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Indira Gandhi National Open University
School of Social Sciences

BPAG-171
DISASTER MANAGEMENT

"शिक्षा मानव को बन्धनों से मुक्त करती है और आज के युग में तो यह लोकतंत्र की भावना का आधार भी है। जन्म तथा अन्य कारणों से उत्पन्न जाति एवं वर्गगत विषमताओं को दूर करते हुए मनुष्य को इन सबसे ऊपर उठाती है।"

— इन्दिरा गांधी

"Education is a liberating force, and in our age it is also a democratising force, cutting across the barriers of caste and class, smoothing out inequalities imposed by birth and other circumstances."

- Indira Gandhi

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Course Contents

INTRODUCTION

Disaster, natural or human induced, is an unwelcome guest and leaves a permanent impression of its visit on the victims. Disasters play havoc with the lives of people. They cause excessive losses to the humanity and infrastructure. Due to disasters, the normal life is thrown out of gear and the existing patterns of regulatory and development administration suffers heavily. The economic, social and psychological dimensions of the wrath of disasters adversely affect the environment around. Frequencies as well as intensity of natural disasters are increasing globally including India. Disaster impacts are felt more in developing countries due to borderline economic status of the vulnerable population, which have inadequate adjustment capacity. India, with a wide range of climatic and topographic conditions, is subject to various types of natural disasters like floods, cyclones, droughts, earthquakes, etc., in various degrees. Ever since, disasters have been causing substantive loss to the community and the exchequer. It not only stalls the ongoing functioning and pattern of life, but puts on hold the development actions planned in the nearby future as the fund earmarked for such development is diverted to disaster relief and response.

There are elements at risk with regard to each disaster. Risk is not an inherent property of a hazard alone. The weak structures are more at risk. It depends on the fury of the disaster as well as the vulnerability of the affected region. Thus, the local communities are required to be prepared to face the aftermath of the disasters effectively. The first step in this direction is to undertake vulnerability analysis, which brings to light the elements at risk such as the population, buildings and infrastructure. The most vulnerable members of the community are the expectant and lactating women, single women, children, old, disabled, handicapped, sick and ailing people. Their needs have to be kept in view while making the analysis. Likewise, the physical vulnerability elements have to be recognised by the community for the purpose of initiating specific measures to reduce the extent of losses in their regions. The community should also identify the potential threats in order to cope with the intensity of future disasters.

Human vulnerability to disasters is an age-old phenomenon. Besides nature's wrath, human interventions have also precipitated many calamities in the recent past. People face the most debilitating consequences in the form of economic and social disruption caused by disasters. The aftermath of disasters is a grim picture of death, destruction and suffering. The long history of disasters and the suffering caused as a result is reason enough to ponder over the question of their management.

The scope of disaster management is quite vast and could be understood through two sub-divisions. These are: Theoretical Foundations and Practical Concerns. Theoretical foundations include elements and facets like planning, organising, staffing, directing, coordinating, reporting, and budgeting. The Practical concerns of the scope of disaster management include subject matter or issue specific namely administration, agriculture, education, food, health, livelihood, livestock, reconstruction, recovery, rehabilitation, relief, rescue, shelter, etc. It also comprises human elements touching upon psychological, social, and economic dimensions. Furthermore, close two-way relationship between disasters and development reveals the development orientations of disasters. In all practical terms, the scope of disaster management is much detailed and comprehensive and calls for a set of systematic approaches to appropriately deal with disasters. Disaster management is not only a post-disaster management activity but is a detailed and proactive approach and exercise to be initiated and put in place at various levels with rather active cooperation of all concerned stakeholders. Gone are the days when relief

distribution in a post-disaster scenario was the only facet of disaster management engaging serious attention.

For disaster management to be effective and efficient, it is not only the government that has to play an active role, but all concerned stakeholders need to work in unison for desired results. Emphasis, of late, has been on sensitising and capacitating the community as the 'first responder'.

Disaster management has evolved into a methodical approach that focuses on systematic observations, their analysis and dissemination of likely events to structure informed application of resources in time. It aims to prevent avoidable loss of life and property, minimise human suffering and expedite recovery and rehabilitation. The most crucial goal of disaster management programmes, as of now, is to take all possible measures for disaster prevention and preparedness to the extent possible besides initiating prompt measures towards effective disaster response, rehabilitation and recovery.

