaster risk together. The chapter below would explain all such indigenous knowledge that existed from ancient days and how it led to the community based disaster management grow as an effective tool for reducing disasters.

8.2 Introduction

Indigenous knowledge has emerged as a significant resource in dealing with many research on development issues and combating disasters. Indigenous knowledge has been traditionally regarded as inferior to science and technology, as it has negatively affected the developmental processes of local communities at large. The term "indigenous knowledge" were found in the literature referred to as folk, local, rural people's, indigenous technical, and traditional enviromental knowledge.

Indigenous Knowledge has been used by many communities around the world from the past few centuries, as a mechanism to survive natural calamities. There are several stories related to how the indigenous people coped with the major disasters, and used indigenous ways to protect lives and property. According to the United Nations International Strategy for Disaster Reduction (UNISDR) (2008), after the 2004 Indian Ocean Tsunami, two success stories emerged, bringing new interest to the concept of indigenous Knowledge. The two stories were of the Simeulueans living off the coast of Sumatra, Indonesia and the Moken, living in the Surin Islands off the coast of Thailand and Myanmar. Both the stories expressed how the local communities survived the devastating tsunami, using the indegenous knowledge passed on orally.

Indigenous knowledge therefore refers to the methods and practices developed by a group of people from an advanced understanding of the local environment, which has been passed on for numerous generations of habitation. The knowledge is differentiated from other types of knowledge and is characterized by a community understanding, maintaining a non-formal means of dissemination, collectively owned, imbedded in a community's way of life, developed over several generations and subject to adaptation as a means of survival.

8.3 Relation between Indigenous Knowledge and Natural Disaster Management

The relationship between indigenous knowledge and natural disasters has gained more interest in recent years highlighting its potential to improve disaster risk reduction through integration of policies into disaster risk education and revamp the early warning systems. The value of indigenous knowledge in disaster management can be explained by the following relation between them and assessing its significance:

Firstly, a specific knowledge of adapting and coping of a disaster by an indigenous community could be transferred to other communities in similar situations and save them from the wreck of a disaster.

Secondly, incorporating indigenous knowledge in the existing practices and policies motivate the indigenous community to share their knowledge and play the leading role in all disaster risk reduction activities.

Thirdly, Disaster management policies often lack information in the local context. The indigenous knowledge can therefore help to improve project implementation by providing valuable information about the local context.

Finally, a successful model for education on disaster risk reduction can be done with the non-formal means by which indigenous knowledge is disseminated.

Several studies on the role of indigenous communities in disaster management have been made so far. According to Kamara (2005), studies in Kenya shows that how the traditional knowledge is used in evironmental conservation and natural disaster management. Example of such practices were such that storm routes and wind patterns were designed for disaster management long in advance, by constructing shelters, such as wind-break structures, walls, and homestead fences appropriately. Similarly, practice was noted on the knowledge of local rain corridors enabling them to prepare for storms. The colour of clouds many indicate that they carry hailstorms and make them aware of an approaching strom so that people run for cover. Knowing that prolonged drought is followed by storm, thunder and lightning during the first few rains enables people to prepare for and to expect a disaster. A change in birds cries of the oneset of their mating period can also indicate a change of season and indicate and approaching hazard.

Knowledge of indigenous methods for disaster management was found to be prevalent in Swaziland. The knowledge included prediction techniques such as Floods could be forecasted from the height of birds 'nests' near rivers, increase in numbers of Moths before a drought, change in the position of the sun and the cry of a specific bird on trees near rivers for predicting the onset of the rainy season for farmers. Dekens (2007:3) supported that indigenous knowledge of communities should be integrated with the present techniques for building a successful model for education on disaster risk reduction. According to him since the 1970s, a growing body of literature has highlighted the inportance of integrating local knowledge and practices into development and conservation projects. Mwaura (2008:4) has put forward that the global scientific community already has acknowledged and endrosed the relevance of Indigenous knowledge at the World Conference of Science in Budapest, Hungary in 1999. The conference recommended that scientific and traditional knowledge should be integrated, particularly in the field of environmental development. In 1999, the World Conference on Science assembled under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO) with the International Council on Science (ICSU) to advocate the

understanding of Indigenous Knowledge Systems (Battiste, 2002:8). The conference participants requested all the sciences to respect, sustain, and enhance traditional knowledge systems and they recommended that scientific and traditional knowledge should be integrated, dealing with links between culture, environment, and development.

8.4 Characteristics of Indigenous Knowledge

According to De Guchteneire *et al.* (2004:6), Indigenous Knowledge has been characterized as following

- It is developed within communities;
- It is orally disseminated in nature;
- It is not systematically documented;
- It is location and culture specific;
- It forms the basis for dicision-making on survival strategies;
- It is concerned with the critical issues of human and animal life;
- It is dynamic in nature and based on inovation, adaptation, and experimentation

8.5 Initiatives that have shaped Indigenous knowledge

International initiatives that shaped Indigenous Knowledge : International initiative in documentation of Indigenous Knowledge was recognized in the Universal Declaration of Human Rights, the Convention Biological Diversity, the Draft United Nations Declaration on the Rights of Indigenous Peoples, the International Labour Organisation Convention No. 168 and the International Covenant on Economic, Social and Cultural Rights. In 1992, the United Nations conference on Environment and Development, the Rio Declaration and Agenda 21 both made reference to Indigenous Knowledge and emphasized the need for governments to preserve and maintain the knowledge. The World Bank also ensured that indigenous knowledge is promoted and recognized. So it launched the indigenous knowledge for Development Programme in 1998. The World Bank also developed a database of Indigenous Knowledge and a multi-lingual website with monthly publication dedicated to sharing and promoting Indigenous Knowledge engagement in development.

In 1995 the United Nations initiated a second International Decade of the World's Indigenous Peoples to strengthen International Commitment and co-operation to find solutions to the issues faced by indigenous peoples. The importance of Indigenous Knoledge was also recognized in the field of sustainable development. In

2002, the World Summit on Sustainable Development noted the importance of Indigenous Knowledge for sustainablity. It also recognized the importance of the relationship between Indigenous knowledge and sustainable development with other fields, like natural disaster mitigation, poverty eradication, climate change, agriculture, mountain ecosystems, biodiversity, forests, health, Africa, and science and technology.

2) Indian initiatives that have shaped Indigenous Knowledge:

The use of indigenous knowledge for disaster risk management activities have received responses from members of Disaster Risk Management Asia Community, Solution Enchange for Disaster Management Community India and Indonesia. Members outlined various traditional practices for early warning and other disaster management activities. In **India**, Orissa, some very interesting practices were found for wealther forecasting and disaster warning. Tribes like Munda, Kondha, Saura, Kolha have been found to have their own way of preserving nature and coping with catastrophes, In Tamil Nadu farmers protect crops from floods, by using flood resistant paddy seed along with indigenous communities from Orissa and Andhra Pradesh practice shifting cultivation and grow drought resistant tuber crops which follow a cycle providing enough space for cosnervation. The traditional warning signals followed by the indigenous people for anticipating hazards were as follows:

Land slide: New cracks or unusual bulges on the ground or street pavements are recorded. Rapid increase in stream water levels; Sticking doors and windows and sudden decrease in stream water levels in rainy seasons are a few signals that make them aware of an upcoming natural calamity.

Earthquake: A particular variety of fish (Singhi) behaves differently and comes to the top of the water level just before an earthquake.

Tornado: Sudden change in the colour of sky also makes people aware of an approaching storm.

Some interesting observations were made when incorporating traditional knowledge into scientific framework for disaster management. Some studies from India stated that as communities were dependent on natural resources and closer to nature, they understood natural phenomenon's very well and so they used traditional knowledge to manage and cope with disasters. Examples could be drawn across several countries, having wooden **buildings** and houses in hilly areas; netted/tied/ mushroom shaped roofs in coastal belts and use of bamboo poles as pillars in mud houses. Cohesive communities or tribal communities with strong traditional governance mechanisms have been found to have evolved their ownindigenous methods. In a

tribal community in Tamil Nadu they have developed an indigenous system of prediction for early warning of tsunamis and earthquakes, tracking floods, and follow typical rescue and rehabilitation methods. The traditional technologies are of three types and they are classified into the following three categories:

a) Implementation Oriented Technologies (IOT),

b) Process Technologies (PT) and

c) Transferable Indigenous Knowledge (TIK).

In the recent times communities having traditional skills and knowledge are gradually loosing effectiveness due to high incidences of disasters and increased multi-level vulenerability of communities. Traditional skills are found to be not adapted and practiced adequately. Every region has its own special characteristic, social regulations and techniques to cope with emergencies. So following one disaster management scheme for all regions would prove to be fatal. Thus the importance of blending indigenous knowledge and modern techniques would be the best possible way to combat disasters.

8.6 Limitations of Indigenous Knowledge:

The main challenges faced by indigenous knowledge are indentified as follows:

- **Marginalization:** Marginalization refers to the belief that Indigenous knowledge is primitive and old-fashioned, and therefore has no value.
- **Un systematic transmission:** Indigenous knowledge is not captured and stored in a systematic way as it is handed over to the next generation by oral transmission which over several generations may detach some vital elements from it and remain as a mere story.
- **Lack of spiritual attachment:** Over reliance on oral transmission of knowledge downplayed the indigenous concepts of god, ancestors, totems and ritualistic practices due to foreign religious influences, thereby affecting their spiritual attachment with environmental resources.
- **Threat of extinction:** Indigenous Knowledge is faced by the challenge of disappering because of the failure to record it, and because of problems associated with preservation and protection of such knowledge.
- **Management of Indigenous Knowledge:** The main problems with the management of Indigenous Knowledge are the methods of identifying it,

access it, the intellectual property rights, the media and format in which it is to be preserved.

- **Reconciliation of Indigenous Knowledge and Western Knowledge:** The major threats to Indigenous Knowledge is how to reconcile it with modern science, without one substituting the other, thereby respecting both of the two sets of values, and building on their respective strengths.

8.7 Community Based Disasters Management

Community based disaster management (CBDM) is a democratic concept used to translate the disaster management strategies from response oriented into implementing strategies of prevention and mitigation for having a desired impact on the ground. To implement this holistic approach and make CBDM work properly it is important for intervention and coordination of all the three key areas such as *Cooperation and Capacity Building, Sustainability and Upscaling* and *Integration of Policy Issues* at the base level. Following the sustainable development goals to develop a disaster resilient community from increasing trend of disaster world wide it is necessary to equip disaster management with necessary elements such as community participation for overcoming the regional disaster with local knowledge and response.

Definition of CBDM:

A condition whereby a community systematically manages its disaster risk reduction measures towards becoming a safer and resilient community. Facilitating CBDM is the how 'to-process' of the community to get to the CBDM state. It is sometimes done along with external actors.

How does it work?

It is through this community based activities that local people are found to participate along with government officials and expert groups to combat disasters. The main idea was to address the problem of the stakeholders by the stakeholders with outside help. The participation of the local community was to discuss issues at the grass root level and take people's involvement into policy making and strategy farming. As this involvement ensures a sense of responsibility and ownership of the part of the local communities they take extra care and initiative to engage themselves into this activity on a continuous basis with long term commitment. This involvement

is important in all the three stages of disaster management that is the pre disaster stage, during a disaster stage and post disaster stage.

The concept of CBDM came from the fact that following a disaster whether major or minor, the worst hit sufferers are the community people residing at that place. So in case of policy implementation if they are involved then it's a two ways benefit approach as they are the people who if involved are the ones to gain by reducing the impact of disasters on one hand and can address the problems as they are the victims. Thus it is to ensure that the community people are given more control and acces to basic resources and civic services.

8.8 Characteristics of CBDM

- Local people and community at large to plan, implement and manage disasters.
- Intervention and dependence should be on local resources, capacities and partnerships.
- All decisions are to be taken by the community
- Programs should focus on developing local capacities
- Disaster preparedness should be based on sustainable development perspective
- Attention to be given to vulnerable communities and ensure their development

CBDM by its very nature demands a decentralized bottoms-up approach with intensive, micro interventions at the local Panchyats, ward or village level with the intention of generating confidence, awareness, knowledge, partnership and ownership for planning and rolling out local disaster management plans encompassing all levels of disaster management continuum. In tune with capacity building CBDM should collaborate with the existing mainstream, institutional mechanisms and social welfare delivery programs to make it holistic, cost effective, multi-dimensional and community centric. The 72nd and 73rd amendments of the constitution emphasized that powers should be devolved and distributed among the Panchayat Raj institution and municipalities to work as self governments and work towards a common goal. The community based organizations shall work in partnership with local authorities of states and union territories. The elected representatives of these local bodies are the key stakeholders through whom effective paticipation and ownership by local communities can be achieved in CBDM.

The CBDM farmework of action follows the steps such as:

a) **Community at-risk of disasters:** This refers to the direct involvement of victims in organizing and making efforts to mitigate disasters.

Frameworks for Implementation of CBDM

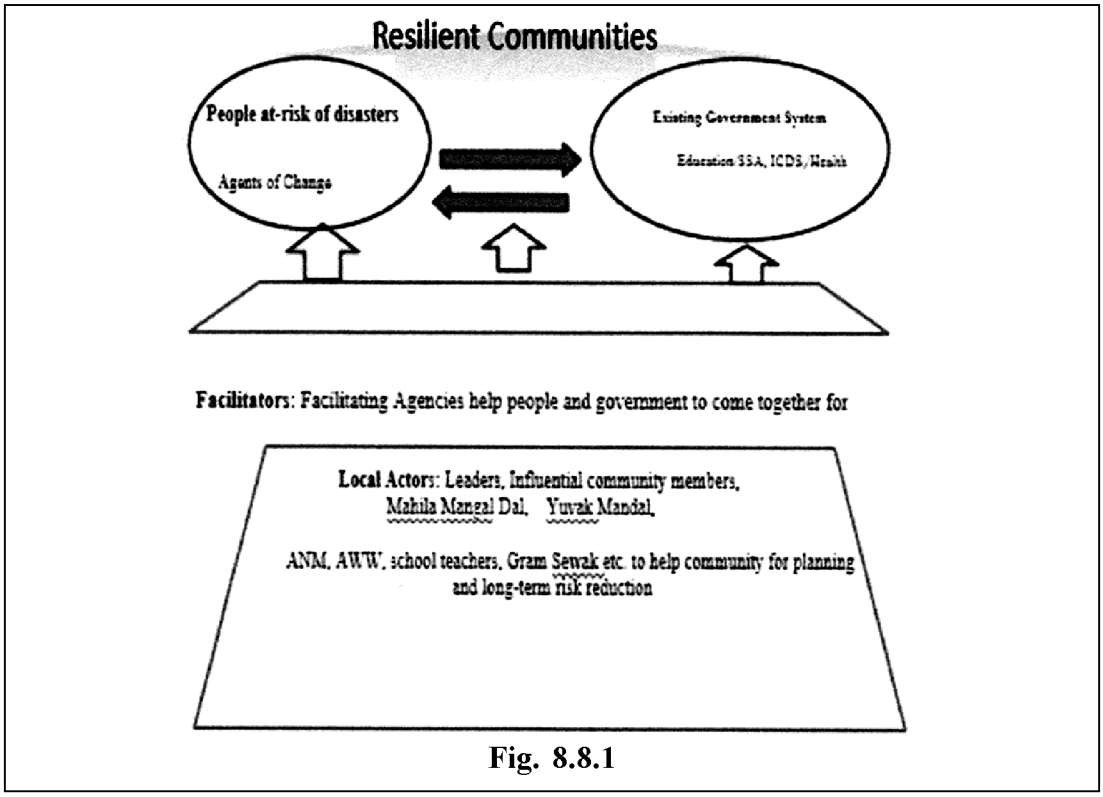


Fig. 8.8.1

b) **Existing Institutions:** The existing government schemes and systems (e.g. ICDS,SSA, PWD) are there to set mandates and provide lifeline services to each and every village through flagship schemes and other development programs by Central and State Governments.

c) **Facilitators:** Organizations or individuals who help to run various systems along with agents work together to build a weaving patterns of processes to bring everything together under the facilitators. Few successful experiences and demonstrative models of CBDM by State Governments, Local Administration and NGOs have indicated the relevance and importance of facilitators in CBDM approach.

d) Local Actors: A number of local actors like community based organizations, ward committees, municipality officials, school & college teachers, students, SHG Members, Yuva members, local level governmental functionaries like ANM, AWW, ASHA etc are found to create awareness and support for the smooth implementation of the programs. They all play a significant role in CBDM.

8.9 Principles of CBDM Programming and Implementation Process

a) Multi stakeholders" Participation: A community with all its social strata is at the helm of the CBDM process and **community participataion** is the key for any CBDM intervention. Thus, when the process for CBDM is undertaken it is important that social equity and social inclusion approaches are adhered to. The participation of other stakeholders in the area like NGOs/CBOs/ community leaders, traders, line departments, elected representatives, banks, etc. are also ensured.

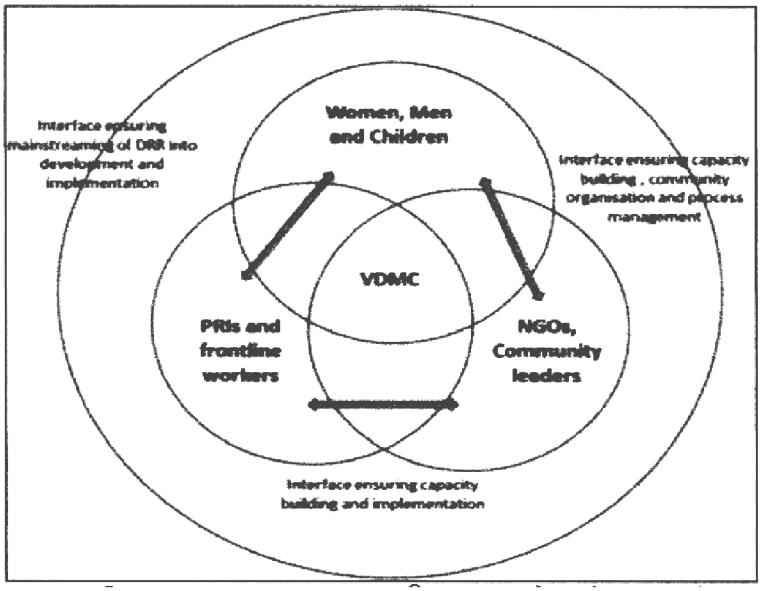


Fig. 8.9.1 : CBDM Programming & Functions

b) **Participatory Approach with community as lead:** A participatory approach is worked out for participatory learning and voluntary action for "risk aware disaster and development planning" through the coordination of various stakeholders from community to PRIs. These levels of participation are participant, concerned citizen, actor and leader. These levels of participation are dynamic in nature and for managing this dynamism a facilitator is brought in.

c) **Involvement of informed facilitators:** An informed facilitator is very helpful in bringing all the stakeholders to a platform and helps them to work in a coordinated manner to achieve the larger goal.

d) **Time and Resource budgeting:** Any work process to be concluded efficiently within a given time frame needs to allocate its resources (human, physical and financial) properly for achieving the desired result. CBDM processes are not just steps but a process of change (attitude, behavioral and capacity) for enhancing resilience of the community. It requires long term commitment by the community as its impact is not visible in terms of economic returns.

e) **Forum for convergence:** Convergence of government schemes and programs at the national and state levels is extremely important for community disaster management. Programs like poverty alleviation, school education and nutrition, mental and child health, drinking water and sanitation programs etc., if implemented properly, can go a long way in empowering communities. These programs must have common points like community mobilization and awareness generation.

f) **Inclusive Approach:** The special needs of women, physically and mentally challenged and socially disadvantaged are needed to be focused particularly after a disaster situation. Therefore, it is necessary for mandatory provision of membership to include women and other disadvantaged groups in various resource groups/ working groups / standing committees to adequately voice their concerns and plan for inclusive DM interventions.

8.10 The Do's and Don'ts for the community 'During' and 'After' a Disaster

Phase I: Early warning

During Disaster	Post Disaster
• It is the duty of the warning team to warn the local vulnerable people to put up red flags on those houses which are required to be evacuated immediately after the warning. • The team should inform the community about the velocity/ movement/direction of the upcoming threat so that people can be evacuated as quickly as possible. Beating drums or blowing "conch" shells would be beneficial to make people aware of the threat. • Keep abreast of news following radio, television or social media. • Any kind of panic should be addressed at its root and stop it from being transmitted further. • Communication through Public Awareness system available with the religious groups or academic institutes or places of worship and social workers could play a very effective role in dissemination of warnings and instructions on evacuation.	• The team, before informing the community regarding weakening of the disaster, should confirm the news from the Block Control Room/PS/ Tahsildar and act accordingly. • Villagers or the victims of towns should be taught the steps they need to take aftermath of a disaster. • Inform Block or Gram Panchayats Control-room Coordination with other teams like shelter and rescue teams to help the community for rehabilitation.

Phase II: Early warning

During Disaster	Post Disaster
• Warnings should be given well in advance to prevent the fisherman and farmers to venture outside during emergency • Help the vulnerable people to get rid of unnecessary baggage and take shelters in their respective places with minimum important belongings • The team should rush to the disaster affected spot and take a note of the casualty informed and take help of the First Aid team if necessary. • Arrange for shifting of acute cases to the nearest Primary Health Care. • Evacuees should be advised to maintain peace and sanitation during stay in the shelters. • Discipline should be ensured during evacuation. • Finding out missing persons within the community is another task.	• Vehicles or boats should be arranged to shift acute cases to the nearest hospital • Roads should be cleaned and garbage free in order to establish proper transportation and movement of casualties. • Help the people to go back to their home. • Contact outside agencies who would like to help the needy • Coordinate with other task force group.

Phase III: Rescue or Shelter Management:

During Disaster	Post Disaster
• People sheltered in disaster camps should be provided with all the basic necessities of life at least for three days at a stretch • It is important to register the names of the evacuees to check on the missing people and inform the Search and Rescue Team immediately	• Provide all kinds of support to the people till they safely go back to their home and start resuming a normal life. • Arrange for and collect relief items from various sources to maintain a buffer stock. • Maintain cleanliness inside and outside the shelter

During Disaster	Post Disaster
• Pregnant women and other disabled persons should be taken special care of. • Health and hygiene should be ensured around the camps. • Foodstuff retained by the evacuees should be first used and then after food from the relief camp should be utilised. Emphasis to be given on the use of safe drinking water. • Pace should be enforced in every camp so as to check spreading of rumors. • Every camp should be provided with a transistor radio to keep abreast of the current situation and the possible threat to avoid confusions.	• Make necessary arrangements to have community kitchen. • Coordinate with other teams and submit an expenditure report to authority.

Phase IV: First Aid:

During Disaster	Post Disaster
• Steps should be immediately taken to address the sick and injured first and then try to shift the victims to the nearest Primary Health Care before it is too late. • Rescue team should be accompanied by enough people for getting the victims and the sick safely to the shelter • Make special arrangements for the pregnant women and the disabled. • Assure the community not be panicked and maintain discipline in the shelter.	• Try to reach the spot immediately to save life of victim and make proper arrangement to shift the patient to Primary Health Care or Government Hospital. • Support any governmental or external organizations such as NGO's to interfere regarding serious cases. • Stop the spread of any kind of epidemic inside the community. If noticed, inform Block or Primary Health Care immediately with accurate information regarding the number and symptoms of the patient.

Phase V: Relief: Food, Water and Sanitation

During Disaster	Post Disaster
• Store required amount of relief materials in the specified shelters. • Make individual family card for the evacuees to distribute dry food or rations properly • Distribute the food stuff and proper care should be taken to see that no individual is left out. • The team member should inform the leader if any item is falling short or required more • Maintain discipline and help governmental/ non govermental organizations to distribute relief without any hassle. • Ensure proper sanitation near shelters. • Arrange and ensure evacuees take boiled or purfied water for drinking. • Demonstrate how to use chlorine/ halogen tablets for drinking water • Use disinfectants in the wells/tube wells. Ensure that the water reserved by shelter management team is safe enough tu use.	• Mobilize governmental or non-govermental relief and help them to make proper distribution • Keep update beneficiary list and forward the external relief to the victims. • Ensure that the Damage Assessment Team make proper enumeration and submit it as quickly as possinle to the diffferent organizations to render timely relief to the victims • Arrange food and other assistance for the people who need more support from the community • Take adequate measures not to allow spread of epidemic inside the community. Help Rescue Team to clean grabage. • Keep the sewerage system clean.

Phase VI: Damage Assessment:

Post Disaster
• Check and update all the lists of beneficiaries • Prepare an authentic list of all the dead and deceased, domestic animals, houses, boats, family belongings, community infrastructures, trees, livelihood assets. • Support the Government functionaries to assess the damage • Inform NGOs and other Charitable Organizations to carry out rehabilitation programs • Help the families to get compensation without any hassle.