Disaster losses can be substantially minimised and the disaster management systems can be more effective, if serious efforts through research, documentation, knowledge sharing, networking, etc., in the area of disaster management are carried out and the same supplement the initiatives undertaken by the laid-down structures in India.

Disaster management education seeks to provide understanding of different types of hazards, disaster management techniques and impediments in the way of disaster reduction. It could play a crucial role in the areas of analysing risks in disaster management, planning for contingencies, streamlining warning systems, mapping disaster zones, developing data bases, preparing emergency response plans, reducing hazards and vulnerability, and conceiving disaster coping strategies.

The Course on Disaster Management at Under-graduate level is to orient the learners about the negative aspects of the disasters and also to sensitise them with the methods and techniques for effective management of disasters so that the losses arising out of disasters could either completely avoided or minimised to a substantive extent. Disaster management is nothing, but in essence it is everything. When it is said that disaster management is nothing, it is because of the fact that various facets given attention to in disaster management are from other disciplines and professions. For example, when policies and programmes for managing disasters are referred to, it is found as having been taken from political science; geographical considerations, regional planning, spatial planning, etc., stem from geography; reference to community, society, individuals, groups, and the like are from the field of sociology; statistical resources, decision making, computation models are from the areas of statistics and mathematics; plan formulation, micro finance, macro finance emanate from economics; ecological foundations are from the field of biology; and past practices as well as treatment to earlier disasters are from the field of history. It makes one feel that disaster management has nothing of its own and so it is nothing. The other side of it reveals that disasters affect the polity, society, economy, environment, development planning, administration, management, etc., and without appropriate management of disasters each of the professions and disciplines that contribute to the management of disasters is out of place unless there are appropriate mechanisms for disaster management. Thus, disaster management is everything and is equally important and significant for all sections of the society. In keeping with the 'vast reach of and impact of disasters', the said course on Disaster Management shall be of significance to almost all disciplines of studies, may it be social sciences; sciences, engineering, architecture, commerce and management; health sciences, etc. This Course

comprises 4 Blocks, having 15 Units, each covering different important facet of disaster management.

Block 1 Introduction

Unit 1 Meaning and Classification of Disasters

It explains the meaning and classification of disasters. It brings to light the long history of disasters. It signifies that disasters have been affecting societies and had been posing problems and threats to the people and structures. The term 'disaster' composed of two words 'bad' and 'star'. It also highlights the major impacts of disaster, namely, loss of life and property, adverse impact on economy and social structure, epidemiological threats, migration, etc. There is mention of various types of disasters in the Unit, viz. Water and Climate related disasters; Geologically related disasters; Chemical, Industrial and Nuclear Related disasters; Accident related disasters; and Biological disasters in the Unit. It specifically focuses on natural disasters, namely, earthquake, volcanic activity, landslide, tsunami, avalanche, flood, extreme temperature, drought, wildfire, cyclone and storm surge, and epidemics. Besides, man-made disasters namely complex emergencies/conflicts, famine, displaced populations, transport accidents and industrial accidents are highlighted in this Unit.

Unit 2 Hazard, Risk and Vulnerability

Hazard, Risk and Vulnerability are three most important and significant concepts in disaster management. Disaster management has undergone a change with the passage of time. It is no more a piecemeal strategy, but an integrated process. In order to understand disaster management thoroughly, the Unit explains the terms 'Hazard' and 'Disaster' and brings forth the differentiation between the two. It further explains the term 'Risk' for you to better understand Risk Perception and Risk Identification. Detailed explanation of Vulnerability and its various types shall help you better understand Vulnerability and Risk Assessment. The concept of vulnerability covers risk of hazards and the measure of risk combined with the relative inability to cope with the resulting stress. In line with it, various factors contributing to both natural and man-made disasters have been discussed in the Unit.

Unit 3 Natural and Man-made Disasters

Disasters are seen as the consequence of inappropriately managed risk, which is a resultant of a combination of hazard and vulnerability. Natural disasters, causing loss of life or property damage, are naturally occurring physical phenomena, whereas man-made disasters are events that are caused by humans and occur in or close to human settlements. In order to have proper understanding of various disasters, different natural and man-made disasters have been discussed at length in the Unit. For better understanding of the learners, natural disasters, referred to in the Unit, are sub-divided in four major types, namely, Geophysical, Hydrological, Climatological, and Biological. Likewise, under man-made disasters, the focus of discussion is on Complex emergencies and conflicts, Famine, Displaced population, and Transport and industrial accidents.

Unit 4 Disaster Profile of India

India is among the world's most disaster prone areas and a large part of the country is exposed to natural hazards, which often turn into disasters causing loss of life and property. Disaster risks in India are further compounded by increasing vulnerabilities contributing to a situation where disasters seriously threaten India's economy, its

population and sustainable development. You shall be able to know about the vulnerability profile of India classified into three geological divisions, that is, Himalayas, also known as the Extra-Peninsula; Indo-Gangetic Plains and the Peninsula. The Unit provides details about major natural disasters in India, namely Earthquakes, Tsunami, Landslides, Floods, Cyclones, Droughts, and Heat Waves and Cold Waves.

Block 2 Disaster Management: Concepts and Institutional Framework

Unit 5 Disaster Management: Act, Policy and Institutional Framework

In keeping with the substantive loss of life and property caused by disasters, a need for coordinated and concerted efforts towards effective disaster management in the country was felt strongly especially after Super Cyclone of Odisha in 1999 and Bhuj Earthquake in 2001. This Unit highlights the institutional arrangements for disaster management in India. To this effect, you shall be able to know about the Disaster Management Act, 2005, as a new multidisciplinary focus on disaster prevention and risk reduction and a move away from a relief-centric regime. It also highlights, at length, the evolution of National Disaster Management Authority and its major functions. It further brings to light the role of other major forces/agencies like National Executive Committee, State Disaster Management Authority (SDMA), District Disaster Management Authority (DDMA), National Institute of Disaster Management (NIDM), and National Disaster Response Force (NDRF). Besides role of Central Government and State Governments and District Administration, the Unit also discusses other important institutional arrangements viz. Armed Forces, Central Armed Police Forces, State Police, Fire Services, Civil Defence (CD) and Home Guards, Civil Defence (CD) and Home Guards, Local Elected Bodies, Community, International Cooperation, etc. It also brings to fore the aims of the National Policy on Disaster Management (NPDM), 2009, and salient features of the National Disaster Management Plan (NDMP), 2016.

Unit 6 Disaster Management Cycle with Focus on Preparedness, Prevention and Mitigation

The focus in disaster management is more towards disaster prevention, preparedness and mitigation. It is more rightly felt required as it not only helps in preventing a disaster or/and minimising its loss to the humanity, but also saves lot of economic losses. Disaster management is a holistic process and is viewed as a Cycle comprising three stages, that is, pre-disaster; during disaster and post-disaster. Each stage consists of various facets. Accordingly, the Unit discusses prevention, preparedness and mitigation in pre-disaster stage; relief and response in during disaster stage; and rehabilitation, reconstruction and recovery in post-disaster stage.

Unit 7 Disaster Relief and Response

Disasters, in most of the cases, occur suddenly and unexpectedly. These cause lot much of devastation and destruction. India is one of the most disaster prone countries in the world. A major disaster occurs in India almost in every 2-3 years and about 50 million people are affected annually from these disasters. On an annual basis, around 1 million houses are damaged along with human, social, economic and other losses. The requirement is to provide relief to the victims immediately after the disaster. The Unit shall enable you to know about disaster relief carried out through a number of efforts including Evacuation, Search and Rescue (SAR) Shelter, Distribution of Food, Water and Fodder, Clearance of Debris, Movement of Injured to Hospitals, Disposal of Dead Humans, Disposal of the Dead Animals, Sympathetic Attitude towards Victims, Assisting

Rescue Teams, Property Security, Information Dissemination and Checking of Rumours, Immediate Damage Assessment, and Filing of Claims. It also refers to Response Mechanism with focus on Emergency Operations Centre

Unit 8 Damage Assessment

Damage assessment is an important tool for retrospective and prospective analysis of disasters to assimilate the extent of impact of a disaster. It is a prerequisite for effective disaster response effort. It makes an initial and preliminary onsite evaluation of damage or loss that has been caused by an accident or disaster. Through damage assessment exercise, an attempt is made to put on record the amount and degree of damage and also to point out what can be replaced, restored or salvaged. The discussion in the Unit is on various elements and dimensions of damage assessment. The unit also lays emphasis on framework of damage assessment in two parts. It brings forth damage assessment plan for assessing loss and damage to various critical sectors, namely, Human Life, Housing, Community Infrastructure, Environment, Livelihood, and Health, etc.