Phase VII: Carcass Disposal:

Post Disaster
• Collect and Identify dead bodies. Then they must be cremated with the knowledge of the owner of the domestic animal • Record the number of the insured animal. • In case of human dead bodies, it is advised to keep record/photograph before cremating, the team should inform family members. • Sprinkle bleaching powder on the areas/spot where the dead bodies were found.

Thus the role of community plays a vital role in dealing with any kind of disasters. It is the community who is found to be affected by the disasters and it is these people who are available for help and it is their help that matters the most for preventing huge loss of life and property. So CBDM has been highlighted as the most important factor for bringing resilience to communities.

8.11 Summary

A detailed and a thorough discussion has been made on the development of Community based disaster management programme and how the concept had grown from the idea of indigenous knowledge of disasters to the community system management.

8.12 Keywords/Glossary

1. **Beneficiary:** A person who derives help of advantage from something, especially a trust, will, organization or life insurance policy.

2. **Rehabilitation:** The action of restoring someone or something to its former condition through reconstruction or training and therapy.
3. **Carcass Disposal:** Dumping or discarding dead animals of human body
4. **Relief:** Financial or physical assistance given to those in need of it
5. **Marginalization:** Peripheral treatment of a person or a group that is insignificant.
6. **Extinction:** Eradication of a thing or specie of threat.

8.13 Assessment questions

1. What do you mean by indigenous knowledge? What is the relation between indigenous knowledge and natural disaster management?
2. What are the characteristics of indigenous knowledge? Discuss the advantages and disadvantages of the indigenous knowledge in disaster management.
3. Define community based disaster management. Explain the characteristics and principles of CBDM.
4. What are the Do's and Don't's of a community during a disaster?

8.14 Further Readings

1. Shaw Rajib, (2012), Community Based Disaster Risk Reduction Vol 10, Emerald Group Publishing Limited
2. Shaw Rajib (2009), Indigenous Knowledge and Disaster Risk Reduction from Practice to Policy, Nova Science pub Inc; UK ed. Edition
3. Srivastava. Sanjay, Chakrabarti, Dhar. PG, Shakya. Binod, (2009), Indigenous Knowledge for Disaster Risk Reduction in South Asia, Laxmi Publications.
4. Shaw Rajib, Uy Noralene, and Baumwoll Jennifer Edited (2008), International strategy for disaster reduction, Good Practices and lessons learned from experiences in the Asia Pacific Region.
5. Sharma Anshu, (2009), Indigenous Knowledge and Disastar Risk Reduction: From Practice to Policy, Published by SEEDS, New Delhi).
6. Kumar Amit (2008), Livelihood Adapive Capacity Based Compilation, Gorakhpur Environmental Action Group (GEAG), Lucknow).
7. Panda Abhilasha, (2008), Indigenous Knowledge Disaster Risk Reduction: Policy Note, UNISDR Asia Pacific, Bangkok, Thailand).

Unit-9 □ Emerging Approaches to Disaster Management: (a) Pre Disaster Stage, (b) Emergency Stage (c) Post Disaster Stage

Content Structure

9.1 Learning objective

- The objective of learning the various approaches to disaster management studies helps to understand the various steps in the disaster management and recovery and have a clear concept of the various types of approaches induced in studying the management approaches.

9.2 Introduction

There are debates between physical scientists and social scientists in conceptualizing a 'disaster' as a physical or social phenomenon and in the due course

of study it has been found to transform from the physical perspective and engineering sciences to social, political, cultural and psychological perspectives or sciences. Disasters were defined as natural phenomena and 'Environment' as an element of disaster. Thus hazards are the primary focus in disaster management and technology is the solution to combat disasters. This technology would be developed by the anthropogenic intervention. In 1950's social scientists started conceptualizing disaster as social phenomena. Thus this shift in approaches towards the study of disaster management and paradigm shifts may be discussed at length in the following subsections.

9.3 Emerging approaches in disaster management

The guidelines, provisions and principles laid down by the UN Conference, IDNDR in 1990's, Yokohama Strategy and the post tsunami lessons learnt from the 2004 Tsunami disaster, The Government of India enacted the National Disaster Management Act of 2005 and constituted the National Disaster Management Authority (MDMA) in 23rd December 2005, to deal with the different approaches of disaster management.

Prior to 1990's most of the countries followed rescue and relief measures after a disaster. Disaster Prevention, Mitigation and Preparedness were not in their agenda. Thus they followed a *'Single Phase Approach' of disaster management.* Following this a *'Two Phased Approach' of disaster management* was also initiated keeping in view the different elements of pre disaster stage and the post disaster stage. Soon as per the requirement of the hour a *'Three Phase Approach' of disaster management* was also launched including the pre disaster stage, on disaster stage and post disaster stage. As the world witnessed a rising trend of disaster, soon it was realized that a more comprehensive and holistic approach for managing disasters were required. Thus the modern disaster management method was introduced comprising of a *'Four Phased Approach'* for managing disasters worldwide.

The four phases of the modern day disaster management approach include:

1. Disaster Mitigation
2. Disaster Preparedness
3. Disaster Response
4. Disaster recovery

Apart from these, there are some basic approaches for addressing disasters and managing post disaster crises which can be described as follows:

Descriptive and analytical approach: This phase of a disaster management particularly studies a disaster to determine, describe and analyze its features, general characteristics, and consequences. The entire process involves just describing the phenomenon in order to have a clear picture and sufficient knowledge about it.

Historical approach: This phase studies the historical background of disasters in order to search for the causative factors of a disaster and study its past trends to analyze its re-occurrences.

Systems approach: The entire phase of disaster management is considered as a system with definite inputs and outputs divided into various components of the disaster to combat disaster crisis as a system based on a set of integrated systems each of which has a role in the occurrence of the disaster.

Environmental approach: This approach considers the environmental setting causing a disaster. Factors such as climatic crisis, loss of biodiversity, environmental disbalance surrounding the environment.

Case study approach: This approach involves individual attention to each disaster separately considering its geological, environmental, social and economic setting in terms of time, place and the subject of the crisis.

Comparative studies approach: This phase particularly compares the different disasters to determine the differences among them in a form and structure to allow progress of the management activity,

Integrated studies approach: This approach integrates all the above-mentioned approaches and is based on three perspectives for handling crises arising from disasters and these are: 1) **Deep vision** that explores the root causes of the disasters, its reasons, and motives through the phases of its development, 2) **Wide encompassing vision** of the disaster and analyzing it's extent, 3) **Forecasting vision** that looks forward and is based on forecasting and expectation in terms of subsequent developments besides their risks, size of losses, and costs.

The concept of Disaster management is thus a systematic holistic approach to combat disasters in various phases by integrating the work of different governmental, non -governmental organizations, rescue operators and voluntary organizations in a common frame. A **planned approach** towards disaster management would be divided into the three phases of management namely pre disaster, emergency stage, and post disaster phase for convenience.

- **I) Pre-disaster Phase(Preparedness)**
  - a) Preparing hazard Zoning maps, predictability/forecasting and warning
  - b) Preparing disaster preparedness plan, land zoning
  - c) Preparedness through (IEC) information, education and communication, awareness
- **2) Emergency stage**
  - a) Training in rescue and search operations
  - b) Immediate relief and assessment surveys
- **3) Post Disaster Stage**
  - a) Rehabilitation, political, social and environmental aspects
  - b) Relief measures and
  - c) Recovery from shocks

Each of these stages shall be discussed at length in the following sub section.

9.4 Stages in Disaster Management

9.4.1 Pre-Disaster Phase (Preparedness)

The Pre-disaster phase involves preparedness to face and respond during a disaster on the basis of anticipations made for planning of disaster phase. The steps taken in this phase is to reduce the expected damage from the potential hazard, control mortality by organizing rescue operations for victims and their safe transportation from the threatened positions to other safe positions. Such risk reduction measures taken together are termed as *Mitigation and Preparedness Activities*

- Preparing hazard Zoning maps, predictability/forecasting and warning
- Preparation of the disaster management plans at household and community level
- Understanding of Hazard Exposures, Vulnerabilities and Triggers
- Community Awareness, Education, Engagement, Information and Warnings
- Collaboration and Disaster preparedness plan, land zoning, strengthening the existing weak structures

- Information Sharing
- Interoperability and Capability Development

9.4.2 Emergency Stage Approach

Emergency stage: Responding to disasters in the emergency stage includes taking of appropriate measures to immediately respond to an event, including action taken and measures planned in anticipation of, during, and immediately after an event to ensure that its effects are minimized and that persons affected by the event are given immediate relief and support. Activities undertaken in this stage are called *Emergency Response Activities.* The purpose of the emergency phase is to save lives, protect property and make victims feel safe.

- Activation and triggers of response arrangements
- Hazard specific activation
- Disaster coordination centers, Training in rescue and search operations
- Declaration of a disaster situation, Immediate relief and assessment surveys
- Communication and systems for public information and warnings
- Evacuation
- Logistics
- Financial management
- Reporting
- Debrief
- Disaster management systems

9.4.3 Post disaster stage approach

Post Disaster Stage: Post Disaster stage management requires to be purposive in achieving early rehabilitation and recovery of affected communities immediately after the disaster strikes. The prime moto is to achieve rapid recovery from the shock. All activities performed immediately after the disaster are termed as *Response and Recovery Activities.* The activities of this phase includes the following:

- Rebuilding destroyed property and repair of essential infrastructure
- Building temporary shelters; allocating financial grants and offer medical care
- Rescue and debris clearance

- Needs assessment should be planned and must be properly delegated to field agencies, and decision-makers
- Incorporation of indigenous traditional knowledge on warning signs
- Incorporate cartographic and geospatial knowledge to denote safe and unsafe areas and teach survival methods
- Infrastructural, economical, and psycho-social rehabilitation should be offered to the badly traumatized victims
- Reconstruction includes the replacement of buildings, infrastructure and lifeline facilities such as roads, bridges and communication links, for long term development prospects

The Relief measures include social response to disasters, organizational involvement of relief workers, preparing zonation maps based on the high incidence of damage and set up priority on that basis for relief disbursement.

The Recovery operations are the ones that are used for rebuilding and reconstruct all lost physical and non- physical structures. They are studied under the three phases as shown in the Figure below:

- Post-impact relief and early recovery
- Recovery and reconstruction
- Transition.

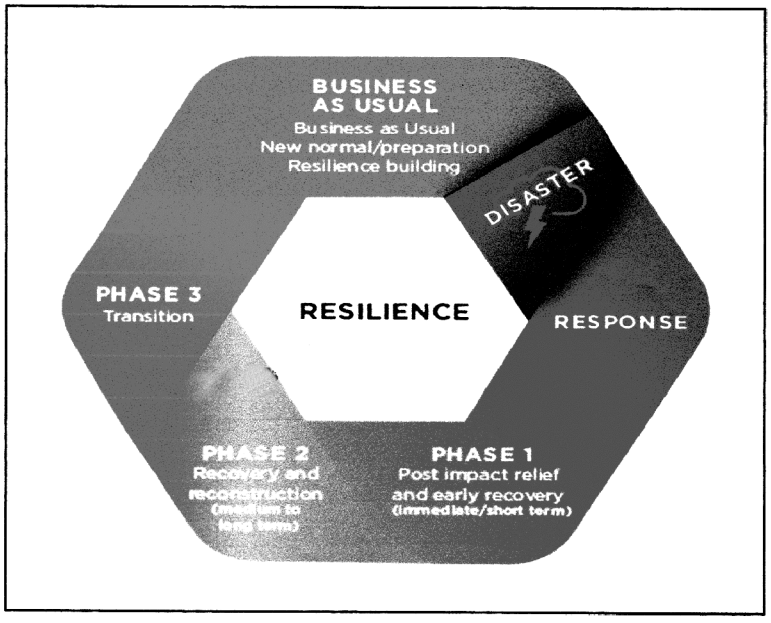


Fig 9.1 Three Phases of Recovery
Source: State of Queensland (Queensland Fire and Emergency Services) 2019

Phase One: Post-impact relief and early recovery

- ✓ Provide immediate and short term recovery (relief)
- ✓ Execute impact and damage assessments
- ✓ Establish recovery groups at the local and district levels
- ✓ Undertake recovery works parallel to the response phase and complete the work when all disaster response activities are assumed by relevant agencies for recovery and reconstruction

Phase Two: Recovery and Reconstruction

- ✓ Recovery is medium termed
- ✓ To achieve the best possible outcomes for disaster affected individuals, and communities integrated execution of the systematic recovery and reconstruction activities are required
- ✓ Continued coordination is required for impact assessments, community engagement, communication and collaboration between functional and recovery groups at all levels
- ✓ The phase concludes when the progressive achievement of key milestones, in the relevant recovery plan, are sufficiently implemented

Phase Three: Transition

- ✓ Continuous effort is required to recover and reconstruct from the damage and then handover responsibilities to agencies or organizations including government, local government, community-based or industry-led sectors to support the functional area
- ✓ To increase resilience of the community as part of recovery
- ✓ The phase concludes when all recovery and reconstruction responsibilities are managed and the victims return back to business as usual and a "new normal'' life

Thus the transition, from formal recovery structures to community planning process is conducted in conjunction with an appropriate public information strategy.

9.5 Community Based Disaster Management Approach

Community Based Disaster management is an approach of bringing people together within the same community to enable them to collectively address a common disaster risk and to collectively combat disasters. The philosophy of community based approach in disaster management is to manage disaster by the community, community organizations and their leadership and using community knowledge, and experience. The main objectives of community based disaster management are to:

(I) to reduce vulnerabilities and increase the capacities of vulnerable communities to cope with disasters to minimize the loss and damage to life and property and

(II) Rapid disaster recovery

It is known that all communities have some vitally important assets to deal with any kind of disasters like knowledge of disaster warning signs, locally safe and vulnerable areas, experience of past disasters, methods of survival and social relations that are often vitally important in coping with crisis. Local communities have an active part to play before and after disasters because:

- More number of lives can be saved during the first few hours after disaster has occurred through local response teams, before outside help arrives.

- The numerous problems of survival and health resulting from a disaster are dealt with more efficiently, if the community is active and well organized (WHO 1989). The key aspect of community involvement is the sustainability of community level initiatives for disaster reduction. External agencies, like government, non-government organizations may initiate and implement community level programs before and after disasters. It is important to involve people in decision making on policies and strategies that should be followed for the development of the community.

Importance of CBDM:

- Local people are capable to initiate and sustain their own community development.
- CBDP, helps the community to engage and direct the risk reduction and the contingency planning process with focus upon the needs of the situation.
- The involvement of the community gives useful insights and ideas about various traditional/indigenous ways of coping with the hazards.

- Community can play a very crucial role in taking right decisions in planning by sharing their valuable experiences.
- Community can also play a vital role in hazard identification and risk analysis with the insights of past experiences of a disaster.

9.6 Knowledge needed at different management levels

The above discussed approaches helps to highlight the key actions to be undertaken at the various levels of disaster management and disseminate knowledge at all the levels appropriately. They are discussed below:

● **Prevention and mitigation:** This phase is to minimize the impact of a disaster with proper planning and actions using:

1) Scientific hazards analysis (natural and man-made)
2) Vulnerability analysis of the elderly, children, pregnant
3) Risk assessment and mapping
4) Simulation and modeling
5) Structural mitigation; buildings and stock assessment
6) Non-structural mitigation; awareness campaign, training, and capacity building

● **Prediction and warning:** In this phase, technological know-how is used to predict and diagnose a disaster and obtain necessary measures to prevent or mitigate it. The technologies used are utilized for the following:

1) Monitoring.
2) Forecasting.
3) Early warning.
4) Scenario identification

● **Preparedness:** Preparedness from disasters minimize the negative impacts of structural and nonstructural damages so to be prepared, a good plan is required for every part of the society:

1) Resource inventory planning.
2) Stockpiling planning.
3) Logistical planning
4) Evacuation planning

5) Communication planning

6) Needs assessment planning

• **Response:** In this phase, all knowledge collected from earlier phases are used to cope with a disaster. This phase may consist of activities that may blend into one another:

1) Situation analysis

2) Early damage assessment

3) Crisis mapping

4) Information, communication with stakeholders

5) Evacuation and shelters

6) Dispatching of resources

• **Relief:** This phase provides relief to vulnerable groups and those at home with the medical assistance. It includes:

1) Search and rescue.

2) Rubble and debris removal

3) Logistics.

4) Delivery of relief supplies

5) Prioritizing actions

• **Recovery, Reconstruction, and Rehabilitation:** This is the most challenging phase of the disaster cycle and covers a wide range of actions. This phase includes the following:

1) Spatial planning

2) Infrastructure development

3) Communication development

4) Water, hygiene, sanitation

5) Housing

6) Livelihoods

7) Social security

8) Transport development

9) Agricultural development

10) Evaluation

Thus we get a detailed over view of the various approaches towards disaster management studies.

9.7 Summary

A detailed overview of different emerging approaches to study disaster and how to manage them has been discussed in the above paragraphs. The management of disasters takes place in various stages and each stage has been discussed thoroughlly. The budding approach of community based disaster managememt study has been also described briefly. The reader will get an idea about disaster management knowledge that is needed at different management levels.

9.8 Key words/Glossary

1. **Emergency Management:** The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps.
2. **Emergency Services:** The set of specialized agencies that have specific responsibilities and objectives in serving and protecting people and property in emergency situations.
3. **Debrief:** A series of questions answered about a completed mission.
4. **Mitigation:** The lessening or limitation of the adverse impacts of hazards and related disasters.
5. **Preparedness:** The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions
6. **Recovery:** The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors
7. **Resilience:** The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions
8. **Vulnerability:** The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

9.9 Assessment questions

Q1. What are the emerging approaches to disaster management?

Q2. What are the various stages of disaster management?

Q3. Identify the relief and recovery measures adopted during disaster management.

Q4. Discuss about the knowledge needed at different levels of management.

Q5. What is CBDM? Explain the significance of CBDM in disaster management.

9.10 References and Further Readings

1. Coppola. P . Damon , 2011, Introduction To International Disaster Management, Published By Butterworth-Heinemann
2. Subhramanium R. 2018, Disaster management, Vikas Publishing House
3. Singh R.B , 2006, Natural Hazards and Disaster Management: Vulnerability and Mitigation, Rawat Publications
4. Kumar Arvind, (2007), Disaster Management Recent Approaches, Anamol Prakashan
5. Kumar. P. (2019), Disaster Management, OakBridge Publishing
6. Manesh Khorram Amir(Ed),(2017)Handbook of Disaster and Emergency Management, Printed in Gothenburg Sweden By Kompendiet.
7. Lassa Jonathan , Paripurno Eko Teguh,, Jannali Ninil Miftahul, Pujiono Puji, Amin Magatani, Pristianto Juni, Sudira Catur, Parian Hening, (2017) Community Based Disaster Risk Management (CBDRM) Guidelines, published by MPBI with the support of PSMB, Lingkar, LJNDP-SCDRR, and translated with the support of APADM and Planas.

Unit-10 □ Regional Perspectives of Hazards in India with Reference to Dimension, Causes, Consequences and Remedial Measures : (A) Hills and (B) Coasts

Content Structure

10.1 Learning Objective

The knowledge of different types of hazards that are found in hilly and coastal areas of the country along with their dimensions of occurrences, types, causes consequences and techniques of addressing them would give a good idea and ample knowledge in mitigating and preventing such hazards from becoming disasters.

10.2 Introduction

Hazards are extreme events caused by either natural or human induced causes that result in colossal losses. As per the definition of UNO *hazard is "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 as put forward by UNCHS, (United Nations Commission for Human Settlements) *as the probability of occurrences of damaging physical events which have potential for causing colossal loss to human health and wealth if they strike inhabited areas.*

India is vulnerable to a large number of hazards and disasters. Its susceptibility to hazards is due to its climatic condition and locational setup. Apart from these the vulnerability of the country to risks is enhanced due to changing demographics and socio-economic conditions, unplanned urbanization, development within high-risk zones, environmental degradation, climate change, geological hazards, epidemics and pandemics. It is not free from the damages of man-made hazards such as Chemical, Biological, Radiological and Nuclear (CBRN) emergencies. More than 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12%) of its land is prone to floods and river erosion; close to 5,700 kms, out of the 7,516 kms long coastline is prone to cyclones and tsunamis; 68% of its cultivable area is vulnerable to droughts; and, its hilly areas are at risk from landslides and avalanches. We shall discuss the hazards of hills and coastal areas separately.

10.3 Hazards in Hilly Areas of India

Hill regions are in general prone to landslides and every' year during rains massive loss of human life and resources occurs due to landslides. Landslides are often triggered by earthquakes Apart from these **hilly regions** are also prone to the various hazards like the cloudburst, floods, fire, wildfire, avalanche, etc. (BIS. 2000).

The Glacial Lake Outburst Flood is one of its kind that caused massive damage at Chamoli in Uttarkhand on 7th February 2021. This avalauche and Glacial Lake Outburst Flood (GLOF) was the second massive blow for the Himalayan state after the 2013 Kedarnath Tradegy.

10.3.1 Landslides:

The Indian subcontinent with its diverse physiographic and seismo-tectonic zones are subjected to varying degrees of landslide hazards. The incidence of landslides in Himalayan regions and other hilly ranges (the western ghats) is almost an annual phenomenon in India. These two regions are the most vulnerable areas to landslides hazards. The fragile Himalayan terrain is prone to mass landslides caused by mass movements. Whereas the Western and Eastern Ghats in the peninsular plateau area are prone to landslides triggered by heavy rainfall events. Landslides in the southern India got public attention from 9 November 2001 when the Amboori landslide of Kerala killed 23 people. The major landslides in the Nilgiri hills are the Runnymede landslide, the Glenmore slide, the Conoor slide and the Karadipallam slide. In the recent times, casualties and damage due to landslides have increased in the Nilgiri hills.

Dimension of landslides in India:

Landslides are common in the sloppy and hilly areas of India. The dimension or stretch of its occurrences are thereby controlled by the slope map of India. Landslides are common along the north western belt of Himalayas from Nanga Parbat in the west to the north eastern boundary of the Himalayas along the syntaxial bend near Namcha Barwa in the east. The hills of south India are not spared from the clutches of severe landslides although their elevation is not the same compared to the

Himalayas. The list of landslide occurrences chronologically in India would give a better view of the dimension of its occurrences in the table (10.1) below :

Table 10.1

LANDSLIDE RECORD IN INDIA OVER THE PAST FEW YEARS

Name of Landslide	State	Year and Date	Cause	Fatality
Guwahati landslide	Assam	September 18, 1948	Due to heavy rains	Over 500 people died in the landslide
Derjeeling landslide	West Bengal	October 4, 1968	The landslide was triggered by floods	1000's of people died according to reports.
Malpa landslide	Uttarakhand	August 11 and August 17 in 1998	–	The entire village washed sway in the landslide
Mumbai landslide	Maharashtra	July 2020	Due to heavy rains	67 people died
Amboori landslide	Kerala	November 9, 2021	Due to heavy rains	Around 40 people died in the incident
Kedarnath landslide	Uttarakhand	June 16, 2013	As a result of Uttarakhand floods	Over 5700 were reported dead and over 4,200 village had been affected by the floods and post-floods landslide
Malin landslide	Maharashtra	July 30, 2014	Due to heavy rainfall	Around 151 people died and 100 people went missing after the disaster
Himachal landslide	Himachal Pradesh	December 7, 2015	Due to sudden rock fall	-

Name of Landslide	State	Year and Date	Cause	Fatality
Karimgang and Hilakandi landslide	Assam	May 18, 2016	Incessant and concentrated pre-monsoon precipitation triggered the landslide	This disaster has killed 18 persons and has also caused severe damage to property, cattle, substantial amount of agricultural land & crop, culverts and various vital road-stretches.
Kalikhola and subsidence, Kangpokpi district	Manipur	June 4, 2017	Blocking of the river course, damming,consequent ingresion of the water in the down/slide slope and rapid toe cutting form the high velocity released water might have triggered the initiation of the failure and move-ment of material downslope. The heavy rainfall prior to 4 June, 2017 and sudden release of water from the temporary dam accelerated further saturation, rapid toe erosion and dragging of the upslope mass and formation of large gaping cracks.	-

Name of Landslide	State	Year and Date	Cause	Fatality
Landslides in Kodagu district	Karnataka	15th to 17th August 2018	Due to the unprecedented heavy rainfall	The disaster caused huge loss of life, damaging property, infrastructure and communi-cation lines. The communication line along Shiradi and Sampaje Roads connecting Mangalore with Bangalore was cut off.
Landslide at BSUP Complex, Durtland Leitan, Durtlang, Aizawl District	Aizawl	2nd July, 2019	Due to continues rainfall for an week	The debris slide killed three persons and injured nine. It resulted in severe damage and trapped the residents living in affected apartments. 18 families were evacuated from the housing complex.
Landslide at Talacauvery, Bhagamandala, Kodagu District	Karnataka	06th August, 2020	Due to intense rainfall	–

Source : Geological Survey of India Report (https://www.gsi.gov.in/webcenter/portal/OCBIS)

Causes of landslides:

The circumstances that promote landslides, are presence of excess water in hilly areas, weak or fragile slopes, nature of rock strength, geological structure, poor

vegetative cover and seismic activity. The essential conditions, which cause landslides, are lack of support in front and lubrication behind. Other factors of triggering landslides are volcanic eruptions, earthquakes, incessant heavy rainfall, quarrying at the base of hill slopes, road construction along unstable hill slopes and heavy snowfalls.