Unit 9 Rehabilitation, Reconstruction and Recovery

In the post-disaster phase, rehabilitation, reconstruction and recovery are important and inevitable aspects that are to be paid utmost care in bringing back the life of people to normalcy. This phase follows immediately after the disaster relief and response. Rehabilitation and reconstruction are the integral part of recovery and effective rehabilitation and reconstruction ensures the resilience of the society. This Unit explains the concept of rehabilitation and its types such as physical rehabilitation, social rehabilitation, economic rehabilitation and psychological rehabilitation. It also analyses the major steps of reconstruction and gives special emphasis to the funding arrangement patterns for reconstruction which encompasses National Disaster Response Fund; State Disaster Response Fund; National Disaster Mitigation Fund; Recommendations of the Fourteenth Finance Commission; District level funds; Member of Parliament Local Area Development Scheme; Prime Minister's National Relief Fund; and other Insurance schemes. Finally, it also discusses about recovery mechanism and the problems involved in recovery areas.

Block 3 Interrelationship between Disasters and Development

Unit 10 Climate Change

In the contemporary context, climate change is a major environmental and developmental problem, which has no boundary. It affects both the natural ecosystem and society directly as well as indirectly. The major reason for climate change is the human activity towards the global atmosphere in the name of development. The impacts are, thus, the increased frequency of extreme weather, flood, drought, sea level rise and extreme climate variability. In this Unit, the concepts such as weather, climate, climate change and its impact are discussed. Moreover, climate vulnerability and climate change adaptation are also explained from the learners' perspective.

Unit 11 Disasters and Development

This Unit highlights the interrelationship between disasters and development. Sometimes, disasters lead to development and likewise development also leads to disasters. Disaster affects development and causes loss of resources, shifts resources to emergency response, depresses the investment climate and also affects the non-formal sector. In the same way, development also increases vulnerability through dense urban settlement,

development of hazardous sites, environmental degradation, technological failures or accidents, imbalance of pre-existing natural or social systems. This Unit discusses the relationship between disaster and development and specifically focuses on the aspects such as development programs and vulnerability; disasters as opportunities for development initiatives; and missed development opportunities. It brings out the importance of developing infrastructure in a sustainable manner. Finally, emphasis is given to long-term job opportunities, livelihood options and the statutory provisions for mainstreaming disaster risk reduction.

Block 4 Disaster Management: Cross-cutting Issues

Unit 12 Relevance of Indigenous Knowledge

The successful and sustainability of risk reduction activities depends upon the involvement of local populace, their knowledge, culture and traditional practices. In this context, increasing the adaptive capacity of the communities helps in bringing back resilience and also in reducing the levels of vulnerability. The adaptive capacity of community could be maximised by laying more emphasis on the traditional knowledge. This Unit enables us to understand the traditional knowledge and in line with it, discusses the indigenous knowledge and disaster risk reduction. It provides details about the indigenous knowledge and early warning system. Further, it also discusses the indigenous knowledge and coping strategies with special reference to cyclone, flood and drought.

Unit 13 Community Based Disaster Management

Community is the first respondent to any kind of disaster and the major stakeholders of the disaster risk reduction activities. They are the major crusader in bringing back resilience of the society. The concept of Community Based Disaster Management (CBDM) is about bringing together the community and involving them in the various phases of disaster management activities. This is a bottom-up approach to deal with a disaster. This Unit explains the concept of CBDM and Community Based Risk Assessment (CBRA), which covers aspects such as hazard, vulnerability, risk and capacity assessment. It highlights the principles of CBDM and brings out the differences between the traditional approach and the CBDM approach. It also focuses on the institutional framework related to CBDM and gives more emphasis on the planning measures in the pre, during and post-disaster phase.

Unit 14 Disaster Management Strategies

Globally, the occurrence of disasters is increasing due to extreme weather conditions, population growth, unplanned urbanisation and increasing pressure on natural resources. It proves that disaster has no boundaries and it makes setbacks on development. It was in such a context that the International Decade for Natural Disaster Reduction convention was adapted worldwide in the 1990s. After that the relief-oriented approach changed towards risk reduction approach. More emphasis was given to improving the capacities of communities through various disaster risk reduction strategies. This Unit, thus, introduces the concepts and components of disaster management strategies. It brings out various disaster management strategies at the international level such as International Decade for Natural Disaster Reduction; Yokohama Strategy for Disaster Reduction; Hyogo Framework for Disaster Reduction; and Sendai Framework for Disaster Risk Reduction. It also highlights the disaster management strategies that were adopted in the Indian context.

Unit 15 Disaster Management: Case Studies

Case studies of past disasters are more important to understand a disaster and also to examine the measures taken to deal with a disaster. Past disasters serve as an opportunity to learn from the experiences and helps in streamlining disaster risk reduction activities. In earlier days, India had followed relief-oriented approach and it did not have proper institutional mechanism to handle a disaster. The major policy changes and the institutional mechanisms were created after the Odisha cyclone in 1999, Gujarat earthquake in 2001 and the Indian Ocean Tsunami in 2005. This Unit highlights the major lessons learnt from the above mentioned three major disasters; besides bringing out the experiences of Uttarakhand Floods, 2013 and Cyclone Phailin, 2013.

BLOCK 1

INTRODUCTION

UNIT 1 MEANING AND CLASSIFICATION OF DISASTERS*

Structure

1.0 OBJECTIVES

After reading this Unit, you should be able to:

- Acquire conceptual understanding of relevant disaster terminology;
- Understand the difference between natural and man-made disasters; and
- Give a general overview of classification of disasters.

1.1 INTRODUCTION

Disaster has been with us as long as recorded history, and probably even longer. Our ancestors have had to withstand disasters. They have suffered the consequences and recovered from them, and life has continued. Most of the old problems remain as threatening as ever. Natural phenomena such as earthquakes, cyclones, volcanic eruptions, tsunamis, wildfires, floods, landslides, and droughts still persist. So do man-made disasters such as major accidents. These disasters continue to cause human casualties, economic and social loss, and damage to the environment. It is certainly true that we have learned to cope with these problems to some extent. However, we have neither eliminated nor contained them.

1.2 MEANING OF DISASTER

The term 'Disaster' owes its origin to the French word 'Desastre' which is the combination of two words – 'des' meaning 'bad'and 'astre' meaning 'star'. In earlier days, a disaster was considered to be due to some unfavourable star. Nowadays, the term 'Disaster' is commonly used to denote any odd event, be it natural or man-made, which brings about immense misery to a region so that it becomes difficult to cope with the situation through local resources.

* Contributed by Dr. Poonam Rautela, Associate Professor, M B Govt. PG College, Haldwani (Uttarakhand).

As per Disaster Management Act, 2005, "*disaster* means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area." A more detailed meaning of disaster, according to the International Federation of the Red Cross and Red Crescent Societies, is: "A disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. A disaster occurs when a hazard impacts vulnerable people" (UNISDR, 2009). Disasters are serious disruptions of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of the affected people to cope using its own resources. The following are the related impacts of disasters:

- Falling apart of normal pattern of life.
- Loss of life and property.
- Adverse impact on economic and social structure.
- Disruption in community needs of shelter, food, clothing and medical help.
- Onset of psychological trauma.
- Loss of livelihood.
- Disruption of communication, transport and infrastructure.
- Law and order problems
- Epidemiological threats.
- Migration (Both short-term and long-term).

However, the above impacts are not always negative, since the negatives could open up positive avenues of development and growth, as depicted in the table below:

Table 1.1: Disaster: Negative and Positive Aspects

Aspects	Negative	Positive
D	Damage	Development
I	Interruption	Innovation
S	Severe	Sharing
A	Antagonistic	Awareness
S	Scourge	Self-sufficiency
T	Trauma	Transformation
E	Emergency	Education
R	Risk	Resilience