The factors of landslides depend on the ratio between shearing forces and resistance of materials to shearing forces as follows:

$$Fs = \frac{\text{strength of resistance of material}}{\text{magnitude of shearing forces}}$$

Fs = factor of safety

When the quotient of the equation is less than (1.0) landslides occur denoting strong magnitude of shearing forces over strength of resistance of materials. Based on this corollary D.J .Varnes (1978) classified landslide causing factors in two categories as **a) factors enhancing shear stress and b) factors reducing strength of resistant materials.**

Types of Landslides: Landslides or the downslope movement of debris rocks and soils by falling, toppling, sliding, spreading, or flowing are classified under the following heads by D.J Varnes shown in the figure below.

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly corse	Predominantly fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth shilde
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
COMPLEX		Combination of two or more principal types of movement		

Fig. 10.1 Types of landslides. Abbreviated version of Varncs[1] classification of slope movements (Varnes, 1978).

The most common types of landslides are described below:

a) **SLIDES:** They are rapid downslope movement of large quantities of debris of varying size. There are two types of slides namely rotational slide and transitional/ block slides. Rotational slides are debris movements along a rotational axis parallel to the ground surface and transverse across the slide. Transitional slides are mass movement of debris along a roughly planar surface either in a single unit as a block slide or as a landslide mass with backward tilting along a rough planar surface.

b) **FALLS:** Debris flow or other earth materials flow from a very steep slopes downward refers to falls. On the basis of materials falls may be rock falls, earth falls, debris falls, topple. There are two types of falls on the basis of subsidence of ground surface namely collapse and settlement.

c) **TOPPLES:** These are land failures by the forward movement of a unit or chunks of units around a pivotal point under the force of either gravity or fluids in the cracks. There are three types of topples, rock topples, debris topples and earth topples.

d) **FLOWS:** Flows are downslope movement of water soaked fine debris and the water plays a dominant role in this mass movement of debris. Flows are of seven types such as rock flows, soil flows, debris flow, debris, avalanche, earth flow, mud flow and creep.

e) **LATERAL SPREADS:** Movement of coherent materials along gentle slopes of flat terrain controlled by lateral extension and caused by liquefaction is known as *lateral spreads*. Two types of lateral spreading are there namely *cambering* and *sackung*.

Consequences of landslides: Landslides are hazards only in areas which are less populated. However, in India due to its population pressure and tourism development along the major hill stations in the country landslides have turned to be massive disasters causing thousands of casualties each year thereby affecting the socio economic and human development of the country. The following are some effects of landslides:

1. Human casualties
2. Damage to roads, railways and other infrastructure
3. Damage to settlements

4. Loss of agricultural crops and land
5. Silting of rivers, lakes and ponds
6. Flash floods and damming of rivers
7. Economic loss

Remedial measures: Management of landslides in hilly areas involves two stage management.

- **Pre Landslide Stage:** This stage involves landslide mitigation, disaster preparedness and disaster prevention measures. *Landslide mitigation* includes preparing family members about landslide vulnerability, develop disaster mitigation emergency plan at government level, plan for quick and safe evacuation, make the community aware of the precursor events of a landslide and prepare them to face it, monitor recurring landslides and set early warning systems and regulate proper land use planning. *Landslide preparedness* would involve equipping the local people and administration with measures that help them to cope with adverse situations. The *Landslide Disaster Prevention* measures include steps like slope stabilization in hilly areas, drainage control measures, protection of hillslopes, infrastructure, towns, villages and stabilization of soils along slopes.
- **Post Landslide Disaster Stage:** This stage involves steps like searching and rescuing operations after a disaster, evacuation of victims to a safer place, providing immediate medical help, planned relief distribution, disburse compensation for the economic loss to the victims, clear debris and resume normal traffic at the earliest and with the help of governmental and NGO aids provide quick rehabilitation to landslide victims.

10.3.2 Cloud Bursts:

Cloud bursts are sudden heavy downpour with thunder and lightning in a limited space and time associated with thunderstorms. According to Dr Ajit Tyagi, former director general of IMD, the only difference between heavy rainfall and cloud burst is intensity of vertical motion in a small area. Cloud bursts are therefore literally known as "Badal Phatna" in Hindi. The scientific description is however given as devastating convective phenomena producing sudden high intensity rainfall less than 10 cm per hour over an area of 20 to 30 sq km. The sudden ascent of moisture laden winds in mountainous areas due to either orographic upliftment or insolational heating by this forced uplift, forms convective cumulonimbus clouds which brings

heavy and copious rainfall within a short span of time. The Himalayas in the north provides the most conducive set up for the formation of cloud bursts with numerous narrow valleys with steep walls, high relief with wind gaps, passes and ablated cirques. Garhwal and Kumaun Himalayas of Uttarakhand and Himachal Pradesh experience cloud bursts very often.

Dimension of Cloud bursts

Cloud bursts in India is commonly found in India stretching from the Himalayan mountainous regions in the north to the plateaus and hills in south India. The most vulnerable areas of high frequencies of severe cloud bursts are concentrated along the belt from western Garhwal Himalayas, including tracts of Chamoli, Uttarkashi, Tehri, Rudhraprayag, Pauri district of Pitthoragarh, Almora, Bageshwar and Nainital of Kumayoun Himalayas through districts of Himachal Pradesh and North eastern states of India. The excessive downpour in Mumbai 2005, was a cloud burst too recording 950mm of rainfall within a span of eight to ten hours.

Types of Cloud Bursts: Cloud bursts are of two types according to their mode of origin.

1) **Cloud bursts in Hilly areas:** When the moist warm unstable air strikes a mountainous barrier the air is forced to rise along the hillslope. This upward movement of the air is accelerated by the latent heat of condensation released during the formation of the most active thunderstorm. Thus huge convective clouds are formed extending up to or more than 15 km height from the ground surface, which when bursts gives copious rainfall equal to or more than lOOmm/hour.

2) **Cloud burst in Plains and Plateaus:** The moist warm air formed due to sudden rise in temperature as a result of intense heating of the ground surface, ascends abruptly from the ground surface to form towering convective clouds which when bursts bring heavy rainfall in the plains and plateaus. This type of rainfall is common in north Indian plains and the plateaus in the south. In plains it occurs with meso-scale circulation and strong upper level divergence.

Consequences of cloud burst hazards: Cloud bursts can be devastating and perilous and affect a wide area within a short span of time. Cloud bursts primarily leads to flash floods in both hilly as well as plains and plateaus. Sudden impact of raindrops on the soil surface leads to uprooting of trees, soil erosion, landslips and

slides, habitat destructions, and massive loss of property upstream. Landslides are triggered by the high rate of surface runoff. Downstream the impact is long drawn as the excessive silt from soil erosion accumulates in the river bed and chokes the river mouth thereby amounting to flood conditions in the valleys and plains.

Remedial measures: Not much plans have been implemented so far for combating from cloud bursts. However, a useful model for cloud burst mitigation has been designed by the Municipal Department of Copenhagen and the plan is yet to be implemented in a 30 years' time. The plan envisaged the following measures:

- Coping with the effects of climate change in the long run
- Fixing flooding limits in streets at 10 cm above which it should attract attention from the municipality
- Decouple 30% to 40% of excess storm water from combined sewage system to level out the expected excessive rainfall
- Concretization and creation of canals
- Greening of the area.

The above mentioned measures could be referred to in case of Indian context as well. The Uttarakhand state disaster authority has incorporated the following measures to be adopted for mitigating cloud bursts in India.

- It is suggested that people should inhabit on the hard rock or firm ground of slopes for safety reasons instead of valleys and along abandoned stream channels.
- Before implementation of permanent treatment measures it is necessary to check locations where ground fissures or cracks have developed and subsidence have taken place so that appropriate measures could be taken for controlling infiltration of rainwater as well as surface water.
- Landslide prone areas should be banned for indiscriminate and unscientific construction.
- Safe disposal of both surface and subsurface water should be given importance and hence drainage measures should be planned and executed. To execute this measures such as providing drain pipes on debris slopes, stepped and wide enough drainage network planned to accommodate heavy downpour events.

- To address slope instability and soil erosion latest bioengineering technology can be successfully implemented by using specific and local vegetation.
- Areas identified as being vulnerable to cloud bursts could be covered by a dense network of rain gauges for better understanding of this phenomenon as it is difficult to predict cloud bursts. Accurate measurement of such events and studies based on different aspects of geology, geomorphology and climatology could help in developing a cloudburst forecasting model.
- Awareness about extreme precipitation events and associated disasters should be propagated among the local people of the vulnerable area.

10.3.3 Flash Flood:

Flash floods are sudden floods caused within a few minutes to a few hours of heavy rainfall from cloud bursts or tropical storms or dam failures, mudslides and breaches in levee. It is flooding that occurs within 3 to 6 hours of the heavy rainfall. Flash floods often uproot trees along the river, and destroy buildings, roads, bridges, on its way. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons sweeping everything before it.

Flash flooding generally occurs in a blink of any eye and therefore people are caught off-guard. The situation may become dangerous if they encounter high, fast-moving water while traveling, the water may rise quickly and trap them, or cause damage to the property without them having a chance to protect the property.

Flash Flooding can happen anywhere. A normally tranquil stream or creek in an area can become suddenly raging torrents with heavy downpour overhead and starts flooding the nearby locality or city streets and highway underpasses.

Coastal flooding from tropical storms, causing sea water gushing towards inland may cause flash floods. Urban flooding can be caused by flash floods and river floods.

Dimensions of Flash floods

Flash floods are wide spread and commonly occurs throughout the country from the northern mountainous areas to the plains, plateau regions and coastal plains. Since flash floods are mostly meteorologically driven so it can happen any time at any place. However special cases like breaching of levees, or dam failures or landslide triggered flash floods are recorded all over India. Flash floods occurred in Mumbai, July 2005, Assam, July 2012, Uttarakhand, June 2013, Jammu and Kashmir, September 2014, Chennai -November 2015. Kerala, August 2018.

Types of flash floods: Floods can be classified in four types based on characteristics of the flood event;

- **Flash floods of a few hours' duration;** Flash floods generally occur from a small duration of few hours but high intensity of rainfall.
- **Single-event floods of longer duration:** At times flash floods may occur from a severe cyclonic depression rainfall of continuous duration for several days but of low intensity rainfall causing floods. Since the flooding is caused from a single event it is called single event flood.
- **Multiple-event floods:** When rainfall from cyclones coupled with a dam failure or overflow of rivers or lack of infiltration capacity of land leading to overland flow all contributes to the flood suddenly then these are called multiple event floods.
- **Seasonal floods:** Some areas are prone to occurrences of flash floods in a particular season specially the rainy season. The drainage basins of major rivers in their upper reaches are prone to such floods during early summers from snow melts or at the beginning of rainy seasons. Seasonal floods may occur in coastal areas as well.

Consequences of flash flooding

The only difference between flash flood and riverine flood is that in case of flash flood it occurs all of a sudden whereas in case of riverine floods the people gets to assess the time of flood from river migrations, and water stage records about flood situations. So flash floods are more devastating hazards and can have long term effects on the economy, environment and its people.

- During flash floods, houses, offices, hospitals, transportation, roads, bridges, water tanks are destroyed and people become homeless
- The environment suffers from floods as flooding destroys the natural balance of the ecosystem
- Post floods the water of the area gets contaminated with chemicals and other hazardous substances and ends up in high degree water pollution
- Flooding brings a lot of diseases and infections including fever, pneumonia and dysentery
- As it occurs suddenly the psychological shock of destruction of everything around makes a person traumatized for years.

Remedial measures for flash floods

It is difficult to predict flash floods. However well planned mitigation measures could reduce the risk of lives and property to a great extent. The measures should be divided into pre disaster phase and post disaster phase for coping with the disaster better.

Pre-Disaster Phase: The implementation of plans and policies should include flash floods at national and regional levels. A combination of nonstructural measures and small-scale structural measures could be more effective in managing flash flood risk. It is difficult to predict the magnitude and exact location of flash floods. Construction of structural measures such as embankments , dams, and levees along river banks may be of some use. There are many nonstructural measures as well that can reduce the impact of flash floods such as proper land-use planning, building according to construction codes, soil management, following land acquisition policies, maintaining insurance and risk transfer, raising awareness about flash floods and strengthening public information, emergency system, and recovery plans. The nonstructural measures are small scale structures built from local materials such as check dams, small-scale levees, and sand bag embankments. These are naturally suitable for local community as they are low in cost and ensure sustainability. The integration between flood management policies, water resource management, and disaster management plan needs to be a priority. A Community Approach may be initiated to combat flash flood risk in the name of Community Management Committee(CMC) to involve local community members and authorities to discuss the local and indigenous knowledge about combating such disasters.

For preparing an inventory map on flash floods historical information on flash flood occurrences is the most important for validation of flood susceptibility models based on different sources, including field data collection, historical archives, interviews with local people, and satellite image interpretation (van Westen, Van Asch, & Soeters, 2006). In recent years, satellite imagery has increasingly been used in the analysis of hazard prone areas. Recent applications of satellite imagery (e.g., ASTER, Landsat, or SPOT data) focused on the detection and assessment of ice avalanches, monitoring large landslides, flood and debris flows mapping.

Post Flood phase: The authorities must take concerted efforts to provide necessary assistance to these flood victims nationwide. The collaboration between governments, NGOs, CSOs and donors plays a pivotal role to fulfill their requirements and to return these regions to a better than normal condition.

10.3.4 Earthquakes:

An earthquake is a sudden shaking of the ground surface ranging from a slight

tremor to a rigorous shaking of the ground causing cracks to open up in the ground. According to **A. N Strahlar and A.H Strahlar**, 1976," **The earthquake is a form of energy of wave motion transmitted through the surface layer of the earth in widening circles from a point of sudden energy release, the focus".** The magnitude of an earthquake is measured by the Richter scale devised by Charles F. Richter in 1935. The magnitude of the scale ranges from 0 to 9 in a logarithmic scale that does not have any upper limit. In India, the Bihar earthquake of 1934, measuring 8.4 magnitude was the greatest earthquake in the world and India as well. The degree of destructiveness or the intensity of an earthquake is measured by the Mercalli scale. In India Medvedev-Sponheuer-Karnik scale, also known as the MSK or MSK-64, (a macro-seismic intensity scale) is used to evaluate the severity of an earthquake occurrence. The intensity of destruction from an earthquake depends upon several factors such as magnitude, epicenter, distance, amplitude of earthquake waves, acceleration, duration, water-table, nature of ground surface, type of building materials etc.

Causes of Earthquake: A number of causes has been assigned to the occurrence of earthquakes. Primarily it is caused due to any disequilibrium caused in the earth's crust. This disequilibrium can be caused due to several factors such as folding or faulting due to plate movements, volcanism, up warping or down warping, hydrostatic pressure release etc. Each cause is discussed below:

- **Plate tectonic:** Most of the earthquakes are generated along active plate boundaries and it is due to the plate movements and tectonic adjustments that causes earthquake waves to set in and travel faster in nearby directions to cause heavy damage. The Pacific Ring of Fire is an active zone for earthquakes to trigger.
- **Volcanic activity:** Volcanic activities are related to tectonic adjustments of plates and this divergence of plates and sudden gushing of magma may trigger setting of earthquake waves.
- **Release of hydrostatic pressure:** The release of hydrostatic pressure suddenly may cause a geological disbalance that may trigger earthquakes. Examples of release of hydrostatic pressures may be sudden burst of dams due to any anthropogenic interference.
- **Collapse of caves:** It mainly occurs in karst areas where due to collapse of caves the land may become unstable and due to the sudden jerk seismic waves may be generated.
- **Induced/ Anthropogenic causes:** Induced earthquakes are caused by human activity, like construction of tunnel, filling of reservoirs and implementing geothermal projects in unstable areas may trigger seismic waves to generate.

Table 10.2 Dimensions of Earthquakes in India:

SOME SIGNIFICANT EARTHQUAKES IN INDIA (1900-2013)					
Date	**Location**	**Disaster**		**Number**	
		Type	**Subtype**	**Killed**	**Affected**
April 1905	Kangra, HP	Earthquake (ground shaking)	Earthquake (seismic activity)	20000	
Jan 1934	Bihar- Nepal Border	Earthquake (seismic activity)	Earthquake (ground shaking)	600	
Aug 1950	Arunachal Pradesh -ChinaBorder	Earthquake (seismic activity)	Earthquake (ground shaking)	1500	
July 1956	Anjar, Gujarat	Earthquake (seismic activity)	Earthquake (ground shaking)	113	219
Dec 1967	Koyna, Maharastra	Earthquake (seismic activity)	Earthquake (ground shaking)	117	52272
Aug 1980	Jammu	Earthquake (seismic activity)	Earthquake (ground shaking)	13	40
Nov 1980	Sikkim. Gangtok Region	Earthquake (seismic activity)	Earthquake (ground shaking)	—	8
Dec 1984	Cachar district (Assam)	Earthquake (seismic activity)	Earthquake (ground shaking)	20	10900
April 1986	Dharmsala	Earthquake (seismic activity)	Earthquake (ground shaking)	6	30
	Manipur-Myanmar Border	Earthquake (seismic activity)	Earthquake (ground shaking)	2	12
Aug 1988	Bihar- Nepal Border	Earthquake (seismic activity)	Earthquake (ground shaking)	382	20003766
Oct 1991	Uttarkhashi, Uttarakhand	Earthquake (seismic activity)	Earth quake (ground shaking)	1500	54383

Date	Location	Disaster		Number	
		Type	Subtype	Killed	Affected
30th Sep. 1993	Latur-Osmanabad Maharashtra	Earthquake (seismic activity)	Earthquake (ground shaking)	9748	30000
22nd May 1997	Jabalpur, Madhyapradesh	Earthquake (seismic activity)	Earthquake (ground shaking)	43	156500
29th Mar. 1999	Chamoli Dist, Uttar Kashi	Earthquake (seismic activity)	Earthquake (ground shaking)	100	477894
26th Jan. 200	Bhuj, Gujrat	Earthquake (seismic activity)	Earthquake (ground shaking)	20005	6321812
26 Dec. 2004	Tamil Nadu, Andaman, Kerala, Andhrapradesh	Earthquake (seismic activity)	Tsunami	16389	654512
8th Oct. 2005	Kashmir	Earthquake (seismic activity)	Earthquake (ground shaking)	1309	156622
18th Sep. 2011	Sikkim	Earthquake (seismic activity)	Earthquake (ground shaking)	112	575200
01 May 203	Doda District (JKK)	Earthquake (seismic activity)	Earthquake (ground shaking)	3	59350

Table : 10.2 Source: NIDM-East Asia, Summit, Earthquake Risk Reduction Centre.

Consequences of Earthquakes: The earthquake hazards are common in any place where there is either a tectonically sensitive surface with lot of folding, faulting and thrusting activity or near instable slopes or near subduction of plate margins as explained by the Plate Tectonic Theory. But there were earthquakes in the past like the earthquake in Bhuj (2001), Kutch (1819). Koyna (1967), Bhadrachalam (1969) and Broach (1970) which cannot be explained by this revolutionary theory. Both direct and indirect effects of earthquake hazards have proven to be great disasters due to its severe impact on the life of people and structures as follows:

1. Slope instability, failure and landslide
2. Damage to human settlements

3. Damage to villages, towns and cities
4. Loss of human life and property
5. Initiate severe fires
6. Ground deformation
7. Cause flash floods
8. Generate tsunami waves

Remedial measures: The earthquake disasters cannot be predicted in precedence. So it is a difficult task to combat earthquakes, a geological disaster. However, mitigation measures may be adopted on a two phase tier as follows:

A) **Pre Disaster Phase:** - This phase includes all activities and measures to be adopted for the purpose of earthquake preparedness, mitigation and prevention of such hazards. The strategies include preparation of earthquake risk and vulnerability zone maps, hazard analysis report, identifying and listing factors contributing to earthquake vulnerability, spreading public awareness, and predicting earthquakes on the basis of crude estimation of earthquakes from precursor events, taking precautionary measures such as avoiding human habitation in high risk zones, restrict groundwater mining, construction of large dams and reservoirs in seismic zones, stop deforestation and mining in hilly regions.

B) **Post Disaster Phase:** The post disaster phase includes three steps of rescue and relief, disaster recovery and rehabilitation. The rescue works include search and save the victims from the trap, provide medical aid, machines and expert hands in rescuing the victims. The provision of relief materials should be instantaneous and evenly distributed throughout the affected areas. The rehabilitation works should include restoration of basic amenities, mental health, socio cultural and economic life of the people. Disaster recovery is a community based approach to recover the community from the agony of the seismic disaster.

10.3.5 Snow storm or Avalanche:

Avalanches are rapid decent of large masses of snow on an inclined surface under the impact of gravity. Small avalanches called sluffs, occur in large numbers, while large avalanches that may encompass a larger area covering squares of kilometers and millions of tons of snow, are frequently found in the hilly areas.

Types of snow avalanches: Snow avalanches are broadly classified under two types, they are:

1. **Loose snow avalanche:** Loose snow avalanches found when large masses of snow with little internal cohesion among the individual snow crystals and lies in a state of unstable equilibrium on a slope steeper than its adjoining areas with a natural angle of repose. This position of snow in case of slight disturbance sets progressively more and more snow in downhill motion. If enough momentum is generated, the entire process of down slope movement may cause massive snow deposition downhill. Such an avalanche originates at a point and grows wider as descent down. Although this type of avalanche is very commonly found in hilly areas, most dry and loose snow avalanches are small in size and only a few-achieve sufficient size to cause damage.
2. **Slab avalanches:** In case of slab avalanches however there is sufficient internal cohesion among the individual snow crystals to enable the formation of a snow layer, or layers, to form a slab of snow that acts 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). Thus depending on the degree of cohesion slab avalanches are of two types *new snow avalanche* and *old snow avalanche.* Slab avalanches are often dangerous, unpredictable in behavior, and account for most of the damage. This is due to the fact that a slab avalanche generally breaks free along a fracture line, and the entire surface of unstable snow is set in motion at the same time thus creating a huge damage. A slab release may take place across an entire mountainside, from slope to slope to adjacent or even distant slide paths. The mechanical conditions leading to slab avalanches are found in a wide variety of snow types, new and old, dry and wet.

   Dry snow avalanches are composed of dust clouds that whirls into the air. Such slides, are also known as powder snow avalanches, as they mostly originate as soft slabs. This wind blast if achieves high velocity may inflict heavy destruction along the avalanche path. The *wet snow avalanches* move more slowly than dry ones and are rarely accompanied by dust clouds. Their higher snow density makes them destructive and as the wet slides reach their deposition zones, the interaction of sliding and stagnated snow produces a characteristic channeling of snow.

Dimensions: Snow avalanches are commonly found in the higher reaches of the Himalayan region. The snowy coverd peaks of the Western Himalayas are particularly prone to snow avalanches. Areas in Jammu and Kashmir, Himachal Pradesh and Uttaranchal deserves special mention. The Gurez valleys, Kargil and Ladakh in the Jammu Kashmir region are frequented by such avalanches every year. The Chamba, Kullu-Spiti and Kinnaur of Himachal Pradesh are vulnerable areas for avalanches. Parts of Tehri Garhwal and Chamoli districts are vulnerable and are prone to snow avalanches.