***Source*:** IGNOU, 2012.

1.3 TYPES OF DISASTERS

As per High Powered Committee Report (2001), disasters can be classified into two major categories (both natural and man-made) and several sub-categories. Overview of the disasters categorises them into:

i) Water and Climate Related Disasters
- Floods
- Cyclones
- Tornadoes and Hurricanes
- Hailstorm
- Cloud Burst
- Heat Wave and Cold Wave
- Snow Avalanches
- Droughts
- Sea Erosion
- Thunder and Lightning
- Tsunami

ii) Geologically Related Disasters
- Landslides and Mudflows
- Earthquakes
- Dam Failures/ Dam Bursts

iii) Chemical, Industrial and Nuclear Related Disasters
- Chemical and Industrial Disasters
- Nuclear Disasters

iv) Accident Related Disasters
- Forest Fires
- Urban Fires
- Mine Fires
- Mine Flooding
- Oil Spill
- Major Building Collapse
- Serial Bomb Blasts
- Festival Related Disasters
- Electrical Disasters and Fires
- Boat Capsizing
- Village Fire

v) Biological Disasters

- Biological hazards
- Epidemics
- Pest Attacks
- Cattle Epidemics
- Food Poisoning

Out of these, some major disasters are focused in the following sections.

1.4 NATURAL DISASTERS

Natural disasters are naturally occurring physical phenomena caused either by rapid or slow onset of events which can be geophysical, hydrological, climatological and biological.

Earthquakes

Earthquake is the result of forces responsible for the structural deformation deep within the earth's interior. Sudden break within the upper layers of the earth, resulting in the vibration of the ground, which when strong enough causes the collapse of buildings and destruction of life and property. Earthquakes usually happen at faults along plate boundaries. Earthquakes often trigger landslides, tidal waves and tsunamis. Magnitude scales, like the Richter magnitude scale, measure the size of the earthquake at its source. On the Richter scale - the most devastating effects are seen on level 6 and above, and if the epicentre of the earthquake is located in highly populated areas, it can cause large numbers of deaths and injuries as well as serious destruction of buildings and infrastructure. The basic characteristics of earthquake include: forecasting is not possible; sudden onset; areas prone to earthquakes are generally well known and identified due to geological features and past occurrences (IGNOU, 2006).

Volcanic Eruptions

Volcanic eruptions happen when lava and gas are discharged from a volcanic vent. The most dangerous type of volcanic eruption is referred to as a 'glowing avalanche'. This is when freshly erupted magma forms hot pyroclastic flows which have temperatures of up to $1,200^0$ C. The pyroclastic flow is formed from rock fragments following a volcanic explosion, the flow surges down the flanks of the volcano at speeds of up to several hundred kilometers per hour, to distances often up to 10km and occasionally as far as 40 km from the original disaster site. There are two modes in which the volcanoes usually erupt. These are explosive eruptions and effusive eruptions. In the former mode of eruption, the gas contents are high and magma is thick and viscous. Sudden release of confining pressure allows the gases to boil explosively from the magma. In the later mode, the gas content in the magma is low and the magma is of relatively low viscosity, therefore the gases boil out less violently (IGNOU, 2006a).

Landslides

A landslide is the movement of soil or rock controlled by gravity and the speed of the movement usually ranges between slow and rapid. It can be superficial or deep, but the materials have to make up a mass that is a portion of the slope or

the slope itself. The term landslide is used in its broad sense to include downward and outward movement of slope forming materials (natural rock and soil). It is caused by heavy rain, soil erosion as well as earth tremors and may also happen in areas under heavy snow. Landslides are difficult to estimate as an independent phenomenon. It seems appropriate, therefore, to associate landslides with other hazards such as tropical cyclones, severe local storms and river floods.

Tsunami

Tsunamis (Japanese for "harbour wave"), also known as a seismic sea wave, are a series of very large waves with extremely long wavelength, in the deep ocean, the length from crest to crest may be 100 km and more. It is usually generated by sudden displacements in the sea floor caused by earthquake, landslides, or volcanic activity (Government of India, 2016). Tsunamis are a series of large waves generated by sudden displacement of seawater by earthquakes or volcanic eruption, capable of propagation over large distances and causing a destructive surge on reaching land (CRED, 2011). Tsunamis can originate hundreds or even thousands of miles away from coastal areas. Local geography may intensify the effect of a tsunami (Kanal, 2013). The impact in coastal areas can be very destructive as the waves advance inland and can extend over thousands of kilometers. Triggers of a tsunami can be: earthquakes, volcanic eruptions, mass movements, meteorite impacts or underwater explosions.

Avalanches

Avalanche describes a quantity of snow or ice that slides down a mountainside under the force of gravity. It occurs if the load on the upper snow layers exceeds the bonding forces of the entire mass of snow. It often gathers material that is underneath the snow pack like soil, rock, etc. A debris avalanche is a type of slide characterised by the chaotic movement of rocks, soil and debris mixed with water or ice (or both). They are often triggered by earthquakes and volcanic eruptions. Snow Avalanche can be classified as "dry snow type" or "wet snow type". Both these types can be further sub-divided into "direct action" or "delayed action" avalanches. It brings forth four categories of Snow Avalanches, namely Dry Snow Direct Action Avalanche; Dry Snow Delayed Action Avalanche; Wet Snow Direct Action Avalanche; Wet Snow Delayed Action Avalanche. (IGNOU, 2003).

Floods

Floods are also a regular phenomenon of the country and almost every year, one or the other parts of the country is frequently affected by floods (Kanal, 2013). A flood is an overflow of water on land which is usually dry. Sometimes a water resource (river, lake or pond) gets flushed too much with water, resulting in floods in the nearby regions. The National Disaster Management Division of the Ministry of Home Affairs defines that "floods are a temporary inundation of large regions as the result of an increase in reservoir, or of rivers flooding their banks because of heavy rains, high winds, cyclones, storm surge along coast, tsunami, melting snow or dam bursts". Flash floods are defined as floods which occur within six hours of the beginning of heavy rainfall, and are usually associated with cloud bursts, storms and cyclones requiring rapid localised warnings and immediate response if damage is to be mitigated (NDMA, 2008). Unusually heavy rain can also cause floods. A particular kind of flood, that is, flash flood, is sudden wherein extreme volume of water flow rapidly and cause inundation.

Extreme Temperature

A heat wave is a prolonged period of excessively hot and sometimes also humid weather relative to normal climate patterns of a certain region. Heat kills by pushing the human body beyond its limits. Conditions that can induce heat-related illnesses include stagnant atmospheric conditions and poor air quality. A cold wave can be both a prolonged period of excessively cold weather and the sudden invasion of very cold air over a large area. Along with frost, it can cause damage to agriculture, infrastructure and property. Cold waves, heavy snowfall and extreme cold can immobilise an entire region. Winter storms can result in flooding, storm surge, closed highways, blocked roads, drowned power lines and hypothermia.

Droughts

Drought is defined as a deficiency of rainfall over an extended period – a season, a year or several years – relative to the statistical multi-year average for the region. It is an insidious phenomenon. Severe and rare droughts occur in arid and semi-arid zones. Droughts can occur due to long spells of water shortage as a result of scanty rainfall, inadequate water management techniques, and sheer government neglect. The severity of drought depends on the degree of moisture deficiency, duration of dry spells, extent of irrigation facilities; and size of the affected area. An erratic pattern, both low (less than 750 mm) and medium (750-1125 mm) makes 68 per cent of the total area in India vulnerable to periodic droughts (IGNOU-NDMA, 2012). Unlike rapid onset disasters, it tightens its grip over time, gradually destroying an area. In severe cases, drought can last for many years and have a devastating effect on agriculture and water supplies. Due to lack of rainfall, there is inadequacy of water supply for plants, animals and human beings. A drought may result in other disasters like food insecurity, famine, malnutrition, epidemics and displacement of populations.

Wildfires

Wildfire is a general term which includes forest fires, grassland fires, bushfires, brush fires and any other vegetation fire. Speed of onset of a wildfire may vary. It can be rapid under conditions of high temperatures and high wind, when major fire fronts advance very quickly. Also, during high winds, fragments of fire from a main front may be carried forward by the wind, starting new fires further ahead. This causes the fire to spread much faster. They occur more in coniferous forests and evergreen broadleaf forests. If the basic requirement of air and the burning fuel (grass, bush, fallen leaves, branches of trees, deadwood) is dry, fires are more likely. Hot sunny days with low humidity and strong breeze are conducive to the rapid spread of fire in a forest. Many trees in forests emit oily or wax-like substance, which intensifies forest fire. Extinguishing a forest fire is not easy. Generally forest fire once started, continues until there is heavy rain or the burning fuel is finished (IGNOU-NDMA, 2012).