Causes of snow avalanches:

- **Steep mountainous slope:** Steep slopes of 30° to 45° or even 50° are generally regarded as dangerous for generating avalanches as layers of snow cover becomes unstable in a sloppy inclined surface and unable to bear the pressure of overlying layers it starts the slide. In fact, convex slopes are more susceptible to avalanches than concave slopes.
- **Snow cover:** The rheology of snow covers and that of ice are both the same. They are composed of visco-elastic materials that exhibit creep behaviour of the substance over time. Snow starts to deform continuously without fracturing as the load on top of it increases. However, this loading rate is very critical. Heavy snow fall over a short duration surpasses this critical rate of loading and leads to a greater probability of avalanche occurrence. Thus, a snow fall of 1m in one day is more hazardous than snow fall of 1m over three days.
- **A weak layer in snow cover:** Layers of snow deposited may form slabs of snow over the mountainous slopes. However, any deformation caused by the layers of snow may initiate the avalanche that is released spontaneously or artificially by an increase in stress by the freshly deposited snow or a decrease in strength due to rain or rise in temperature and weakening of the layer of snow below the top layer due to ice melting.
- **A trigger to initiate movement:** Triggers that originate a snow avalanche may be either internal or external. Internal trigger may be generated by internal stress due to snow ruptures and internal metamorphism. External triggers are initiated by ice fall, falling cornices, earthquakes, rock falls, thermal changes, blizzards, loud sounds such as shouts, machine noise, and sonic booms.

Consequences of snow avalanches:

- **Destruction of infrastructure:** The forces generated by moderate or large avalanches can damage or destroy most manmade structures.
- **Road block and transport problem:** Where avalanches cross highways, passing vehicles can be swept away and destroyed, killing their occupants. The debris from even small avalanches is enough to block a highway or rail-road.
- **Death of People and Animals:** Asphyxiation is the most common cause of death caused by an avalanche. People and animals are buried deep in the snow and they are suffocated to death due to a lack of oxygen.
- **Communication and utility disruptions:** Power lines, telephone and cable lines can be broken so that people go without electricity for several days, with no way to communicate with others and delay rescue missions. Oil, gas, and water pipes may burst, leak, or be crushed leading to a lack of supply of these important necessary requirements.
- **Crop Failure:** Snow avalanches may result in thick covers of snow accumulated in valleys covered with good crop and destroy the same.
- **Flash flood:** Incase of a snow avalanche the ice falling may disrupt the flow of a river or displace water from a lake, thereby causing flash floods to occur, which are very dangerous in nature.
- **Adverse impact on the economy:** Strong avalanches may cause great damage to life and property. The local tourism industry and small scale ancillary industries suffer great loss. The government has to incur a lot of expenditure in disbursing funds for immediate rescue operations and post-disaster management. Private property is also lost during the disaster.

Remedial Measures: The remedial measures may be divided into the following phases of activities:

- **Early warning phase:** To anticipate an avalanche and warn the people there are two methods that is applied and they are:
  - **a)** Examination of the snow cover structure for identifying patterns of weakness on the underlying structure which would particularly lead to slab avalanches.

b) The second method is the analysis of the meteorological factors affecting snow depositions. Emphasis would be given to local climate, pattern of snowfall, snow type, and avalanche characteristics. Forecasting wet spring avalanches depends on knowledge of the heat input to the snow surface.

- **Control Strategies:** Two major types of avalanche control structures are as Prevention Structures and Prediction structures.

a) **Prevention Structure:** Preventive structures are constructed for preventing the occurrence of avalanches. There are various types of preventive structures and they are discussed below :

(i) **Avalanches Prevention Forest:** Afforestation is the best way to reduce the impact from an avalanche. The forests prevent movement of avalanches by the resistance of tree trunks and branches, increase the stability of snow cover by uniformly distributing it and control quick changes in snow cover.

(ii) **Stepped Terraces:** Construction of stepped terraces helps to reduce the impact of avalanches. Terraces also help in stabilizing the snow cover. They are easy to construct but are not effective in controlling surface layer avalanches.

(iii) **Avalanche Control Piles:** Avalanche Control Piles are spaced at an average distance of 5 meters in avalanche prone zones of mountainous slopes to control the surface layer of avalanches.

(iv) **Avalanche Control Fence:** Avalanche Control Fence are installed on mountainous slopes of avalanche prone zones to prevent the downslope movement of surface layer avalanches.

(v) **Suspended Fences:** Suspended fences are installed in places where there are in steep slopes or in areas of weak foundations because of poor ground conditions. These useful in smaller areas.

(vi) **Snow Cornice Control Structures:** These are structures installed at the top of mountain peaks to prevent the development of snow cornices which initiates an avalanche.

(b) **Protection Structures:** These are structures that are installed in the path of an approaching avalanche or snow deposit in areas to change the direction of flow of an avalanches, to reduce their energy to block their flow or to

allow their passage. The different types of protective structures are discussed below:

(i) **Protective Fences:** Protective fences are made up of steel and are similar to retaining walls that are used to block an approaching avalanche. They are normally constructed of steel and are used mainly for blocking small avalanches.

(ii) **Retaining Walls:** To block the flow of avalanche into the roadside obstruct daily transport retaining walls are installed.

(iii) **Deflecting Structure:** These structures are installed to deflect the flow of an avalanche to avoid the impact of the avalanche in road traffic.

(iv) **Snow sheds:** Snow sheds are roofed structures installed over a road to allow the flow of an avalanche over the roof of the snow sheds. This is considered as the most reliable of the various avalanche protection structures.

(v) **Retarding Structure:** These are structures to control and reduce the flow velocity of an avalanche. Structures such as earth mounds, retarding piles, and retarding fences are constructed for this purpose.

(c) **Other Control Measures:** Some other controlling measures apart from the ones discussed above are discussed below:

(i) **Prediction and Forecasting:** Prediction and forecasting of a hazard in advance is the most effective method of reducing the risk from the hazard and thereby can also efficiently dispose of dangerous snow deposits and cornices.

(ii) **Disposal of Avalanches Potential Snow Packs:** The easiest way to prevent avalanches is to search for ways that dispose of snow packs on hazardous slopes by hard labour, by use of blasting powder. In general, small avalanches are usually disposed of by blasting.

- **Search and rescue operations:** Search and rescue operations are externally organized services for dealing with victims of an avalanche emergency. They are also known as self-rescue or companion rescue operations. The survivors in a snow avalanche among the victims are the first responders. There for all victims should have prior knowledge of self- rescue and companion rescue. The standard equipment's carried by the rescuers in western countries are avalanche cords, beacons, probes, shovels and other devices like Emergency

Position-Indicating Radio Beacons (EPTRB) containing the Global Positioning System (GPS), and mobile phones. Quick Response Teams (QRTs)are to be organized equipped with the latest rescue tools such as snow clearing equipment, probes, communication capability, and medical emergency aids. The QRTs should be composed of trained personnels drawn from different branches of the local administration and the National Disaster Response Force (NDRF) to effectively manage the disaster.

10.3.6. Forest Fire:

Forest fires are defined as combustion or burning of forests due to causes that ignite the fire naturally and spreads drastically within minutes to a large area. They are often known as *Wildfires* as forests starts burning at a high rate without any control. A fire is composed of four parts namely gaseous, heat, flame and smoke. Here the fire gas refers to release of carbon mono-oxide due to the combustion process. Flame is the light given off during the burning process. Heat refers to the warmth of the burning fire. Smoke is the mixture of harmful vapour clouds with fine solid particles and gases. The process of this burning forests spread and continues for days by consuming all the natural fuels.

The history of Forest fires indicates that they have burned across the earth for millions of years. Evidence of forest fires exists today in petrified trees that lived long ago and over the years it gradually turned into a hard rock or have fossilized into a charcoal called ***"Fusain"*** in the tree trunks. The marks in the charcoal indicates that the tree was once in the path of a fire and that the marks are called fire scars on a living tree.

Thus forest fires existed since prehistoric time and has been a part of man's cultural traditions. It was never much damaging for the forest ecosystem. In fact, small and limited forest fires are essential for a healthy forest ecosystem. However, large uncontrolled fires of increased intensity badly damage the forest and has become a matter of much concern for society today.

Types of forest fires

Forest fires are not the same always and may differ, depending upon its nature, **size,** spreading speed, behavior etc. However, forest fires can be still classified under four categories depending upon their nature and size:

- **Surface fires:** Surface fire refers to the burning of the undergrowth and dead materials along the floor of the forest. It is the most common type of fire that burns surface litter, other loose debris of the forest floor and small vegetation.

It is in fact very useful for the growth and regeneration of forest but if blown in size, then this fire may engulf not only the undergrowth but also the middle layer of the forest.

- **Underground fires:** The fires of low intensity, consuming the organic matter beneath and on the forest floor litter are sub-grouped as underground fire. These fires usually spread entirely underground and burn for some meters below the surface.
- **Crown fires:** Crown fire is one of the most spectacular and unpredictable fires ignited from surface fires that burn the top of trees and spread rapidly from top to down of trees and shrubs by wind. In most of the cases these fires are invariably ignited by surface fires. Since it starts from the top of the ground it is uncontrollable and poses grave danger to the fire fighters becoming trapped and burned.
- **Firestorms:** Among all the forest fires, the fire advancing and spreading most rapidly is the firestorm, which is an intense fire affecting a large area. Air makes the fire spin violently like a storm with flames flying out from the base and burning trees blows out fire like a twister. Temperatures inside these storms can reach around 2,000 degrees Fahrenheit and cause heavy damage to forests.

Dimensions of Forest fire

Forest fires are mostly concentrated in the order of central, southern, western, northern, western Himalayan and north eastern states of India respectively. The central states of Chattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odissa and West Bengal recorded the highest rate of forest fires since 2003 as per the FSI reports 2017. The southern states of Andhra Pradesh, Goa, Karnataka, Kerala, Lakshwadeep, Tamil Nadu, Poducherry, Telengana are next to the central states in records of forest fire. Following these states are the western states of Gujarat, Rajasthan, Daman and Diu, Dadara Nagar Haveli. The Northern, Western Himalayan and North Eastern states are least affected.

Causes of forest fire: Fire comprises of three components to form a triangle called the fire triangle. Of these the two components i.e. fuel and oxygen are naturally available in forest whereas the third component i.e. heat, is the only component that ignites and initiates fire in the forest. Heat may be supplied by either natural or artificial reasons. Depending upon the source of the heat, the causes for forest fire may be classified as natural or artificial.

Natural causes

The Natural causes, responsible for the Forest Fire, can be summarized as follows: -

- **Lightning:** Lightning and thunder during thunderstorms may lead to the occurrence of forest fires. Occasional lightning induced forest fires have been recorded throughout history from India, Southeastern and Central United States, Australia, Finland and Eastern and Southern Africa (Kaushik, 2004). Natural forest fire sometimes become a potential hazard to the forest ecosystem by causing damage to vegetation and wildlife, and releasing huge amount of particulate matter and gaseous pollutants into the atmosphere.
- **Friction:** Friction induced forest fires from the sparks of rolling stones colliding in the mountainous areas during dry seasons may lead to massive forest fires. This occurs only when there is considerable combustible material present on the floor which can flare up in presence of strong winds. A devastating forest fire broke out in Gwar village, of Rudraprayag district in Uttarakhand (Feb,2001) due to this frictional sparks of rolling stones,
- **Dry bamboo:** In areas, where dry bamboo is available in abundance, forest fires may occur by the rubbing together of clumps of dry bamboos.
- **Volcanic eruptions:** Volcanic eruptions often leads to massive forest fires naturally.

Anthropogenic causes

Almost 90% of the forest fires are caused by anthropogenic intervention. At times it is a deliberate action on part of the human beings either for personal gains or rivalry or merely due to negligence or just by accident. Again forest fires may sometimes originate due to accidental or unintentional reasons as well. A few such instances are discussed below:

- **Deliberate or intentional causes-** Intentional forest fire is caused by people for some personal gain or rivalry with forest department. Examples are:

a) **Shifting cultivation-** Most of the forest fires in India are set by small-scale farmers or landless rural people deliberately. National estimate shows that almost 4.35 million hectares of area are affected by fire caused by shifting cultivation leading to forest destruction. The most highly affected states are

Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

b) **For growing good grass / fodder crop-** Forest fires are also caused intentionally to meet the need of fodder for grazing cattle. In the country although some 12.5 million hectares of land is officially classified as permanent pasture or grazing land, most of this area is virtually devoid of grass. Thus a major portion of the grazing requirement is met from forest area by setting fires to produce new flushes of grass in the dry season.

c) **Growing *tendu* leaves-** For growing *Tendu* leaves or (Diospyros melanoxylon) shrubs used to wrap bidi for the poor man's substitute for cigarette, collectors often set fires in the summer months to promote a better flush of leaves thus damaging forest lands. In central India, this practice of setting fires in the forest to increase the production of *tendu* leaves are very common.

d) **For illicit felling** - Smugglers and poachers are found to start forest fires to hide the stumps of illicit felling. The poachers use forest fires for scaring wild animals and hunting too.

e) **For cleaning forest paths:** Villagers at times set small fires to clear off their pathways from dry litter like, tree twigs, branches, leaves etc. This fire, when becomes uncontrollable, turns disastrous.

f) **To settle scores** - In some cases forests may also be set on fire by some rouges for settling gains with the forest department or any staff from the department.

- **Accidental or Unintentional causes:** Forest fires may be ignited due to human negligence, and they are discussed below:

a) **Collection of Non Timber Forest Produce (NTFP)** - Collection of NTFP by tribals or local habitants residing near the forest has been regarded as one of the major causes of forest fire. For easy collection of NTFP, the collectors ignite fire, which accidentally may spread in the forest, resulting into a major fire disaster. Example are Mahua and Sal tree.

b) **Burning farm residue-** Farmers set fire to their agricultural fields immediately after harvests to regain the lost fertility of soil. However, many times, these fires if not put out completely, may spread to the adjoining forest areas as a forest fire.

c) **Protecting crops from the wild animals-** Forest are set to fire by villagers residing near the forest to keep the wild animals away from their crop and cattle. If this fire is not put out completely, it may result in a disastrous forest fire.

d) **Careless throwing of cigarettes, bidi stubs, match sticks by grazers/ travelers-** Travelers, tourists, nomadic grazers, villagers or even forest laborers sometimes throw un-extinguished cigarettes, *bidis,* and match sticks in the forest areas which may result in forest fires capable of destroying valuable timber worth millions of rupees.

e) **Negligence:** In camp fires and fairs forest fires break out due to human negligence.

f) **Sparks from transformers or vehicles passing through the forest-** The sparks from transformers installed in the forest or near it and from moving vehicles may sometimes result into fires in forest.

g) **Uncontrolled prescribed burning-** Just before the onset of the fire prone season, forest department conduct controlled burning in the forest areas. Controlled burning is done to burn all the combustible material in the forest before the dry season to prevent major forest fires. However, at times due to carelessness this fire may spread and result into large inferno.

h) **Resin tapping-** Careless handling of resin from *Chir* pine cones during resin tapping season in the summer may also start a fire in the forests, if the wind begins to blow at high speeds.

i) **Charcoal making and wine extracting in the forest-** Charcoal making industries (both legal and illegal) of small or large scale and illegal extracting of wine are common in Indian forests. Sparks from these activities may lead to **forest** fires.

j) **Sparks from the house kitchens near the forest-** The households residing near a forest generally use fire wood as fuel for cooking and other purposes. Sparks from such household burning may sometime result in fire in the nearby forest.

k) **Heating coal tar for road construction** - Charcoal heat to smelt coal tar during road construction in forest areas, may strike a fire in the dry litter resulting in huge forest fires.

I) **Hunting by tribals-** Forest tribal searching for wild animals often set fire on the wild grass. Sometimes fires are ignited by local inhabitants for preventing growth of leeches.

Consequences: Forest fires become devastating disasters if not controlled on time and is a major cause of degradation of forest and environment. It is estimated that in India the proportion of forest areas prone to forest fires annually ranges from 33 percent in some states to over 90 percent in others. Forest fires in about 95 percent cases are anthropogenic and result into wide ranging adverse ecological, economic and social impacts. Uncontrolled forest fires not only burn down the vegetation, but also the surface organic matter, increasing the frequency of causing soil erosion and flooding. Wildlife patterns and habitat are also disrupted and affected by fire. The situation becomes serious due to lack of fire protection mechanisms, fire- fighting planning knowledge and incentives to protect the forest. The following are the list of consequences from uncontrolled forest fires:

- **Loss of valuable timber resources:** Valuable timber species like *teak, sal, chir, deodar, sheesam,* rosewood etc. are adversely affected by fire. They are not only lost but their quality also deteriorates.
- **Impact on ecosystem:** Forest fires have huge impact on the ecosystem and it is evident from the example that repeated forest fires in the Himalayas have converted mixed forests of oak and chir to pure *chir* forest. Again uncontrolled fires in the past have resulted in unfavorable conditions for oaks to grow while making conditions more favorable for *chirs* to grow. This spreading of pine forest at the cost of indigenous oak forest, is a very serious threat to the ecological balance in the Himalayan region.
- **Degradation of water catchments and loss of water-** The removal of litter after a forest fire decreases the water holding capacity of soil and the rainwater washes away the top fertile soil of the forest resulting into loss of soil fertility. The reduction in soil moisture due to decreased litter decomposition creates a possibility of forest fire in future.
- **Loss of wildlife habitat:** Forest fires results in destruction of the wildlife habitat and the life of an animal simultaneously. The forest fires in in Nepal claimed the life of red pandas, leopards, monkeys, deer, bear and other species.
- **Reduction of forest cover:** Forest fire leads to overall loss in forest cover and the entire forest area turns into ashes and remains as a degraded land of no use.

- **Global warming:** Forest fires and global warming are related and shares a dangerous relationship. The close linkage between high fire activity and inter annual and decadal-scale climate oscillations indicates that fire occurrence increases during the La Nina phase of the ENSO in southern United States, Patagonia and Argentina. Whereas a marked increase in fire activity occurs in tropical rainforests during El Nino phase. The changing weather pattern is one of the major factor in contributing to current increase in instances of forest fires.
- **Microclimate change:** The changed microclimate due to removal of litter and duff, after a forest fire and opening of the canopy by killing shrubs and trees and darkening of the soil surface by residual soot can increase insulation causing temperature increase. As a result, the changed area becomes unhealthy for living of both wild animals and local people.
- **Soil erosion:** The soil of the fire affected area loses its water holding capacity and becomes vulnerable for erosion
- **Impact on ecosystems:** Loss of soil from hill slopes produces several significant ecosystem impacts such as degradation of water quality and lack of soil productivity all of which affects the aquatic animals and their habitat.
- **Causing floods:** Forest fires cause destruction of the top soil and reduce the water holding capacity and infiltration capacity of soil. This causes high water yield during rainy season thereby causing floods.
- **Deteriorating biological environment:** Forest fires inflicts serious health hazard by creating polluting smoke and noxious gases. The burning of forests gives off not only carbon dioxide but also many other noxious gases like carbon monoxide, methane hydrocarbons, nitric oxide and nitrous oxide that lead to global warming and ozone layer depletion. Thousands of people suffer from serious respiratory problems due to these toxic gases.
- **Adverse impact on health system:** The forest fires are source of smoke that cause air pollution and rise in the temperature The forest fires covers the mountains with smoke, resulting in loss of visibility to about 200 meters. And rise in temperature by 2 to 3 degree Celsius. This results into uneasiness among the local people of the region.

- **Socio-economic impact:** Forest fire is a major cause affecting human settlement and their socio economic life deteriorates threatening both human life and property.
- **Carbon sequestration potential:** Trees act as carbon sinks when they absorb carbon dioxide from atmosphere and build up the same in the form of wood. While the wood is burnt the reverse process takes place whereby carbon- di-oxide is released into the atmosphere thereby resulting in permanent destruction of important sink of carbon dioxide.
- **Threat to life and property:** A forest fire that spreads outside the forest can consume buildings and other infrastructure. There are also indirect dangers to life and property due to forest fires.
- **Reducing tourism values:** Smoke and haze generated by forest fires repeal tourists from visiting the place thereby harming the revenue generation of the region.

Remedial Measures: The following are the recent developments in combating forest fires in India

- **National Action Plan on Forest Fires:** The National Action Plan on Forest Fires (NAPFF) owes its origin to the recommendations made by the Parliamentary Standing Committee on Science, Technology and Environment and Forests and prepared a comprehensive action plan in its 293rd report. The NAPFF is a holistic management towards combating forest fire scenario in the country and steps include fire prevention, fire control, post fire activities, community mobilization etc. The preparation and funding provisions of State Crisis Management Plan from Central financial support, coordination of various agencies are also a part of the Plan.
- **World Bank Study on Forest Fire in India:** The World Bank and MoEFCC under joint collaboration conducted a study on forest fires in India and came up with several prevention and management policies in India in 2017-18 drafted in a report recently. The major recommendations of the report include: Preparation and implementation of a National Action Plan; Review of Working Plan code, Continued development of systems for early warning and fire danger rating, More systematic use of silvi-cultural practices for preventing fire. Working with local communities to modify and prevent unwanted fire, Modernizing the forest fire fighting and response system,

Strengthening the assessment of the economic impacts of fire, silvi-cultural practices for restoring and rehabilitating fire-degraded forests.

- **Current Focus areas of Forest Survey of India:** The achievements of FSI in the area of forest fires are briefly described below:

  I. Evolution of Near Real Time Forest Fire alerts

  II. Forest Fire Alert System Ver. 1.0(2004-2017)

  III. Forest Fire Alert System Ver. 2.0 (2017-2018)

  IV. Automation of the process

  V. Customized Alerts

  VI. Improved users experience

  VII. Control Panel for State Nodal Officers

  VIII. Forest Fire Alert System Ver. 3.0 (FAST 3.0)

  IX. Large Forest Fire Monitoring Programme using near real time SNPP-VIIRS data

  X. Spin-offs by Creation of Large Fire Database at National Level, Development of National Forest Fire Database and Continuous monitoring of fire affected areas for planning, research

  XI. Large Forest Fire Dashboard in FSI website

  XII. FSI Forest Fire Geoportal

  XIII. WMS Service (Web-Map Service)

  XIV. Custom Mask Out including Industrial Area

  XV. Improved Feedback System

- **Early warning alerts for Forest Fire:** Forest fires are difficult to predict in advance so the Forest Survey of India, with years of experience and fire related data, developed an indigenous **"Early Warning Alert System for Eorest Fire" in** 2006. The alerts to State Forest departments are based on parameters like Forest Cover, Forest Type, Climatic Variables etc. The Forest Fire Alert System software is indigenously developed by FSI. The Satellite Data Processing support is provided by NRSC, ISRO and the Satellite is provided by NASA. In spite of coarser spatial resolution, the effectiveness in terms of Fire Detection and the Fire Alert Dissemination Algorithms are vigorous in nature.

10.4 Hazards in Coastal Areas of India

The coastal areas are a transitory part of the land and the sea. The shoreline of the coastal area is constantly shifting by geomoiphic processes of erosion and sedimentation, periodic storms, flooding and sea level changes. There are wide varieties of the meteorological, hydrological and geological phenomenon along with anthropogenic influence, which produces threat to coastal zones. The most important are Cyclonic storms, Flood, Heavy rainfall, Tidal and Storm Surge, Tsunami, Sea level rise and Coastal Erosion.

Earth System Science Organization (ESSO) and Indian National Centre for Ocean Information Services (INCOIS), Hyderabad along with Integrated Coastal and Marine Area Management (ICMAM), Chennai have carried out mapping and demarcating of multi-hazard coastal vulnerability for the coastal states of India. The purpose of the study was to assess the relative vulnerability of different coastal environments and quantify the basic information at a regional to national scale using seven risk variables, viz. shoreline change rate, sea-level change rate, coastal slope, mean significant wave height, mean tidal range, coastal regional elevation and coastal geomorphology. Most of the above mentioned variables are highly dynamic in nature and require a large amount of data from different sources to be acquired, analyzed and processed thus posing a serious limitation in forecasting events.

The vulnerability of Indian coast line, has been studied and in general it demarcates the vulnerability into four classes (very high, high, medium and low), carried out first time on a macro-synoptic scales (at 1:1,00,000) covering the entire Indian coastline. The general trend suggests varied degrees of vulnerability along coastal states of Tamil Nadu, Andhra Pradesh, Odisha, Kerala, Maharashtra, Goa, Gujarat and islands of Andaman and Nicobar Islands and Lakshadweep. The Gulfs of Kambhat and Kachchh in Gujarat show very high vulnerability indices, with the inlets of Kachchh showing localized vulnerability. Relatively low vulnerability indices are reported along the zones of Mangroves that help in breaking the large amplitude waves, dissipating the energy and hence act as a natural barrier. Now let us discuss each hazard separately.

10.4.1 Cyclonic storms:

India being a tropical country is subjected to tropical cyclones every year in a good number throughout the western and eastern coastal plains of India. Tropical cyclones are closed low pressure systems with diameters of about 650 kilometers and clockwise or counter clockwise air circulation, originating either in the Arabian Sea,

Indian ocean or the Bay of Bengal, having wind speeds 180 to 400 km per hour accompanied by tidal surges and heavy rainfall.

Types of Tropical Cyclonic Storms

Generally tropical cyclones are varied in size, extent and weather conditions. However, the following are the few types of tropical cyclones:

- **Tropical Disturbances or easterly waves:** They are migratory wave like cyclones associated with easterly trade winds between 5° to 20 ° north latitude that yields heavy rainfall with thunderstorms. Generally, these disturbances are common in the Caribbean Sea and the North Pacific Ocean.
- **Tropical Depressions:** They are small centers of low pressure surrounded by a single closely spaced isobars with wind velocity between 40 to 50 km per hour. These type of depressions are generally found along the ITC zone and affect the weather conditions of India and North Australia. When these storms originate in the Bay of Bengal they generally move in north westerly and westerly directions bringing copious rainfall resulting in severe floods.
- **Tropical storms:** They are centers of low pressure surrounded by many closely spaced isobars wherein the winds move towards the center with velocity ranging from 40 to 120 km per hour. These cyclones often turn violent and brings disastrous effect in the low lying areas of Bangladesh, West Bengal, Orissa, Andhra Pradesh and Tamil nadu.
- **Hurricanes or typhoons:** They are extensive tropical cyclones surrounded by several closely spaced isobars with wind speed exceeding 120 km per hour and diameters ranging from 160 to 640 km.

  Hurricanes are known as cyclones in India and Typhoon in China. The center of the cyclone records the lowest pressure ranging between 900 to 950 mb. This center is called the eye of the cyclone. The waves caused in the ocean due to this cyclone are called cyclonic waves or storm surges.

Dimension of Tropical Cyclones

Tropical cyclones originating in the oceans mainly hit the coastal areas almost every year and brings in havoc for the coastal communities residing along the coastal areas. The western coastal plains are subjected to tropical depressions and cyclones arising from the Arabian sea every year during the period from May and October to December particularly during the south west monsoon period in general. Maharashtra

and Gujarat are the worst affected regions in the western coastal plains. The eastern coastal plains are mostly affected by cyclones in the month of May when the extreme high diurnal temperature triggers the growth of well-defined cyclones in the Bay of Bengal and the progress of such cyclones landward wrecks the coastal communities along West Bengal, Orissa and Andhra Pradesh with severe damage. A few isolated cyclones originate in the southern Bay of Bengal and brings in heavy damage to the coast of Tamil Nadu. The southern coast line along the eastern margin are mostly affected by cyclones generated in the post monsoon months of October to December and affect Andhra Pradesh and Tamil Nadu in its passage.

Consequences of Cyclones: Tropical cyclones have tremendous effect on a nation's economy and development along with loss of many innocent lives. The damages may be listed as:

- ✓ Loss of life and property
- ✓ Destruction of basic infrastructure
- ✓ Disruption of daily transport and communication
- ✓ Destruction of coastal agricultural crops and animal husbandry
- ✓ Loss of natural forest cover specially the mangrove vegetation covers and loss of biodiversity
- ✓ Loss of business and reduced income
- ✓ Damage to public and private properties and institutions
- ✓ Destruction of fruit orchards
- ✓ Spread of diseases like malaria, dengue and stomach infections
- ✓ Contamination of surface and subsurface waters
- ✓ Ship wreckage and disruption of international shipping
- ✓ Eroding coastal areas at a mass scale with destruction of coral reefs and limestone caves thereby affecting the tourism industry.
- ✓ Education and cultural disruption caused leads to social problems *S* Psychological problems arise from loss of family members.

Remedial measures: The remedial measures for managing coastal cyclones includes two stage process

- **Pre Cyclone Disaster Stage:** This stage involves the enhancement of the state of preparedness by establishing proper early cyclone warning systems, detecting, identifying the position, tracking of cyclones, estimate the storm

severity, communicating warning messages to the coastal community. India has developed effective mechanism of detecting and tracking cyclones through Meteosat-5 and INSAT radars. The mitigation and preventive checks include assessing risk and vulnerability of cyclones, mapping them and creating protective buffers through massive plantation of mangrove vegetation. Land use planning and implementation of zoning as per CRZ regulations along with measures such as building storm barriers, recovering old and weak structures, educating the fishermen about identifying an approaching storm, and effectively evacuate the victims from landfall cyclones.

- **Post Cyclone Disaster Stage:** This stage involves fast rescue operations, quick relief and financial disbursement, medical help, restore electric and water supply, transport and communication, offer rehabilitation, community programmes for psychologically shocked people and control outbreak of diseases.

10.4.2. Tidal and Storm Surges:

A storm surge is an abnormal rise of water generated by a storm, over and above the astronomical tide whereas a storm tide is the water-level rise during a storm due to the combination of storm surge and the astronomical tide. This rise in water level can cause extreme flooding in coastal areas particularly when storm surge coincides with normal high tide, resulting in storm tides reaching up to 20 feet or more in some cases

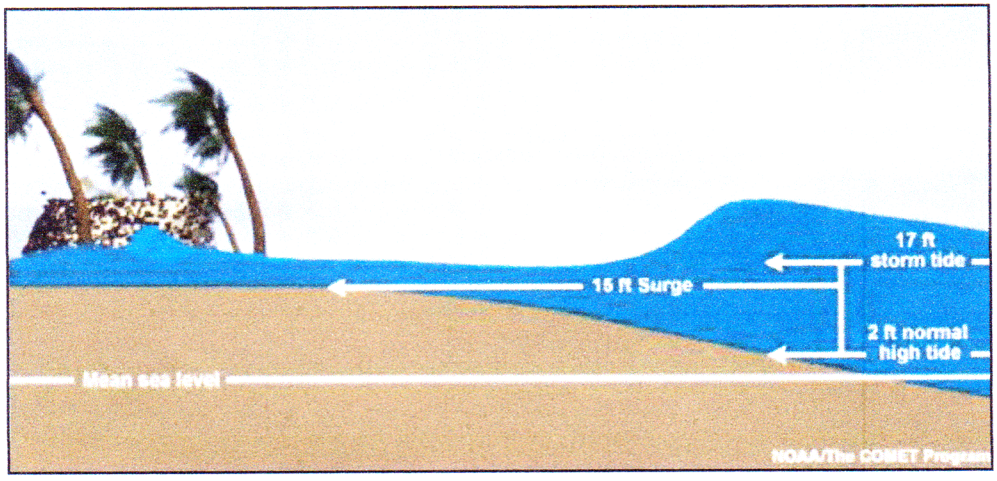


Fig. 10.2 (a) Tidal and Storm surge diagram

The process of storm surge:

A storm or a low pressure system generates the wind that blows across the sea surface. Friction between the wind and water pushes the water in the direction of wind. Tides are caused by the gravity of the sun and moon which contribute to the rise in ocean water level. The sea now starts to pile up water along the coastline due to the approaching storm due to the influence of the winds and tides.

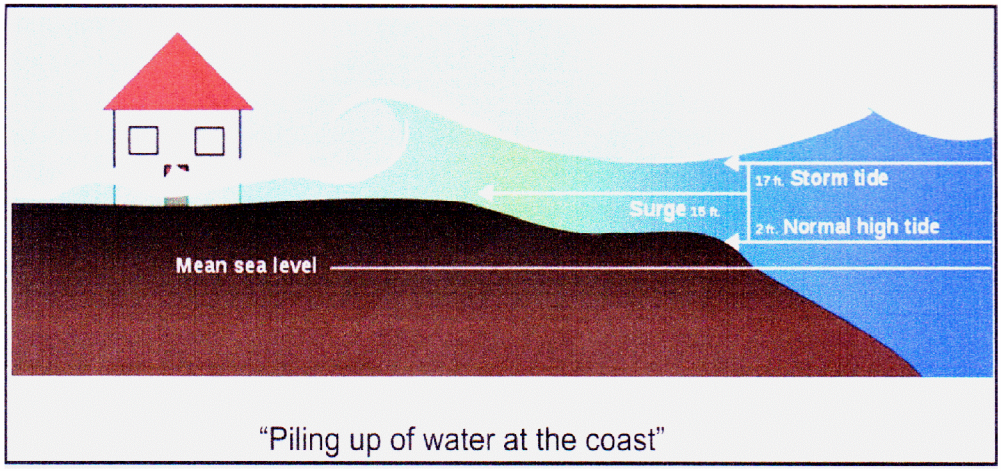


Fig. 10.2 (b) Tidal and Storm Surge process diagram

Dimensions of storm surges and tides:

The coastal areas and off-shore islands of Bengal and adjoining Bangladesh are the most storm-surge prone areas followed by the East coast of India between Paradip and Balasore in Orissa. The Andhra coast between Bapatla and Kakinada holding estuaries of two major rivers Krishna and Godavari are also vulnerable to storm surges. The coast of Tamilnadu between Pamban and Nagapattinam also deserves special mention in recording storm surges. Gujarat along the west coast of India has also recorded severe storm surges in the past.

Causes of storm surges and tides:

Storm surge is produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm. Storm surges may be caused due to several factors and they are discussed below:

- **Wind -** Storm surges are usually associated with a tropical storm, their speed for forward motion, direction, and angle of approach to the coast.
- **Low storm pressure over the ocean:** The more intense is the low pressure, the stronger is the storm surge.

- **Tides -** The tides influence and contribute to storm surge height.
- **Slope and width of the continental shelf -** The slope, width of the continental shelves shallow are found to be more prone to larger storm surges
- **Coastal geometry:** Storm surge is much depending on the shape of the coast line. *"Experiments suggest that the curving coasts not only shift the peak surge position but also affect its height* ***(Dube et al 1982)****"*

Consequences of storm surges:

Coastal hazards like storm surge expose a coastal area to risk of property damage, flooding, loss of life and environmental degradation. Storm surge is the main reason behind most of the casualties during tropical cyclones that occurs frequently due to strong storms formed in coastal regions. The occurrence rate of storm surge has increased drastically over the years and the trend is expected to continue in future as a consequence of climatic changes, increase in world-wide sea levels, increase in temperature etc. The following are the consequences of storm surges discussed below:

- **Coastal Flooding:** A storm surge can lead to extreme flooding in coastal areas, causing property damage, loss of human life, coastal erosion, change in ecosystem etc.
- **Damage to infrastructure:** Storm surge can cause damage to building foundation, framing, and collapsing the entire stability of the structure. Non-structural damage, like failure of mechanical, electrical and plumbing systems affecting the usability of the building are also common during storm surges. Transportation facilities like roads, railways, bridges, ports, communication systems are also disrupted delaying the response and recovery in disaster management.
- **Environmental degradation and health hazards:** Loss of soil fertility due to saltwater intrusion affecting the agricultural land, changes in the wetland ecosystems, the floodwater carrying toxic substances such as heavy metals, ammonia, pesticides, untreated sewage and phosphate polluting the waters cause problems like degradation of water quality and decrease in dissolved oxygen, resulting in dead organisms and can also often lead to epidemic disaster.
- **Erosion of Beaches:** Beaches are eroded by a storm surge. Repeated attacks by storm surge waves and tides have taken a toll on coastal beaches and islands, toppling beachfront homes, and eroding large stretches of the coast.

Remedial measures:

We cannot completely avoid any hazard, but proper study of the area under exposure and an adequate disaster management plan. Thus coastal hazard management has become an important aspect of coastal planning so as to develop the resilience of society towards coastal hazards. Hard engineering structures, soft protection measures, and managed retreat from the coastline are some of the possible management options

- **Hard engineering techniques:** Hard coastal defensive structures are the most effective option for surge mitigation and stabilizing shoreline at a fixed position. Groins, Sea walls, Revetments, Breakwaters, fixed dams, retaining walls are some protection structures used commonly in developing countries due to its low instalment and maintenance cost compared to higher technology option like storm surge barriers which is effectively implemented in developed countries.
- **Soft engineering techniques:** Soft coast measures make use of environmental friendly techniques to achieve the same objective of hard defense structures. Soft techniques aim in achieving a balance between the need for protection against erosion while maintaining and enhancing shoreline functions. It includes developing a natural shoreline, mangrove forest, bioengineered seawalls. Geo-tubes, beach replenishment etc. Even though in most cases they are considered to be temporary defense structure with a fair amount of success, the long term goal of the planners is to develop soft coast so that we can completely abandon the hard structures.
- **Building Practices:** Foundation type and first floor elevation are the main determinants of a residential building's vulnerability. Buildings with an elevated first floor are found to be less vulnerable to damage compared to buildings with the first floor on street level; however, buildings with an elevated first floor could still sustain significant damage, depending on the foundation type.
- **Managed retreat and controlled construction practices:** Congested construction practices near coastal area is a major threat during storm surge as it will increase the exposure and slow down the evacuation process. Managed retreat is a non-structural measure were a certain area is cleared for surge flooding is a good choice of mitigation measure.

- **Community preparations for storm surge event:** Preparedness is one of the most important pre-disaster phase of disaster management cycle which aims not only in increasing the community resilience (capacity to face a disaster), but also focus on the sustainable development of the community
- **Early forecasting and warning system:** Early warning is a major element of disaster risk reduction. Early action often prevents a hazard turning into a human disaster, warning provides people enough time to implement the action plan. One of the main reason behind the pathetic condition in Kerala during Ockhi Cyclone (December, 2017) was the absence of an early warning. People were unaware of the occurrence cyclone or the surge followed by it
- **Educating people at risk:** Coastal residents can be empowered by giving proper education regarding the storm surge impacts, actions to be taken, 72-hour disaster kit etc. It also helps in keeping themselves alive until rescue arrives.
- **Evacuation Plan in case of emergency:** An evacuation plan lays out how to escape safely from the vicinity of disaster prone area to rescue shelters during an emergency. It involves activities like provision of transportation and communication facilities, opening shelters, rescue & relief etc.

10.4.3 Tsunami and sea level rise:

Tsunami is a Japanese word where 'tsu' means harbor and 'nami' means waves. They are also known as 'seismic sea waves' as they are generated due to seismic activity under sea. They are at times referred as 'high energy waves'. These are high energy waves of high magnitude generated under the sea due to earthquakes, volcanic activities or massive under sea landslides.

Types of Tsunamis:

Tsunamis are of two types namely deep sea or distant tsunami and local tsunami.

- **Distant tsunamis:** The waves that move out to the deep sea much faster causing less damage to the coastal communities are called distant tsunamis.
- **Local tsunami:** The waves that move towards the coast but with lesser speed compared to the distant tsunamis waves but causes much damage to the coastal communities are known as local tsunami.

Causes of Tsunami: Tsunamis or large scale displacement of ocean waters may be generated due to various causes discussed below:

- **Undersea earthquake:** Powerful earthquakes exceeding the magnitude of 7.0 on Richter scale may generate tsunamis and cause damage to the nearby coastal areas. The tsunami of 26th December 2004 in the Indian ocean was generated due to undersea earthquake.
- **Undersea landslide:** Plate movement and other tectonic adjustment of the sea floor often causes massive submarine landslides that displaces volumes of sea water upward thus generating tsunamis.
- **Collision of convergent and divergent plates:** Collision of plates during convergence results in formation of subduction zones causing sudden upward movement of immense volume of sea water generating tsunamis. In case of divergence of plates, large masses of water are upwelled and diverted in the direction of plate movement thus causing high waves or tsunamis.
- **Volcanic eruptions:** The violent eruptions of volcanic islands near the sea causes the water to upwell and gushes out in the form of tsunamis. In 1883 the eruption of Krakatoa volcano generated a 120 feet high tsunami and caused heavy damage to the coasts of Java and Sumatra.

Dimensions of Tsunamis: Tsunamis are mostly found along the Pacific ring of fire and accounts for about 86% of the tsunami generation in the world. Although tsunamis are less common in the Indian ocean however rare phenomena are recorded off the Indian coasts.

Consequences of Tsunamis: Tsunamis move with a wreck for creating a havoc along the coastline. Some of the consequences are discussed below:

- **Damage to infrastructure:** All physical and non- physical structures such as buildings roads, boats and ships, communication along with non -physical structures that are a part of the infrastructures are damaged such as electric cables, pipelines etc
- **Loss of life:** Both men and animals lose their life in this kind of a damage from a disaster.
- **Damage to property:** Public property such as beaches, small islands, ports and harbours, naval and airport bases, are lost due to tsunamis.
- **Scarcity of drinking water:** The deposition of salts on coastal lands contaminates water and causes scarcity of drinking water.
- **Destruction of marine ecology:** The marine ecology is damaged and hence causes a disbalance in the entire marine ecosystem.

- **Outbreak of diseases:** Several types of diseases spread like epidemics immediately after a tsunami due to contaminated water. Apart from this the fear psychosis caused after the disaster impact causes trauma and restlessness.
- **Social problems:** Mental stress and psychological disorder along with loss of income from economic disruptions all generates a pressure on the living of the victims that creates social problems and increase crime.

Remedial measures: The tsunami disaster management phases may be dived into two stages: The Pre Disaster Phase and the Post Disaster Phase. Each stage is discussed below:

1) **Pre Disaster phase:** This phase is composed of three steps and they are tsunami preparedness (P), tsunami mitigation (M), tsunami protection (P). These three steps are interrelated and the following steps are adopted for combating tsunamis:
   - First job is to identify and map the areas of tsunami occurrences
   - Identify the vulnerable areas such as mangroves, coral reefs, beaches, coastal sand dunes and sea backwaters and plan a protective line of defensive action in advance.
   - Demarcate CRZ and evacuate human settlements from vulnerable areas.
   - Install tsunami meters for tracking under water earthquakes or tectonic adjustments and TWS (Tsunami warning system) for early prediction of tsunami. The IOTWS (Indian Ocean Tsunami warning and mitigation system) has been already set up under the leadership of UNESCO in 2006 to provide warning to inhabitants along the Indian ocean coastline. The ITEWS (Indian tsunami early warning system) was set up at INCOIS or Indian National Centre for Ocean Information in Hyderabad in October 2007 immediately after the tsunami disaster of December 2004. Establishment of DART (Deep ocean assessment and reporting tsunami) and BPR (bottom pressure recorder) along with radar based coastal monitoring systems were installed.
   - Plan for timely evacuation of casualties from vulnerable areas to safe places
   - Train government officials and local people with tsunami guidelines.
   - Warning hooters to be installed for quick response to tsunami attacks.
   - Avoiding coastal settlements and building protective sea walls and breakwaters to reduce the impact of the hazard.

- Provision for community education and immediate medical help must be made
- Equipment's for searching and rescue operations must be arranged well in advance
- Provisions for aerial surveys may be made assessing damages.

2) Post disaster stage: The post tsunami disaster stage includes the three 'R' s namely relief, recovery and rehabilitation. The relief work should start immediately after the disaster and distribution of relief materials should start by both governmental and non -governmental support. The recovery phase is a long term phase where the mental agony from a disaster is treated is therefore a difficult task. The rehabilitation programmes are also long term issues for restoring all the facilities and structures requires huge monetary funds and time.

10.4.4 Coastal Erosion

A coastal area may be defined as a broad zone that extends from the landward limit of marine processes to the seaward limit of alluvial processes. Coastal erosion is the net landward shift of the shoreline. Coastal erosion, is a global problem affecting almost every country around the world having a coastline. It is a hazard affecting the coastal areas due to several changes in the climate, atmospheric disturbances and constant changes in the water bodies.

Types of coasts:

Dimensions: Between 1990 and 2016, 33 per cent of India's coastline underwent massive erosion and in the last 26 years, India's coastline has undergone major changes. The loss or gain of the Indian coastline is shown below.

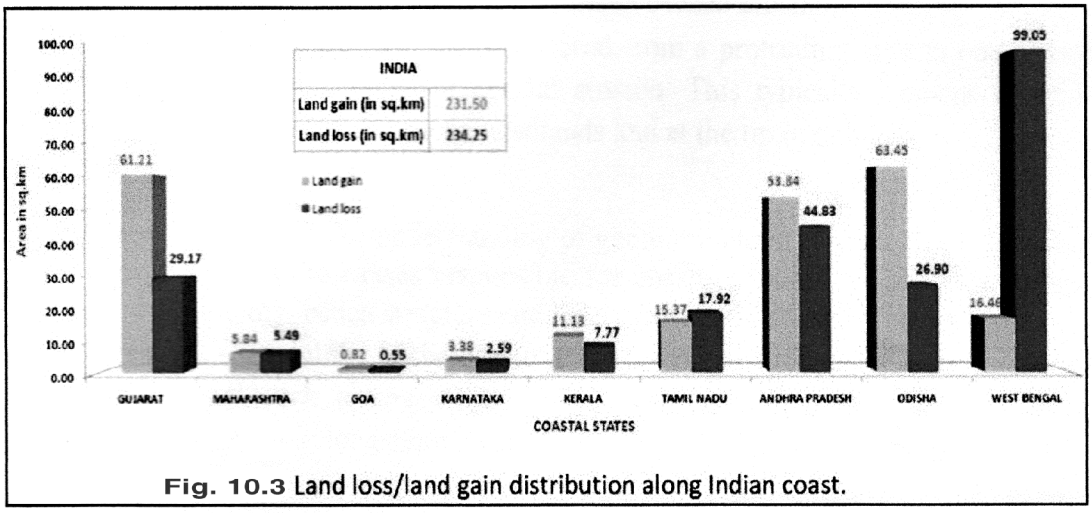


Fig. 10.3 Land loss/land gain distribution along Indian coast.

Coastlines are not static and undergo long term and gradual changes. A state-wise analysis shows that the maximum proportion of eroded coastline was in West Bengal (63 %) of the 534 km long coastline was eroded. West Bengal was followed by Puducherry (57 %), Kerala (45 per cent) and Tamil Nadu (41%). Apart from Kerala, the west coast is relatively stable (48%) compared to the east where (only 28%) has been deemed stable.

Causes of coastal erosion: The causes of coastal erosion can be categorized under several heads such as natural factors, physical factors and human factors:

Natural factors:

- **Waves:** Waves are regarded as the primary cause for coastal erosion. As the wave strike a cliff face, the water gushes inside the cracks and crevasses of the cliff face thereby exerting pressure on the surrounding rock. This eventually enlarges the cracks and with time these cracks grow larger to form caves and as intensity of erosion increases these caves disappears and what remains are stumps.
- **Transport gradient:** It is another cause of natural coastal erosion that indicates that with an increasing rate of transport gradient in the direction of the net transport, erosion rate of the coastal areas also increases. Transport gradient increases due to wave conditions at certain stretches, a curved coastline, or special bathymetric conditions.
- **Loss of sand:** Loss of sand in an inland accumulating beach due to breaching, over wash of barrier island by wind transport and offshore loss during extreme wave and storm surge conditions results in coastal erosion.
- **Protruding areas:** The loss of material from a protruding area to one or two sides is a natural cause of coastal erosion. This typically happens in areas composed of till or sandstone headlands and at the tip of deltas.

Physical Factors:

- **Geomorphology:** An understanding of geomorphological processes is essential to understand the causes responsible for coastal erosion due to wave energy, wave anatomy, beach structure and assess the rate of coastal erosion.
- **Geology:** The geology of the coastline also affects the rate of erosion. In case of differential rock arrangements, the coasts are eroded maximum. A steep gradient enabling longshore sediment transport is the reason of structural erosion.

- **Sea level rise:** Rise of sea level due to plate tectonic adjustments may also lead to coastal erosion.
- **Sediment budget:** Sediment budget is a concept that applies to sandy and muddy shores. It is another factor controlling most coastal land loss. Sediment budget refers to the balance between sediment added to and removed from the coastal system. Coastal erosion from a deficit in the sediment budget refers to nearshore processes that remove more material from the shore than is added.

Anthropogenic factors:

- **Transportation:** It is observed that high rates of land loss are documented along ship channels, service canals and along natural tidal channels that are frequently used as transportation routes. Bow waves of large ships and swells of smaller vessels alternately rise and fall generating local waves and currents thereby eroding the banks and enlarging the navigation channels. Rates of land loss caused by these artificial processes are controlled therefore by the amount of boat traffic, channel age, channel-bank composition, and channel setting.
- **Tourism:** Tourism attracts a damaging impact on the coastal area due to the development of tourist infrastructures, careless tourist operators, developing tourist activities at the cost of nature.
- **Coastal construction:** Engineering structures such as groins, breakwaters, seawalls/bulkheads, and revetments are designed to control coastal land loss but it is found that they can accelerate land loss of adjacent beaches by changing wave refraction patterns and thereby depleting sand supply.
- **River modification:** Dams used for storing potable water supplies, controlling floods, and provide recreation facilities have a negative impact on coastal land loss by trapping sediment and get rid of peak flood discharges. It is these discharges that are responsible for depositing most of the sediments at the lower reaches of rivers and transporting most of the sediment to the coast.
- **Hydrocarbon and ground water extension:** Land subsidence can be induced by several different activities that involve large volume extraction of underground resources (water, oil and gas, sulfur, salt). This induced subsidence, which is either sub-regional or local in extent, has its greatest

impact on flat coastal plains and wetlands near sea level where minor lowering of the land surface results in permanent inundation.

- **Climate alteration:** There is growing concern that global wanning of the atmosphere will cause continued thermal expansion of the oceans and rise in global sea level. This increased volume of water will cause flooding of low-lying coastal regions.
- **Coastal Excavation:** Excavation of coastal lands for economic development involves dredging and mining of wetlands and uplands. Excavation causes the most rapid and direct conversion of land to open water through techniques such as dredge marinas, open pipeline trenches, create or enlarge navigation channels and mosquito control ditches, construction of waterfront developments with finger canals, and channels providing access to drilling rig locations.
- **Wetland losses:** Wetland losses by burial of wetlands drained for agricultural or urban infrastructural developments causes coastal land loss. The Indian Sundarban is a good example of this type of wetland losses.

Consequences:

- Loss of habitat, beach and landscape quality
- Loss of infrastructural facilities like buildings, road transport etc
- Degradation of coral reef and its site
- Increases turbidity of water
- Increases the coastal vulnerability and makes it prone to Tsunamis
- Destroy the tourism industry
- Reduction in sand volume affects natural littoral processes
- Scenic beauty of the place diminishes
- Loss of boat anchorage
- Increases the frequency of floods in the lower reaches
- Increases the wave energy impact on the beaches thereby endangering people
- Water quality diminishes
- Marine and associated ecosystems becomes more fragile

- Primary production of fishes decreases
- Increases the annual expenditure of the country for disaster mitigation

Remedial Measures: Protection works to prevent coastal erosion should be based on long-term basis and must be planned to suit the particular site conditions on the basis of thorough field investigation and available data. The measures to control coastal erosion includes non-structural and structural techniques or their combination.

- **Non-structural measures:**

The Non-structural measures refers to techniques such as adaptation to natural coastal processes and moderation of coastal erosion aimed at dissipation of the wave energy and maintaining the natural topography of the coast. These measures are also called *soft solutions*. Some of these are:

a) Artificial nourishment of beaches

b) Coastal vegetation such as mangrove and Palm plantation

c) Sand bypassing at tidal inlets

d) Dune reconstruction/rehabilitation

- **Structural Measures:**

The structural measures, are also known as the hard *structural/engineering measures* used to build physical structures near the coast to prevent or restrict water from reaching the potential damage areas. These solutions influence the coastal processes to reduce the rate of coastal erosion. The structural measures used for coastal erosion prevention are as follows:

a) Seawall

b) Revetment

c) Off-shore breakwater

d) Groins/groynes/spurs

e) Offshore-Reefs

f) Artificial Headland

Other than this **monitoring of coastal erosion** there is another way of mitigating coastal erosion. It includes activities such as shoreline mapping through remote sensing and video analysis, conducting beach profile surveys with the help of aerial photographs and studying historical maps.

10.4.5 Submarine landslides:

Submarine Landslides are downslope movement along an inclined surface of the seafloor, of weak geologic materials, fine-grained sediment or fractured rock caused by earthquakes, large storm waves, or high internal pore pressures. Submarine landslides occur worldwide in areas such as lakes, near-shore areas, fjords, active and passive continental margins or slopes and they are either river fed or glacial-dominated. Slope instability is therefore a potential hazard for many underwater development and construction projects. Submarine landslides can involve huge amounts of materials being dislocated as large as 20.000 km^3 in volume and runout distances as great as 140 km.

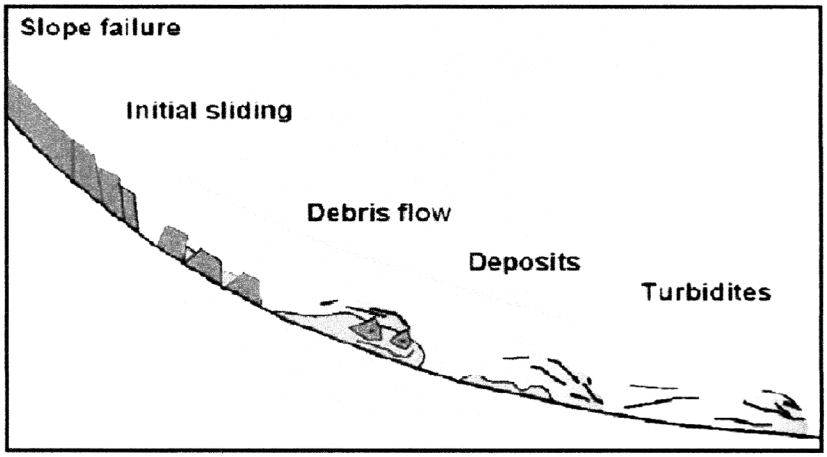


Fig. 10.4 Schematic representation of submarine landslide evolution. From (Bryn et al., 2005).

Types of Submarine Landslides

Submarine landslides can be identified by two features: a distinct headwall region (the rupture surface, the headscarp itself) and the removed mass, which usually changes behavior between initiation and final deposition. For example, a cohesive slide block may remain completely intact, break up into smaller pieces, or disintegrate into a flow (Morganstern, 1967; Hampton, 1972). Failures involving slope-forming materials of different lithologies and volume vary in resultant headscarp morphology. Failure events are often categorized by the geomorphology and velocity of the flow into the following categories:

- **Subaqueous rock fall/avalanche:** These are rock falls in areas of steep topography, like along the walls of fjords and submarine canyons.

- **Creep:** Creeps are periodic movements of debris slowly leaving behind a stair-like topography.
- **Translational slides:** These movements are more or less well-defined along slippage planes. It may be considered as the initial stage of larger scale slope failure events.
- **Rotational slide or slump:** They are a type of sliding slope failure in which a downward and outward rotational movement of the slope occurs along a concave up-slip surface leaving a curved-shaped scar
- **Debris flows:** Debris flows refer to transport of un-lithified fine-grained sediments under the impact of gravity. The strength of the surrounding fluid binds the grains of the debris together. Debris flows are very common processes of transporting sediments far distances even on low slope gradients.
- **Turbidity currents:** These are powerful and fast-moving currents comprising of sediment and water in greater density than the surrounding water. It may be also formed by turbidity currents resulting from the deformation of slumps and slides. Deposits resulting from these currents are labeled as turbidites. Turbidites display a graded bedding of five layers ranging from coarse grain material on the bottom layer to fine grained sediment on the upper.

Dimensions of submarine landslides: Submarine landslides in the Indian ocean occurs due to its proximity to the Sunda trench which when triggers submarine slides the Andaman and Nicobar Islands are the most affected. It is the subduction zone created by the overriding of the Indonesian archipelago under the Indo -Australian plate causes several submarine slides along the Indian ocean

Causes of Submarine Landslides

Submarine Landslides occur due to various causes related to geological attributes and environmental factors affecting the submarine environment. Each cause is discussed separately below:

I. Weak Geological Structure

The presence of weak geological structures or layers may contribute to submarine landslides at various scales. This fact has been confirmed by seafloor imaging such as swath bathymetric mapping and 3D seismic reflection data.

2. Overpressure

Overpressure from the rapid deposition of sediments in layers can often affect the equilibrium and trigger landslides under the sea.

3. Earthquakes

Earthquakes are very often thought to play the key factor which trigger most major submarine landslides. Earthquakes provide significant environmental stresses that results in increased pore pressures and slope destabilization which leads to land failure.

4. Storm wave loading

Storm waves from cyclones and hurricanes can lead to submarine landslides in shallow water regions along the coasts.

5. Gas hydrates

Gas hydrates are ice-like substances consisting of water and natural gas that lie beneath many submarine slopes and can contribute to the triggering of a landslide. Gas hydrates, that are stable at the normal temperature and pressure conditions are found on the seabed. When the temperature rises or the pressure drops the gas hydrate becomes unstable allowing some of the hydrates to dissociate and discharge bubbles that contribute in the trisserine of landslides.

6. Groundwater seepage

Groundwater seepage and increased pore water pressure can cause submarine landslides coupled with other causes such as earthquakes, gas hydrate dissociation and glacial loading.

7. Glacial loading

Slope failures are common along the glacial margins due to glacial loading ranging from small scale mass wasting processes in fjords to large scale slides covering several thousand square kilometers.

8. Volcanic island growth

Slope failures of several cubic kilometers often occurs due to the growth of volcanic islands on the ocean beds .The slope failures are caused by large bodies of lava formed above weak marine sediments which are prone to failures.

9. Oversteepening

The scouring action of oceanic currents cause over steepening of the slope which in case of a slight tremor would trigger off submarine landslides. The submarine landslides are commonly found near fjords, active river deltas on the continental margin, submarine canyon fan systems, open continental slopes, and oceanic volcanic islands and ridges.

Consequences:

- Tsunami formation and propagation
- Flow impact on objects
- Disappearance of valuable land near the shoreline
- Destruction of seafloor installations like cables, pipelines or oil wells

Remedial measures:

To predict submarine landslides, it is important to investigate slope stability in near-shore areas even if there is no infrastructure on the seafloor. A landslide hazard evaluation generally comprises of the following:

(i) Geophysical mapping, for analyzing episodes of landslides and the seafloor morphological investigations—typically involving swath bathymetry and side-scan sonar systems— are one of the most important aspects of landslide hazard evaluations

(ii) To conduct sediment sampling at in-situ for analyzing the *present* slope stability

(iii) Protect structures both on the sea bed and on the land along with estimating the *associated probabilities* causing landslide scenarios

(iv) A sediment sampling programme through soil sampling is required for analyzing slope stability evaluations and provide an idea of past land sliding history. Calculating the *run-out* distances and *velocities* of those landslides is based on the actual soil composition and its rheology.

(v) Offshore monitoring or early warning system gained impetus in the context of tsunami prediction. Such systems are composed of gauge stations at the

shore, GPS-equipped buoys in the open sea, a real-time transmission system, an analysis unit simulating the ensuing tsunamis and impact scenarios, and

(vi) Setting up and implementing constructive and organizational mitigation measures.

10.4.6 Harmful Algal Bloom:

Blooms of autotrophic algae and some heterotrophic protists found increasingly in coastal waters around the world are collectively named as harmful algal blooms (HABs). A harmful algal bloom (HAB) also referred to as Red Tides some times by scientists, occurs when toxin-producing algae grow excessively in a body of water. Algae are microscopic organisms that live in aquatic environments and use photosynthesis to produce energy from sunlight, just like plants. The excessive algal growth, or algal bloom, becomes visible to the naked eye and can be green, blue-green, red, or brown, depending on the type of algae. Algae are always present in natural bodies of water like oceans, lakes, and rivers, but only a few types can produce toxins. In these algae, toxin production can be stimulated by environmental factors such as light, temperature, and nutrient levels. Algal toxins when released into the surrounding water or air can seriously harm people, animals, fish, and other parts of the ecosystem.

Causes of algal blooms: Algal blooms are attributed to two primary factors: **natural processes** such as circulation, upwelling relaxation, and river flow; and. **anthropogenic factors** such as eutrophication. Other factors are thermal condition of water due to climate change, nutrients from fertilizers or solid wastes. In general, most harmful algal blooms are caused by plants that form the "base" of the food chain. These include both microscopic species of algae, referred to scientifically as phytoplankton and the micro-phyto-benthos, as well as the larger macro-algae. Other HABs are caused by accumulations of non-chlorophyll-containing cells (heterotrophs) that are similar in form to microscopic algae. A bloom occurs when an alga or heterotroph rapidly increases in numbers. Such high abundance can result from explosive growth caused by a metabolic response to a particular stimulus or from the physical concentration of a species in a certain area due to local water circulation patterns.

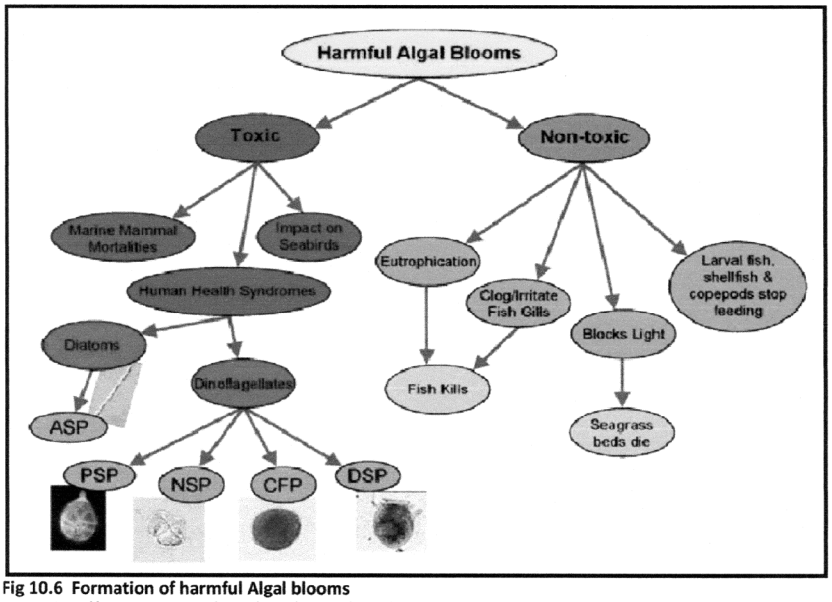


Fig 10.6 Formation of harmful Algal blooms
Source: http://www3.mbari.org/earth/2014/lessons/HABs/D_HABs/HABsConceptMap.png

Asp = Aspergillus Flavus

PSP = Paralytic Shellfish Poisoning

NSP = Neurotonic Shellfish Poisoning

CFP = Ciguatera Fish Poisoning

DSP = Diaffhetic Shellfish Poisoning

Types of HAB: There are three main types of algae which can form into harmful algal blooms: cyanobacteria, dinoflagellates and diatoms. All three are made up of microscopic floating organisms which, like plants, can create their own food from sunlight by means of photosynthesis

Dimensions of algal bloom: India is one of the major maritime countries, that is endowed with a long coastline of approximately 7,500 km and embraced by two important seas, that is the Arabian Sea (AS) on the west and Bay of Bengal (BOB) on the east coast of India. This marine environment embodies diverse habitats such as estuaries, mangrove swamps, brackish water lakes, coral reefs, islands and offshore waters that support a great diversity of flora and fauna. The coastline includes 12 major ports, six each on the west and east coasts of India. Reports of algal bloom have been recorded off the coasts of Malabar, Cochin backwaters, Kerala, Kaikani in Mangalore, Dharamtar creek Mumbai, Goa, Brackish water fish farm in Kodi in Karnataka, Minicoy island in Lakshwadeep, Calicut, Mandapam in

Tamilnadu, Vishakapatnam in Andhra Pradesh, Gopalpur in Orissa are the places where concentration of HAB is noticed.

Consequences of HAB

HAB's have very harmful effect on human health. For example, eating seafood contaminated by toxins from algae called *Alexandrium* can lead to paralytic shellfish poisoning, which can cause paralysis and even death. The algae *Pseudo-nitzschia* produces a toxin called domoic acid that can cause vomiting, diarrhea, confusion, seizures, permanent short term memory loss, or death, when consumed at high levels. HABs that occur in freshwater, like the Lakes, ponds, tanks and other drinking water sources, are dominated by the cyanobacteria *Microcystis*. This organism produces a liver toxin that can cause gastrointestinal illness as well as liver damage.

10 110.3 HABS AND THEIR HEALTH EFFECTS.

Organism	Water Type	Color	Toxin	Target tissue	Health effects
Alexandrium sp.	Salt	Red or brown	Saxitoxins	Nerves and muscles	Paralytic shellfish poisoning, paralysis, death
Karenia brevis	Salt	Red	Brevetoxins	1. Nervous system 2. Respiratory system	1. Gastrointestinal illness, muscle cramps, seizures, paralysis 2. Respiratory problems, especially for asthmatics
Pseudo-nitzschia	Salt	Red or	Domoic acid brown	Nervous system	Amnesiac shellfish poisoning, vomiting, diarrhea, confusion, seizures, permanent short term memory loss, or death
Microcystis	Fresh	Blue-green	Microcystin	Liver	Gastrointestinal illness, liver damage

Source: NIEHS

Other effects include damaging the environment by depleting oxygen in the water, which cause fish deaths in a mass scale, or simply by blocking sunlight from reaching organisms deeper in the water. The economic impacts of HABs to fisheries. Closures of shellfish beds, lost production in fisheries (both aquaculture and wild), severe reductions in local/regional tourism and recreational areas, are some of the socio economic impacts. Closed fisheries lose revenue in millions each week.

Remedial measures:

Management strategies to reduce the impacts of HABs by either ***prevention*** ~ avoiding the occurrence of blooms or reducing their extent; ***mitigation*** ~ minimizing HAB impacts on human health, living resources, and coastal economies; or by ***controlling*** actions that directly reduce the bloom population. Examples *of prevention* strategies might include reducing pollution inputs to a region in an effort to decrease the number or size of bloom events, or using new technologies to prevent the transport of bloom organisms in ballast water from one coastal area to another. *Mitigation* strategies may be like introducing moving fish cages from the path of a HAB, or reducing the quantity of fish food to minimize their susceptibility to a bloom. Strategies adopted for *controlling* HAB may include direct application of chemicals or other biological agents that kill or disrupt HAB cells during blooms.

A report, named *Prevention, Control and Mitigation of Harmful Algal Blooms: A Research Plan,* held in May 2001 in Silver Spring, Maryland outlines a forward-looking research program like the ECOHAB program by providing the means for academic, government, and industry scientists and engineers to combine their efforts with those of coastal communities and managers in order to reduce the impacts of HABs along coastlines.

An Environmental Sample Processor, developed with NIEHS support at the Woods Hole Center for Oceans and Human Health can be left in a body of water to continually test for HABs. (Illustration by E. Paul Oberlander, Woods Hole Oceanographic Institution)

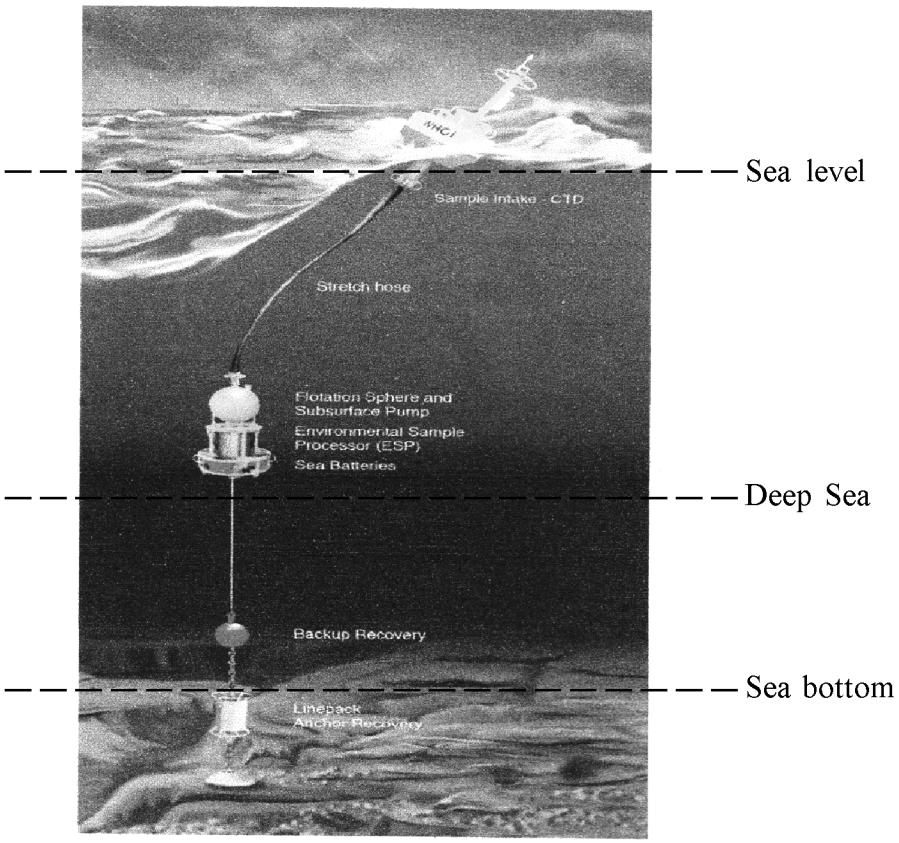


Fig. 10.7 A schematic of the ESP mooring assembly. (Paul Oberlander, WHOI)

A number of research groups monitoring HABs along the Indian coasts focussed on phytoplankton ecology along the Indian coasts and have been involved in a national coordinated multi-institutional research programme on "HABs in the Indian EEZ", funded by Ministry of Earth Sciences (MOES) with **Centre for Marine Living Resources and Ecology (CMLRE)** as the project coordinator. The primary goal of the programme was extensive monitoring of HABs in the Indian EEZ, identification of causative toxic/harmful micro-algal species, dynamics of bloom formation, spread and crash and its ecological consequences on marine ecosystems. The CSIR-National Institute of Oceanography (NIO) initiated the *Ballast Water Management Programme in India* (BAMPI), for carrying out Port Baseline Biological Surveys (PBBS) along the major ports of India. It is supported by the Directorate General of Shipping and Ministry of Shipping, India. In addition to this, there are other government sponsored programmes to explore the biodiversity of the seas around India and other oceanographic studies that provide useful information related

to HAB dynamics. A phytoplankton-monitoring programme under the Indian Expendable Bathythermographic (XBT) programme was funded by the Ministry of Earth Sciences since the early 2000. Regular oceanic cruises are plied between Chennai-Port Blair and Port Blair-Kolkata transecting the Bay of Bengal for collecting relevant data. Apart from these the Remote Sensing provides a synoptic tool for detection and monitoring of HABs on a global scale. A new bio-optical algorithm has been developed to provide accurate assessments of chlorophyll a (Chl a) concentration for detection and mapping of algal blooms from satellite data in optically complex waters of the Arabian Sea (Shanmugam, 2011). The algorithm is derived using Sea-viewing Wide Field-of-view Sensor (Sea WiFS) bands, and it is subsequently tuned to be applicable to Moderate Resolution Imaging Spectro-radiometer (MODIS)/Aqua data. In recent times the Indian National Centre for Ocean Information Services (INCOIS) has modified and adapted the Red Tide Indices as Bloom Index (BI) for detecting blooms in Indian waters.

Conclusion :

Thus on the basis of the above discussion, it can be concluded that hazards or disasters can be natural or anthropogenic, but at the same time they occur differently in hilly and coastal areas. Their type, form, dimension, effects are all controlled by the natural environment and guided by the landform features. All hazards can turn into disasters only when it affects the majority of the population of the region and claims life and property. The knowledge of the processes of mitigation and preparedness are therefore important to combat hazards and disasters.

10.5 Summary

A detailed discussion has been done on the causes of hazards occurring in hilly or coastal areas. Their consequences have been identified and possible remedial measures to combat such hazards have been suggested. The significance of this study is that it allows to identify each hazard separately and learn to fight such hazards with proper knowledge.

10.6 Key Words/Glossary

- **Coastal zone:** The area extending from the high tide mark on land to the edge of the continental shelf, where there is a sharp increase in the depth of water

- **Carbon sequestration:** The process of removing carbon from the atmosphere and depositing it in a reservoir.
- **Seismograph:** An instrument that measures the amount of energy released in an earthquake by sensing the vibrations.
- **Protists:** A single celled organism of the kingdom of Protista such as a protozoa or simple alga.
- **Micro climate:** the climate of a very small and restricted area.
- **Epidemic:** Widespread occurrence of an infectious disease in a community at a particular time.
- **Cambering:** a slight convexity of an up fold from the leading edge to the trailing edge.
- **Sackung:** It is a linear scarp that runs parallel to an elongated ridge or faces uphill.

10.7 Assessment Questions

1. What are landslides? How to mitigate the occurrences of a landslide?
2. Why are forest fires dangerous for the ecosystem? State the causes of forest fires taking examples from India
3. What is the difference between storm surge and storm tide? Explain the causes and consequences of a storm surge.
4. What causes tropical cyclones to occur? What are the measures adopted by Indian government for protecting the coastlines from this disaster?
5. What is HAB? What are the causes and consequence of HAB? State the remedial measures adopted to mitigate HAB.

10.8 Further Readings

1. Satendra Dr. (2003), Disaster Management in the Hills, Concept Publishing House, New Delhi.
2. Chakraborty. C. Satyesh, (2007), Natural Hazards and Disaster Management, published by Pragatishil Prokashak, Kolkata.

3. Basu Ranjan, Bhaduri Sukla, Edited Volume, (2007), Contemporary Issues and techniques in Geography, published by Progressive Publishers, Kolkata.

4. Singh Savindra, Singh Jitendra, (2018), Disaster Management, Published by Pravalika Publications

5. Valdiya .K.S (2014), Coping With Natural Hazards: Indian Context, Published By Orient Longman, Hyderabad, India.

6. Government of India, Ministry of Home Affairs, (2011), Disaster Management in India.

7. Bushaw-newton, K.L and Sellner, K.G 1999, (Online), Harmful Algal blooms, in NOAAS State of the Coastal report. Silver Spring, MD National Oceanic and Atmospheric Administration.

(http://state-of-coast.noaa.gov/bulletins/html/hab/_14/hab.html)

Unit-11 □ National and International Policies for Disaster Management

Content Structure

11.1 Learning objectives

The last decade of the new millennium witnessed many changes in the national and global frameworks for reducing and mitigating disasters. The national and global agendas and policy frameworks discussed chronologically would give a vivid idea about the strategies adopted by national and international organizations and studying their success and failures would help to analyze the present day condition.

11.2 Introduction

The following discussions in the subsequent paragraphs revels the status of national and international organizations for combating disasters by understanding their agendas, policy guidelines, aims and objectives and finally assessing their limitations to face the global challenge.

11.3 Disaster Management in India

The country India is exposed to many natural hazards due to its location and climatic conditions. It is in fact the most disaster prone areas of the world. The major natural hazards include floods, cyclones, droughts, and earthquakes. India being the second most populous country in the world with 1.2 billion populations and a developing economic base is very vulnerable to hazards and it takes only a few seconds to transform a hazard into a disaster. Striking disasters often cause significant damage to property and loss of life. The Government of India therefore recognizes the need to shift from a post disaster reactive approach to a pre-disaster pro-active approach which includes preparedness, mitigation, and prevention. The Government of India enacted the Disaster Management Act in 2005, adopted a National Policy on Disaster Management in 2009, and in 2015 adopted three International Agreements including the Sendai Framework for Disaster Risk Reduction. Sustainable Development Goals 2015-2030, and the Paris Agreement on Climate Change. The country has adopted a multi-hazard, and multi-sectoral strategy approach, which in turn will create a disaster resilient country.

India's propensity to fall a prey to disasters may be attributed to the following causes:

- Extreme population pressure
- Unplanned urban growth

- Industrialization
- Environmental degradation
- Development within high risk zones
- Climate change
- Human induced activities

11.4 Trend of Disasters in India

The trend of country's disaster shows that India has experienced a severe period of drought resulting in 1.5 million deaths between 1965 and 1967.India also suffers from periodic flooding and floods left approximately five million people homeless in 1999. The same occurred in 2007, displacing 3.5 million. Floods in August-September 2010 left around two million people homeless and cost dozens of lives in northern India. More than half of India is prone to earthquakes and New Delhi is reported to be one of the most earthquake prone cities in India because of its proximity to fault lines, suffering five earthquakes measuring 5.5 or higher in the past 300 years. The last major earthquake took place in Gujarat, India in January 2001 causing an estimated 25,000 deaths, and resulting in 600,000 to be homeless. Many deaths were caused by the collapse of substandard buildings. The Tsunami in December 2004, caused by an earthquake off the coast of Indonesia measuring 9.0, greatly affected the Indian islands of Nicobar and Andaman, and southern states of Tamil Nadu, Andhra Pradesh, and Kerala. This disaster resulted in more than 10,000 deaths in India.

INFORM is a global, objective, and transparent tool for understanding the risk of humanitarian crises. INFORM gives each country a risk score of 1 -10 (1 being the lowest and 10 the highest) for each of the dimensions, categories, and components of risk, as well as an overall risk score. The higher the score the more vulnerable a country is. The purpose of INFORM is to provide an open, transparent, consensus-based methodology for analyzing crisis risk at global, regional or national level.

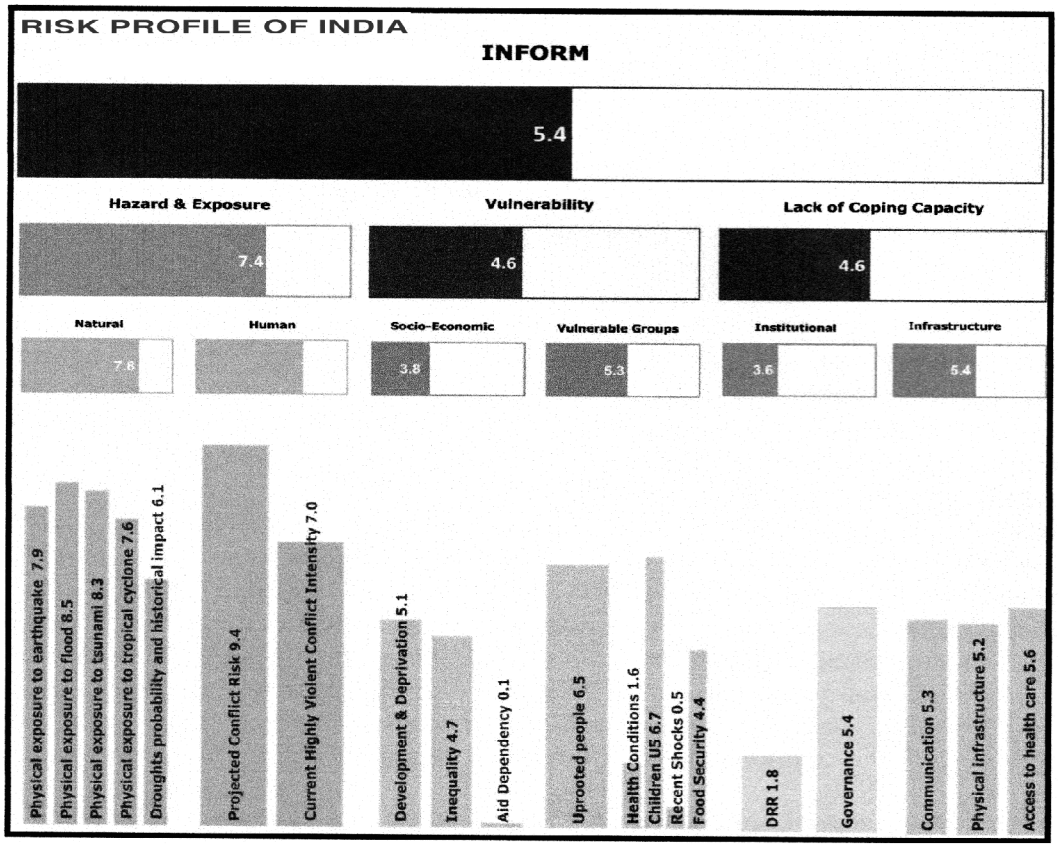


Fig. 11.1 INFORM: Country Risk Hazard and Exposure for India

11.5 Vision of India

To build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response.

11.6 Objectives of National policy

The objectives of the National Policy on Disaster Management are:

- Promoting a culture of prevention, preparedness and resilience at all levels through knowledge, innovation and education.
- Encouraging mitigation measures based on technology, traditional wisdom and environmental sustainability.

- Mainstreaming disaster management into the developmental planning process.
- Establishing institutional and techno legal frameworks to create an enabling regulatory environment and a compliance regime.
- Ensure efficient mechanism for identification, assessment and monitoring of disaster risks.
- Developing contemporary forecasting and early warning systems.

11.7 National Policies for Disaster Management in India

The Prime Minister of India serves as chairman of the **National Disaster Management Authority (NDMA)** in India. In **2005**, the Disaster Management Act established the ***NDMA***, as an organization for the institutional mechanisms of disaster management at the State and District levels. The **Vision** of the NDMA is *"To build a safer and disaster resilient India by a holistic, pro-active, technology driven and sustainable development strategy that involves all stakeholders and fosters a culture of prevention preparedness and mitigation"* The government of India determines to practice mitigation in order to prevent damage and destruction caused by natural and man-made disasters. The Indian government combines the efforts of all government agencies, Non-Governmental Organizations (NGOs) and active participation of people for combating disasters. India plans on achieving this by adopting a technology-driven, pro-active, multi hazard, and multi-sectoral strategy, which in turn will create a disaster resilient country.

The NDMA is responsible for the policies, plans, and guidelines, as well as to ensure timely and effective response to disasters. Therefore, it has the following responsibilities:

- Develop policies on Disaster Management
- Approve the National Plan
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan
- Create guidelines to be followed by the State Authorities in drawing up the State Plan
- Promulgate guidelines to be followed by the different Ministries or Departments of the Government of India for the Purpose of integrating the

measures for prevention of disaster or the mitigation of its effects in their development plans and projects

- Coordinate the enforcement and implementation of the policy and plans for disaster management
- Recommend provision of funds for the purpose of mitigation
- Provide such support to other countries affected by major disasters as may be determined by the Central Government
- Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with threatening disaster situations or disasters as it may consider necessary
- Establish broad policies and guidelines for the functioning of the National Institute of Disaster Management ***(NIDM)***

11.7.1 *National Policy on Disaster Management, 2009*

The National Policy framework has been prepared after due deliberation and keeping in view the National Vision to build a safe and disaster-resilient India by developing a holistic, proactive, multi-disaster and technology driven strategy for disaster management. In order to translate this vision into policy and plans, the NDMA has adopted a mission mode approach involving a number of initiatives with the help of various institutions operating at the national, state and local levels. Policies and guide lines are evolved after numerous consultations with central and state ministries and other stake holders in a consultative and participatory manner. This Policy framework is also in conformity with the International Strategy for Disaster Reduction, the Rio Declaration, the Millennium Development Goals and the Hyogo Framework 2005-2015.

The themes furnished in this policy are:

- Community-based disaster management, including last mile integration of the policy, plans and execution
- Capacity development in all related areas
- Consolidation of past initiatives and best practices
- Cooperation with agencies at the national, regional and international levels; and
- Compliance and coordination to generate a multi-sectoral synergy.

The objectives guiding the policy formulation from the national vision thus evolved includes:

- Promoting a culture of prevention and preparedness - by center-staging DM as an overriding priority at all levels and at all times
- Encouraging mitigation measures based on state-of-the-art technology an environmental sustainability
- Mainstreaming DM concerns into the development planning process
- Putting in place a streamlined institutional techno-legal framework in order to create and preserve the integrity of an enabling regulatory environment and a compliance regime
- Developing contemporary forecasting and early warning systems backed by responsive and fail-safe communications and Information Technology (IT) support
- Promoting a productive partnership with the Media, NGOs and the Corporate Sector in the areas of awareness generation and capacity development
- Ensuring efficient response and relief with a caring humane approach towards the vulnerable sections of the society
- Making reconstruction an opportunity to rebuild back better and construct disaster resilient structures and habitats

11.7.2 National Disaster Management Plan (NDMP), 2016

The National Disaster Management Plan *(NDMP)* provides a framework for and direction to government agencies for all phases of the disaster management cycle. The NDMP is updated periodically with emerging global updates on expanding knowledge base in disaster management. It is in accordance with the provisions of the Disaster Management Act, 2005, the guidance given in the National Policy on Disaster Management, 2009 (NPDM), and the established national practices. The (NDMP) specifies who is responsible for what at different stages of managing disasters. The NDMP is envisaged as ready for activation at all times in response to an emergency in any part of the country. It is designed in such a way that it can be implemented as needed on a flexible and scalable manner in all phases of disaster management: a) mitigation (prevention and risk reduction), b) preparedness, c) response and d) recovery (immediate restoration to build-back better).

The NDMP is consistent with the approaches promoted globally by the United Nations, in particular the Sendai Framework for Disaster Risk Reduction 2015-2030.India will endeavor to contribute to the realization of global targets by improving the entire disaster management cycle in India by following the recommendations in the Sendai Framework and by adopting globally accepted best practices.

11.8 International Policies on Disaster Management

Progress in diminishing the effects of natural hazards in future would require a fundamental shift in public perceptions of natural disasters. Hazard reduction policies and practices need to be integrated into the mainstream of community activities throughout the world. This process should build on successful programs, encourage national and international cooperation, and find new policies to be implemented for combating disasters. The result should be the widespread existence of new and expanded hazard reduction programs and policies that are compatible with the global communities.

The United Nations has been taking different measures since the 1970's in response to a diverse range of severe disasters which have claimed the lives of thousands of people. Disasters such as the earthquakes in Iran in 1962 and 1968, and hurricane Florida in October 1963, which devastated Cuba, Haiti, Jamaica, the Dominican Republic, and Trinidad & Tobago, and others. Recurrence of disasters and its devastating effect inflicted on a nations development especially the developing ones is disgraceful. So the need for an integrated approach for disaster management all over the world was the need for the hour. It thus led the United nations to take actions that would go beyond a simple reactive response to a more integrated approach, encompassing policies that are properly studied, planned and prepared for combating disaster situations to mitigate the effects of the disasters.

The development of these new approaches gradually took shape and became established over the 1970s and 1980s. Over these years the UN General Assembly passed several resolutions to promote the study, prevention and mitigation of natural disasters. Then, at the end of the 80s, the United Nations General Assembly decided to call the 1990's as the **"International Decade for Natural Disaster Reduction (IDNDR)"** with the aim of getting the international community, under the patronage of the United Nations, to focus special attention on instigating international cooperation for natural disaster reduction. The basic objective of IDNDR was to decrease the loss of life, property destruction and social and economic disruption caused by natural

disasters, such as earthquakes, tsunamis, floods, landslides, volcanic eruptions, droughts, locust infestations, and other disasters of natural origin. For the purpose of getting the IDNDR started, on 1 January 1990 the General Assembly adopted Resolution 44/236 of 22 December 1989, *"The International Framework of Action for the International Decade for Natural Disaster Reduction"*, which represented the first tool for coordinated international action to reduce such disasters.

To fulfil the mandates established within the International framework of action, at the proposal of the scientific and technical committee, a World Conference of representatives of national committees for the IDNDR was convened from 23 to 27 May 1994 in Yokohama (Japan). Almost 155 countries took part at the conference where the results of the first period within the plan of action for the Decade were analyzed, actions prioritized to carry out were discussed, and approval was given for the *"Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation"* which was adopted by the UN General Assembly under Resolution.

Table 11.1. Global framework of International policies for Disaster Management and reduction.

1989	The International Framework for Action for the International Decade for Natural Disaster Reduction (annex of res. 44/236): Call for concerted international action for natural disaster reduction, technical & scientific buy-in
1994	The Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action. First blueprint for disaster reduction policy guidance (inclusion of a socio-economic perspective), enlarging the initial concept of disasters to include environmental and technological disasters Emphasis on community-based approaches to vulnerability (introduction of resilience)
1999	The International Strategy for Disaster Reduction: Developed new mechanisms and pushed for further commitments from policy-makers. The General Secretary urged: "We must, above all, shift from a culture of reaction to a culture of prevention. " Focus on risk assessment and management
2004	The Hyogo Framework for Action (2005-2015): Integrated disaster risk reduction into policies, plans and programmes of sustainable development and poverty reduction, focusing on national implementation, through bi-

	lateral, multi-lateral, regional and international cooperation. It is known as the first plan to explain, describe and detail the work that is required from all different sectors and actors to reduce disaster losses
2015	The Sendai Framework For Disaster Risk Reduction (2015-2030)

11.8.1 The Yokohama Strategy (23rd to 27th May 1994)

Appealed to promote the concept of prevention from disasters to be the most effective means to reduce disasters, as is evidenced by the principles upon which is based its Plan of Action:

- Risk assessment
- Integration of disaster prevention and preparation for disaster events into development policy and planning at national, regional, bilateral, multilateral and international levels
- Development and strengthening of capacity to prevent and reduce disasters and to mitigate their effects on a national, regional and international level
- Early warning of disasters and effective dissemination of information

After the IDNDR was over, it was necessary to examine the successes achieved so far and to discuss the guiding principles for international action to reduce disasters in the future. For this the ***"International Decade for Natural Disaster Reduction (IDNDR) programme forum"*** **was organized, which took place in Geneva from 5 to 9 July 1999.** At the Forum the relevance of implementing the IDNDR 10-year programme was stressed and in its conclusion the forum called on the international community and the United Nations to build on the progress achieved so far over the decade with the intention of ensuring risk management and disaster reduction to become the key elements in the policies of governments.

At the end of IDNDR it urged the UN system to support and consolidate the organizational structure to incorporate activities aimed at disaster reduction after the end of the decade and to adopt the International Disaster Reduction Strategy *"A safer world in the 21st century"*, which was approved at the forum. The secretariat (UNISDR) and the inter-agency task force provided continuation of the Yokohama Plan of Action within the ***International Strategy for Disaster Reduction (ISDR)*** **2000,** which succeeded the decade as the instrument for coordinated action by the

international community to reduce disasters. Thus the IDNDR was replaced and continued in the name by the *International Strategy for Disaster Reduction* (ISDR). The ISDR specified its purpose as *"to enable societies to increase their resilience to natural, technological and environmental disasters and hazards and to reduce associated environmental, human, economic and social losses"*. The prime goal therefore was to reduce human, social, economic and environmental losses due to natural hazards (and related technological and environmental disasters) with the building of disaster resilient communities.

11.8.2 Objectives of the ISDR

The ISDR worked with the following four objectives as tools towards reaching disaster reduction for all:

— Increase public awareness to understand risk, vulnerability and disaster reduction globally.

— Obtain commitment from public authorities to implement disaster reduction policies and actions

— Stimulate interdisciplinary and inter-sectoral partnerships, including the expansion of risk reduction networks

— Improve scientific knowledge about disaster reduction

In late 2001, with the intention of examining implementation of the Yokohama Strategy and Plan of Action in the context of the framework for implementing the ISDR, the UN General Assembly gave its approval to convene the 2nd World conference on Disaster Reduction, which was held from 18 to 22 January 2005 in Kobe, Hyogo, (Japan) and was attended by some 168 UN Member States.

11.8.3 Hyogo Framework for Action:

With consensus from about 168 participating countries, approval was given at the conference for the *"Hyogo Framework for Action (2005—2015)*. The main goal for this forum was to build the resilience of nations and communities to disasters", as the successor to the Yokohama Framework for Action. The framework was established with the general intended objective for 2015 as "The substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries". To achieve this outcome, the framework set three strategic goals that should guide the actions to be undertaken:

- The more effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels, with a special

emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction.

- The development and strengthening of institutions, mechanisms and capacities at all levels, in particular at the community level, with potential to systematically contribute to building resilience to hazards.
- The systematic incorporation of risk reduction approaches into the design and implementation of emergency preparedness, response and recovery programmes in the reconstruction of affected communities

Backed by a broad consensus the Hyogo Framework for Action have laid down the following tasks and duties;

For the States:

- To designate suitable national coordination mechanisms for the implementation and follow-up of the Framework for Action and report information to the ISDR secretariat.
- To make national assessments of the status regarding Disaster Risk Reduction (DRR) and share this information with the relevant regional and international bodies.
- To perform periodic examination of the progress made nationally in implementing the Framework for Action and send a situation report to existing international frameworks for this puipose.

For Regional Organizations and Institutions:

- To set up specialized regional collaborative centres or strengthen those already in existence to undertake research, training, education and capacity building in the field of disaster risk reduction.
- To coordinate and publish periodic reviews on progress in the region and on impediments and support needs, and assist countries as requested in the preparation of periodic national summaries of their programmes and progress in implementing the framework.

For International Organizations:

- To develop standards, keep databases and devise indicators and indices, among other actions, to support states in preparing national assessments and situation reports in relation to implementation of the framework.

To address these demands the UN General Assembly approved the creation of the Global Platform for Disaster Risk Reduction, which would act as a world forum for coordinating and reviewing progress in implementing the framework. Setting up and managing the global platform was entrusted to the UNISDR Secretariat, which drew up the procedures for it to come into operation, which it did in 2006.

The establishment of this global platform in 2006 represented a cornerstone of the UN system for disaster reduction. The first meeting of the global platform took place from 5 to 7 June 2007 in Geneva and since then it has consistently met on a biennial basis to examine progress in implementing the international instruments used in disaster risk reduction. It is currently the leading world forum for strategic advice, coordination and review with respect to concerted international frameworks for disaster reduction.

11.8.4 The Sendai Framework for Disaster Risk Reduction (2015-2030)

The Third World Conference, at the end of Hyogo framework, on Disaster Risk Reduction, that took place in the Japanese city of Sendai from 14 to 18 March 2015 was to establish a new framework for action to strengthen the international community's commitment towards combating disasters. The result was the approval of the **"Sendai Framework for Disaster Risk Reduction 2015-2030".** It is based on recognition of the success achieved by its predecessor and assumes addressing the challenges after 2015 and obtain significant disaster reduction by 2030. For achieving this it is necessary to shift the conceptual focus from disaster management to disaster risk management. It represents a 15-year plan of action that defines seven global targets and four priority areas for action (see Table 11.2) aimed at enhancing the capacity of communities to face challenges and manage the risks around them so that they can build up their resilience and consequently reduce damage in relation to the threats to which they are exposed.

Table 11.2: Summary of the Sendai Framework for Disaster Risk Reduction 2015-2030

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION (SFDRR) 2015-2030

Expected outcome for 2030	The substantial reduction of disaster risk and losses in lives, livelihoods outcome and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries

Goal	Prevent new disasters and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience

SEVEN GLOBAL TARGETS

Four Targets to be Reduced by 2030	Three Targets to be increased by 2030
Reducing global disaster mortality and manage to bring down the average global mortality rate per 100,000 persons in the 2020-2030 decade compared to the 2005-20 1 5 period	Increase the number of countries with national and local disaster risk reduction strategies by 2020
Reduce the number of affected people globally. Lowering the average global figure per 100,000 persons in the 2020-2030 decade compared to the 2005-2015 period	Enhance international cooperation through adequate and sustainable support to complement their national actions for implementation of the Framework by 2030
Reduce economic loss caused directly by disasters in relation to gross domestic product (GDP) by 2030	Increase the availability of early warning systems and information for the population
Reduce damage caused by disasters to critical infrastructure and the disruption of basic services	

FOUR PRIORITIES FOR ACTION

Priority 1	Understanding disaster risk
Priority 2	Strengthening disaster risk governance to manage disaster risk
Priority 3	Investing in disaster risk reduction for resilience
Priority 4	Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

As a response to the Sendai Framework mandate an open-ended intergovernmental working group of experts were set up by the UN General Assembly to assess disaster damage for states, study indicators and terminology relating to disaster risk reduction. After completing its assignment, the working group issued a report with recommendations on global indicators associated with the global goals in the Sendai Framework for Disaster Risk Reduction 2015-2030, which was adopted by the General Assembly via Resolution 71/644 of 1 December 2016.

2015 has been a determinant year for international development policies. The adoption of the Sendai Framework in March was followed by two other major negotiations:

a) the United Nations summit for the adoption of the post-2015 development agenda (in New York, September 2015), and

b) the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (in Paris, in November-December 2015) to discuss a new climate agreement to succeed the Kyoto Protocol

The above paragraphs give a brief outline of the several international policies for combating global disasters.

11.8.5 Potentialities and Limitations of SFDRR

The ***SFDRR*** is a culmination of international efforts adopted by 187 UN member states to build a global agreement on disaster risk reduction

Potentialities of the SFDRR

The scope of the SFDRR is broad and includes threefold actions:

1. To prevent further creation of risks,
2. To reduce the existing risks, and
3. To strengthen the resilience of countries to reduce risks

From the above points two new concepts emerges on the most vulnerable communities of developing countries, as discussed below:

Migrations of victims - The SFDRR puts down that almost 144 million people were forced to migrate from their homes over the last 10 years due to disasters so it must incorporate effective policies to include provisions for accommodating them to safe shelters.

Protecting Livestock - The SFDRR includes the need to keep livestock and working animals safe during disasters.

11.8.6 Limitations of SFDRR

The SFDRR is also not free from challenges and three main areas have been noticed:

Firstly, in spite of the positive achievement of the establishing seven targets, the SFDRR fails to explain the vague terms like "substantially" incorporated in the framework.

Second, the absence of mention of conflict throughout the SFDRR is political rather than technical

Thirdly, to solve the issue of financial inadequacy financial aid must be enhanced from international cooperation to adequately support developing countries.

11.9 The 2017 Global Platform

The 2017 Global Platform for Disaster Risk Reduction was organized in conjunction with the Mexican government at Cancun from 24 to 26 May 2017 to review the efforts made globally to implement the Sendai Framework in the last two years. The 2017 Global Platform played host to over 5,000 delegates across a forum of world leaders, two ministerial round tables, four plenary sessions, two special sessions, 15 working sessions and numerous special events. Discussions in all the sessions managed to indicate the following issues before implementing the Sendai Framework in the next few years:

- A need to monitor the implementation of the Sendai Framework.
- A need to substantially increase the number of countries with national and local disaster risk reduction strategies by 2020.
- The Sendai Framework should be consistent with the agendas for sustainable development and climate change.
- A need to establish new alliances for developing tools, technologies and methodologies for reducing disaster risks.

The above mentioned international policies for disaster management shows how advancement has taken place over the years for combating the rising trends of disasters.

Conclusion

There has been a dramatic increase in diasasters and the damages caused by disasters in the recent past. Over the past decade, the number of natural and manmade disasters has been unavoidable. Accordingly to the statistics, the number of diasasters per year increased 60% during the period 1999-2001 and the highest increase was noted in the countries of low human development. In general, the disaster management policy responses are influenced by various methods and tools for cost-effective plans and sustainable mediation. However, there are no long-term, inclusive and coherent institutional arrangements to address the global disaster issues with a long term vision. The integrated planning between these sectors is almost lacking between disaster management, development planning and environmental management institutions. Absence of a central authority for integrated disaster management policies and lack of their coordination within and between disaster related organizations creates a problem for both state level or international agencies during adoption of disaster preparedness and mitigation policy measures. Thus in conclusion, it may be stated that with a greater capacity of the individual and community awareness the disasters or their impact could be reduced by following the policy frameworks of both national as well international levels and by carrying out an integrated planning at the global as well as at the state level.

11.10 Summary

To sum up it was noticed that the last decade of the new millennium witnessed many changes in the national and global frameworks for reducing and mitigating disasters. The national and global agendas and policy frameworks thus discussed above chronologically would give a vivid idea about the strategies adopted by both the national and international organizations. Studying about the success and failures of each interventions would help us to analyze the present day conditions and cope disasters better in future.

11.11 Key Words/Glossary

1. **Resilience:** The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions.

2. **Response:** The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.
3. **Disaster Risk Reduction Plan:** A document prepared by an authority, sector, organization or enterprise that sets out goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives.
4. **Climate Change** :(a) The Inter-Governmental Panel on Climate Change (TPCC) defines climate change as: "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/ or the variability of its properties, and that persists for an extended period typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use".

   (b) The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".
5. **Capacity Development:** The process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions.
6. **Prevention:** The outright avoidance of adverse impacts of hazards and related disasters.

11.12 Assessment questions

1. Discuss the trend of rising disasters in India. Why is it necessary to have proper policies to address disasters?
2. What is INFORM? What are its findings? What are the objectives of National Disaster management policies of India?
3. Explain the international policies on disaster management. What are the seven global targets?

4. Explain the Sendai Framework for Disaster Risk Reduction. Discuss its potentialities and limitations.
5. What are the objectives of National Disaster Management Policy of India? Explain in detail the policies enacted so far.

11.13 Further Readings

1. Handmer. John, Dovers Stephen (2013), Handbook of Disaster Policies and Institutions; Improving Emergency Management and Climate Change Adaptation, 2nd Edition, Routledge.
2. India Disaster Management Reference Handbook, August 2018
3. Sena. Lelisa, Michael. W. Kifle (2006), Disaster prevention and Preparednes, Produced in collaboration with the Ethiopia Public Health Training Initiative, The Carter Center, the Ethiopia Ministry of Health, and the Ethiopia Ministry of Education.
4. Asia report on "The Sendai Framework For Disaster Risk Reduction A Three Year Outlook (2036-2018) At A Global Shift", February 2016.
5. Government of India, Ministry of Home affairs,'' National Policy On Disaster Management 2009" Approved by the Union Cabinet on 22nd October, 2009.
6. Gupta K Harsh, (2003), Disaster Management, published by University Press.
7. Coppola P. Damon, (2015) "Introduction to International Disaster Management", published by Butterworth-Heinemann; 3 edition

Unit-12 □ Role of Geospatial Technologies (RS and GIS) in Disaster Management

Content Structure

12.1 Learning Objective

The primary objective of the study of geospatial technologies in disaster management is to utilize the technology to save mankind from the wraths of nature and man-made disasters. With the rapid advancement of scientific knowledge and expansion of scientific technologies it is the need of the hour to incorporate them in studies for managing and overcoming from severe disasters and help mankind to survive in this beautiful world.

12.2 Introduction

India is vulnerable to both natural and manmade disasters. All disasters vary in time and space. GIS techniques helps to identify the disaster prone areas, detect its

vulnerability and act as a decision making tool for analysis of its severity and impact with the help of different GIS layers, presently socio-economic and geo-spatial data retrieved through the use of various technologies are used for management and planning of disasters along with tackling the disastrous condition. GIS, RS & GPS along with evolution of computer technology is helpful for rapid expansion of geospatial technologies for managing, predicting and helping to mitigate the disasters.

Preparing maps in advance using GIS technology for hazard zone mapping helps during emergency conditions to evacuate people and manage the disaster efficiently. Real time geographic data is helpful in improving the allocation of resources for response. GIS technologies are much in use for modeling of a disaster and anticipating its risks and human adaptations to hazards.

12.3 What are Geospatial Technologies?

Geospatial technologies refer to all collective systems that acquire, store and handle remotely located specific data and information about the surface of the earth. Geospatial technologies are comprised of various **Remote Sensing** techniques (Active and Passive Sensors, Satellites, Radar, Sonar, etc), the Global Navigation Satellite System (GNSS) and software's like Geographic Information System (G.I.S).

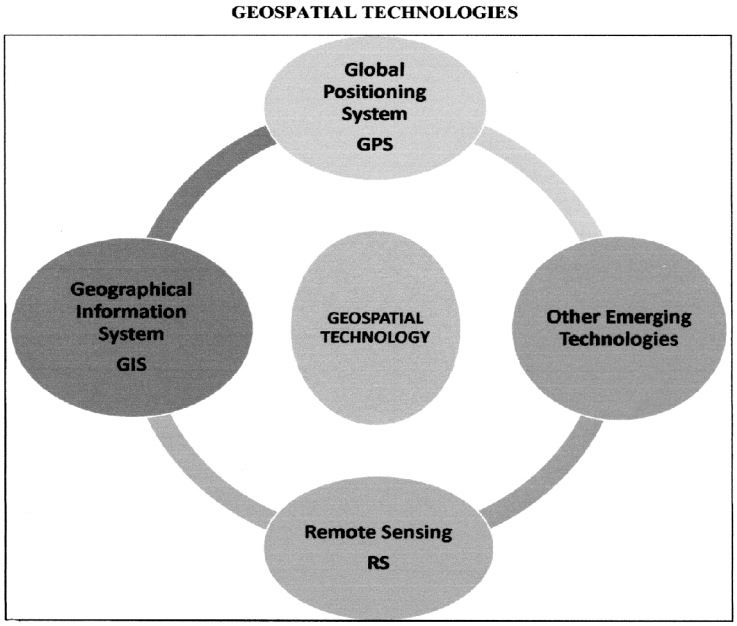


Fig. 12.3.1

Source : Modified from Havell, 2014

12.4 What Are Geospatial Tools?

The term geospatial refers to those interdependent resources such as maps, data sets, tools, and procedures that tie every event, feature, or entity to a location on the earth's surface and use that information for a particular purpose. Geospatial tools can take many forms including paper maps; in-car navigation systems; Internet sites; software and databases of local governments; and analytical, mapping, and visualization tools that support decision-making in private and public-sector organizations.

12.5 Types of Geospatial Data and Tools

1) **Remote sensing** is the collection of data from a wide range of automated systems, including satellites and aircraft, and ground-based sensors and surveillance cameras.

2) **Geographic information systems** (GIS), which are among the most important and widely used of geospatial tools, are software systems used to capture, store, manage, analyze, and display geospatial data resources. A coordinate system is used as an organizing principle for these data resources.

3) **Computer-assisted design (CAD) systems** are widely used to create and manage three-dimensional digital models of buildings and other engineering structures. When accurately registered to the earth's surface, CAD data can be combined with other geospatial data.

4) **Clearinghouses, Geo-libraries, Archives, Geoportals, and Geo-browsers** are web sites that provide access to large collections of geospatial data sets.

5) **Spatial decision-support systems** (SDSS) provide decision-makers the information they need when decisions involve location. They are designed to make comparisons between many possible alternatives.

12.6 Role of Geospatial Technologies in Disaster Management

Geospatial technologies have widespread applicability in assessing and predicting disaster vulnerabilities all over the world. Acquiring spatial data for effective planning and collaborative decision making in disaster management is gaining acceptability among planners and scientists. Interesting intergovernmental initiatives with the goal of promoting scientific networks for earth observation systems were

setup like the *Global Earth Observation System of Systems* (GEOSS), which comprises of 88 nations, the European Commission and 64 international organizations and the *Infrastructure for Spatial Information in Europe* (INSPIRE) that has emerged as an action of the European Commission to promote the accessibility of geo-information in the formulation, implementation and evaluation of policies of the European Union. Another notable data sharing in the context of natural disasters is the Network-Centric Operations (NCO), originated in the US Department of Defense (DoD) in 1996.

Combating disasters require a holistic approach of integrated solutions that include site specific ground emergency response network coupled with well-informed digital databases supported by various geospatial technologies. Analyzing digital data and preparing maps for visual interpretation and assessing the spatial applications of various techniques are essential in predicting pre, during, and in post phases of disaster management and response.

12.7 Importance of Geospatial techniques in Disaster Management

(1) The fast dissemination of the disaster information and news through the virtual communities through various innovative means (e.g., mobile phones, mashups, crowdsourcing)

(2) Disaster risk reduction and resilience can be studied only through interdisciplinary approaches where geospatial techniques and other technologies are correlated

(3) Improve general awareness and communication through spatial data; via the Internet (the underwater cables) and the World Wide Web (telegraphy and news agencies)

(4) Developing long-term strategies for recovery efforts, risk reduction, restoration, and monitoring programs.

(5) Formation of online disaster communities, made up of the victims and their families, governments, news outlets, non-governmental organizations, humanitarian aid groups, and an interested public, form in response to cataclysmic events.

(6) The integration of the internet with GIS applications has been applied to such

areas as 3D real-time emergency response, serving maps on the internet for emergency escape routes, and mobile GIS and digital video for urban disaster management.

(7) Geospatial modeling has been used for such things as determining evacuation routes, tracking hurricanes, and ascertaining refugee populations.

(8) The geospatial technology enhances the ability for interactive communication of relevant information quickly and efficiently, provided people have the means to access the technology

(9) Different types of information can be made rapidly available that depict the geographic extent of the event, and satellite images provide a bird's-eye view of the location.

(10) People living around the world have the opportunity to learn about the human tragedy that results from a disaster, and this fosters a sense of global community. This sharing of knowledge of place and disaster is one of the main characteristics of the *global village.*

(11) The integration of mapping, Global Positioning Systems, satellite imagery, and interactive geographic information systems provides important opportunities for developing and sharing information on disasters. *"Technological gift giving"* during disaster events has resulted in special licensing arrangements, innovative data sharing, and new applications. Mashups—the mixing of hybrid web applications from multiple sources—combine satellite imagery with maps and geospatial data helps to provide data for planning a discourse.

(12) Maps and satellite images are ubiquitous throughout the online disaster landscape. Global and regional consortiums provide technical advice about disaster response, training opportunities for GIS disaster applications, direct access to satellite imagery, technical help in processing digital data, and links to other information portals.

These are a few organizations that provide the international community with disaster recovery plans, geographic information and they aim to universalize the access to satellite imagery. The names of such organizations are *United Nations Institute for Training and Research* **(UNITAR),** *Operational Satellite Applications Programme* **(UNOSAT),** which provides the international community with *The Radio and Internet for the Communication of Hydro-meteorological Information for*

Rural Development **(RANET)** project and uses internet technology to disseminate early warning information, satellite imagery, weather, and climate data to rural areas. ***GIS Corps*** coordinates short-term, volunteer GIS services to underprivileged communities worldwide. Immediately after the Haitian earthquake, *Map Action* had a team on the ground to assist in relief coordination through developing maps of relief deliveries.

12.8 Using Geospatial Information in Emergency Management Cycle

All disasters have a temporal and spatial footprint on the earth's surface. The goal of all types of disaster management policies is to reduce the impact of disasters on the communities to the lowest degree. Using geospatial tools, responders can determine where impacts are greatest, locate damaged buildings or injured residents so that they are able to act more quickly, especially during the critical period immediately after the event when there is the greatest possibility of saving lives. To address the issues and challenges of a post disaster phase the emergency management professionals have specified a host of activities that are important at alleviating the losses that disasters inflict. This approach, known as **Comprehensive Emergency Management,** specifies four phases of modern disaster management: preparedness, response, recovery, and mitigation (Fig no 2). Each of these phases can be improved upon with the help of geospatial technologies.

12.9 Phases of Disaster Management with Geospatial Tools

1) **Preparedness:** Preparedness refers to the readiness of a community to face a disaster and involves in activities undertaken in the short term before a disaster strikes. It includes the readiness of organizations and communities to respond effectively. During this phase, hazards can be identified and plans can be developed to address the situation. From the **geospatial perspective,** preparedness objectives include identifying data requirements, developing data sets, and sharing data across agencies. The **geospatial tools** can be used to display the distribution of hazards and risks as they exist now and risks as they may exist under different future development scenarios. This enables local and regional planners to work with emergency managers to plan for more sustainable futures through the avoidance or mitigation of higher-risk alternatives.

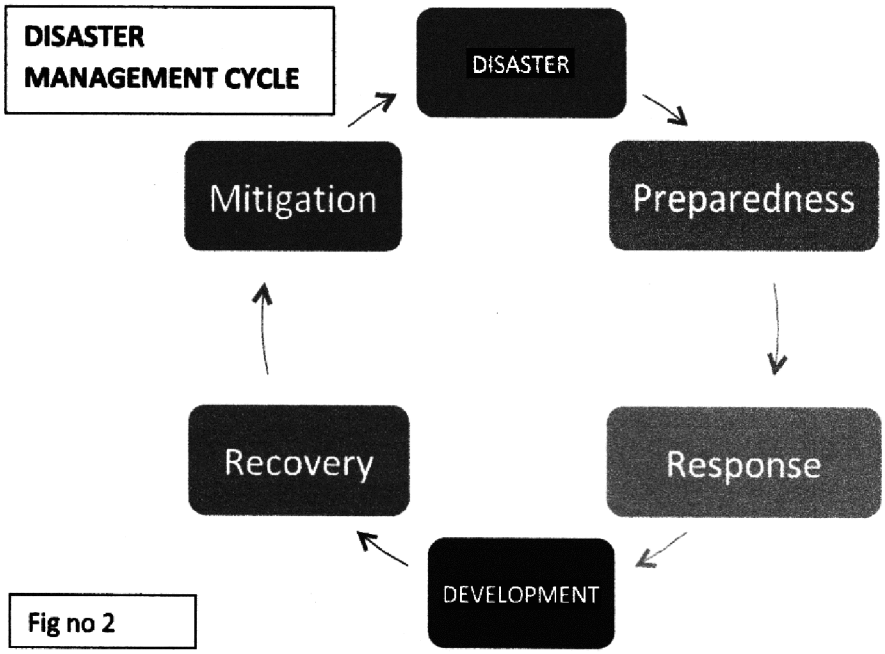


Fig no 2

2) **Response:** Response activities refers to all the ventures and tasks that are undertaken immediately following a disaster to provide emergency assistance to victims. The response phase starts with the onset of the disaster and is devoted to reducing life-threatening conditions, providing life-sustaining aid, and stopping additional damage to property. **Geospatial information** and analysis are important inputs in management and decision making. Activities during this period include image acquisition, processing, analysis, distribution, and conversion to information products. Other geospatial data are collected, collated, summarized, and converted into maps, reports, and other information products. During the response phase immediately following an event, geospatial models can also be used to provide damage estimates (e.g., immediately after an earthquake). Example stream gauge data can be issued for flood warnings or the use of Doppler radar data, can be used for warning from severe thunderstorms and cyclonic activity.

3) **Recovery:** Recovery refers to a state where the normal state is retrieved and includes several short- and long-term activities undertaken after a disaster. **Geospatial activities** during recovery phase include the use of geospatial information and analysis to help managers direct the recovery process. Important task being capturing and archiving geospatial data collected as part

of the disaster management cycle, along with the procedures that were used to turn those data into information and then to disseminate the information, to the mass. These data can be used to inform mitigation, planning and research about disaster processes.

4) **Mitigation:** Mitigation refers to diminution of the impact of disaster and includes those activities undertaken in the long term that are designed to prevent emergencies and reduce the damage. Mitigation involves implementing policy changes and new strategies by identifying and modifying hazards, assess and reduce vulnerability to risks, and diffusing potential losses. Geospatial assets can inform mitigation planning in important ways, like the opportunity to visualize and measure the effects of disasters through Simulation Models (e.g., to prepare a model for studying the inundation area from changes in stream elevations with or without the presence of levees). It can help planners to make redevelopment decisions based on cost -benefit analysis by comparing the cost of changes and estimates of the savings that result when a hazard is mitigated. Geospatial tools are particularly beneficial for being able to permit the evaluation of multiple alternatives at the same time.

Thus in cases of all phases of emergency disaster management cycle, geospatial data and tools have been used and it shows how it has the potential to help save lives, reduce damage from disasters and cut down on costs incurred during emergencies. Great progress has been made in the last four decades in the development of geospatial data and tools, such as remote sensing, satellite imaging, GPS and Geo-browsers that gives the exact locations of objects on the Earth's surface and makes it easier for anyone to not only witness the magnitude of a disaster but plan for rescue and recovery accordingly.

12.10 Challenges of using Geospatial Information

Although use of geospatial technologies has proved to be beneficial in case of emergency management as well as for predicting disasters but it is not rid of its limitations. A huge amount of data acquired is frequently scattered under several jurisdictions in different and often incompatible formats. Large amount of data is either under government agencies or is maintained by the private sectors. Now the problem arises when they are unwilling to share the data on grounds of security and restrictive agreements. Additional problems arise when for being unable to make use

of information's is due to lack of knowledge, training and operational infrastructure in the backdrop of constantly changing technological environment.

12.11 Future emergency management

- Governments should be strengthened to include the full range of various agencies and sectors that share geospatial data and tools, in order to provide strong national leadership.
- The problem of data security should be addressed through a system that would restrict access to appropriately authorized emergency management personnel through proper scrutiny.
- Personal, technical and procedural problems to be addressed through intensive preparedness exercises by groups involved in all aspects of disaster management.
- Local, federal and central governments should take up the issue of lack of funding in geospatial technologies for emergency disaster managements in annual budgets to increase the nation's level of geospatial preparedness
- Academic institutions offering emergency management curricula should emphasize on acquiring knowledge on geospatial data sharing and programs. Geospatial professionals should also receive increased training in emergency management processes and practices.
- Effective policies are required for backing up geospatial data and keeping the data sets in geographically separate locations. The geospatial data collected during the recovery and response efforts may be extremely useful in future for preparing models or further research, but it is disappointing because these data are often not archived.

  Satellite imagery has been increasingly used in the recent years for analyzing hazardous areas. Previous applications of satellite imagery were ASTER, Landsat, or SPOT data that focused on the detection and assessment of ice avalanches, monitoring large landslides, and debris flows mapping. However, with the development of the spatial resolution of satellite imagery (high and very high resolution), different types of problems otherwise difficult are now being able to be analyzed, investigated, identified, and extracted, thereby helping to calibrate and validate the susceptibility to build models. Different

types of high-resolution remote sensing used for preparing the inventory maps for different types of natural hazards, are Google Earth (<l-m resolution), IKONOS (0.81-m resolution), Quick bird (0.6-m resolution), Astro Digital (5-m resolution), Orb View-3 (1-m resolution), SPOT-5 (2.5-m resolution), and Geo-Eye panchromatic satellite images (0.5-m resolution).

Thus geospatial technologies and GIS database with various themes and sub themes helps us to manage disasters efficiently when such catastrophic events occur.

12.12 Summary

To sum up the study of geospatial technologies in disaster management it must be made has been clear that giospatial technology today is an indispensible tool for analysing, predicting and combating disasters over the globe. It is the knowledge to use this technology that matters to save the mankind from the wraths of nature and man-made disasters. With the rapid advancement of scientific knowledge and expansion of scientific technologies it is now the need of an hour to incorporate them in studies for managing and overcoming severe disasters and help mankind to survive in this beautiful world. The entire concept has been discussed lucidly by defining geospatial technologies, its role, importance, phases of utilization and chellenges. The future scope of the study has also been discussed for future management needs.

12.13 Key Words/Glossary

1. **Digital Data** - In a most generalized way, a digital image is an array of numbers depicting spatial distribution of a certain field parameters (such as reflectivity of EM radiation, emissivity, temperature or some geophysical or topographical elevation.
2. **Digital Image Processing** - Digital Image Processing is a collection of techniques for the manipulation of digital images by computers. Three steps of DIP are Preprocessing, Display and enhancement and Information extraction
3. **Geographic Information System (GIS)** - GIS is a system of hardware, software, data and personnel to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information
4. **Global Positioning System (GPS)** - A network of satellites continuously transmit coded information, which makes it possible with help of an instrument (hand held or vehicles) to precisely identify locations on earth by measuring distance from the satellites.

5. **Geoinformatics** - Geoinformatics is the science and technologies which develops and uses information science and computer infrastructure to address the problems of geography, geosciences, related branches of engineering etc. Geoinformatics combines geospatial analysis and modeling, development of geospatial databases, information systems design, human-computer interaction and networking technologies. Geoinformatics is a broader term covering Remote Sensing, GIS, GPS & Internet Mapping Services.

6. **Remote Sensing** - Remote Sensing is the science and art of obtaining information about phenomena through the analysis of data acquired by a device that is not in direct contact with the object, phenomena or area under investigation.

7. **Radiometric Resolution** - Radiometric Resolution or radiometric sensitivity refers to the number of digital levels used to express the data collected by the sensor. It is commonly expressed as the number of bits (binary digits) needs to store the maximum level. For example, Landsat TM data are quantized to 256 levels (equivalent to 8 bits). Here also there is a tradeoff between radiometric resolution and signal to noise. There is no point in having a step size less than the noise level in the data. A low-quality instrument with a high noise level would necessarily, therefore, have a lower radiometric resolution compared with a high-quality, high signal-to-noise-ratio instrument. Also higher radiometric resolution may conflict with data storage and transmission rates.

8. **Spatial Resolution-** Spatial Resolution of an imaging system is defines through various criteria, the geometric properties, of the imaging system, the ability to distinguish between point targets, the ability to measure the periodicity of repetitive targets ability to measure the spectral properties of small targets.

9. **Spectral Resolution** - Spectral Resolution refers to the width of the spectral bands. As different material on the earth surface exhibit different spectral reflectances and emissivities. These spectral characteristics define the spectral position and spectral sensitivity in order to distinguish materials. There is a tradeoff between spectral resolution and signal to noise. The use of well -

chosen and sufficiently numerous spectral bands is a necessity, therefore, if different targets are to be successfully identified on remotely sensed images.

10. **Temporal resolution** - Temporal resolution refers to the frequency with which images of a given geographic location can be acquired. Satellites not only offer the best chances of frequent data coverage but also of regular coverage. The temporal resolution is determined by orbital characteristics and swath width, the width of the imaged area.

12.14 Assessment questions

1. What do you mean by Geospatial technologies? What are the various tools used by geospatial technologies?
2. Discuss the role and significance of geospatial technologies in addressing disasters.
3. How is geospatial technology helpful in emergency management?
4. What are the various phases of disaster management using geospatial tools?
5. What are the key challenges of using geospatial tools? What is the future of Geospatial Technology in managing disasters?

12.15 Further Readings

1. National Research Council 2007, Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management. Washington, DC: The National Academies Press. https://doi.oiu/iu.i 7226/11793
2. Nayak. Shailesh, Zlatanova Sisi (2008), Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters, published by Springer-Verlag Berlin Heidelberg
3. Tomaszewski Brian, (2014), Geographic Information Systems (GIS) for Disaster Management 1st Edition, published by Routledge
4. Zlatanova Sisi, Li Jonathan, edited (2008), Geospatial Information Technology for Emergency Response, Taylor & Francis Group, London, ISBN 978-0-415-42247-5

5. Nair. S. Srija, (2012), Training Module Geoinformatics Applications in Disaster Management, Published by National Institute of Disaster Management, Ministry of Home Affairs, New Delhi - 110 002

6. Johnson Russ, (2000), GIS Technology for Disasters and Emergency Management, by Environmental Systems Research Institute, Inc., USA.

7. Oosterom. Van. Peter, Zlatanova Siyka, Fende M Elfriede, (2005), Geo-information for Disaster Management, published by Springer Berlin Heidelberg New York.

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