Cyclones and Storm Surges

A cyclone is a large-scale air mass that rotates around a strong center of low atmospheric pressure. Cyclone is characterised by inward spiraling winds that rotate about a zone of low pressure. The term “cyclone” refers to the storms’ cyclonic nature, with counterclockwise rotation in the Northern Hemisphere and clockwise rotation in the Southern Hemisphere. A tropical cyclone is a storm system characterised by a low-pressure centre and numerous thunderstorms that produce strong winds and flooding rain. A tropical cyclone feeds on heat released

when moist air rises, resulting in condensation of water vapor contained in the moist air. Depending on their location and strength, tropical cyclones are referred to by other names, such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, or simply as a cyclone. A storm surge is a coastal flood or tsunami-like phenomenon of rising water commonly associated with low pressure weather systems (such as tropical cyclones), the severity of which is affected by the shallowness and orientation of the water body relative to storm path, and the timing of tides. Most casualties during tropical cyclones occur as the result of storm surges.

Epidemics

Epidemic is a derivation of two Greek words *epic* (upon/among) and *demons* (people). An epidemic is the unusual increase in the number of cases of an infectious disease which already exists in a certain region or population. It can also refer to the appearance of a significant number of cases of an infectious disease in a region or population that is usually free from that disease. Epidemics may be the consequence of disasters of another kind, such as tropical storms, floods, earthquakes, droughts, etc. Epidemics may also attack animals, causing local economic disasters. The types of diseases generally recognised as communicable or transmissible include: hepatitis, typhoid, diphtheria, malaria, cholera, influenza, enteritis, diarrhea, skin diseases, food poisoning, etc. Health affecting lifestyle like smoking, drug addiction and health related events like accidents also fall into category of epidemics. But during disasters, we are more concerned about the epidemics of communicable diseases (IGNOU, 2003).

Check Your Progress 1

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Define 'disaster' and list its various types.

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2) Briefly discuss the nature of Earthquakes and Landslides.

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3) Explain the nature of Cyclones and Storm Surges.

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1.5 MAN-MADE DISASTERS

Technological or man-made disasters are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents. Some disasters can result from several different hazards or, more often, from a complex combination of both natural and man-made causes of vulnerability. Food insecurity, epidemics, conflicts and displaced populations are some of the examples.

Complex Emergencies/Conflicts

It is a humanitarian crisis in a country, region or society, where there is total or considerable breakdown of authority resulting from internal or external conflict and which requires an international response. On a national level, conflict may involve warlike encounters between armed groups from the same country which take place within the borders. Such outbreaks of war may pose large-scale medical problems such as epidemics, lack of water, accumulation of rubbish, displaced persons, refugees, food shortage, hunger, etc. Internationally, war may break out between two or more armies from different countries. Similarly such conflict may cause large scale mass movements of refugees and displaced persons. Such "complex emergencies" are typically characterised by extensive violence and loss of life; displacements of populations; widespread damage to societies and economies and the need for large-scale, multi-faceted humanitarian assistance.

Famines

Food-security emergencies are complex disasters with multiple root causes. Severe drought and/or conflict can produce an acute food emergency, whereas chronic food insecurity is often a reflection of poverty, a worsening debt crisis, and economic effects at household level of the HIV/AIDS pandemic or mismanagement or abuse of water resources. In such cases, food can be both unavailable (insufficient production) and inaccessible (distribution problems, beyond consumers' purchasing power). Poor nutrition, brought on by food shortages, reduces people's resistance to disease, and makes outbreaks of preventable diseases likely. Water shortages, which force people to use polluted water, increase the risk of waterborne diseases. Food-security problems may drive populations to other areas, such as the outskirts of towns, in search of better living conditions.

Displaced Populations

"Displaced populations leave their homes in groups, usually due to a sudden impact, such as an earthquake or a flood, threat or conflict. There is usually an intention to return home. Migration and displacement are interlinked, but must be distinguished. Displaced populations – either across borders such as refugee influxes, or within a country because of disasters or armed conflict – usually need relief operations combined with efforts aiming at collective and lasting solutions. Migration on the other hand usually involves more individual social assistance, legal protection and personal support. The responsibility for refugees and all displaced populations primarily rests with the host government. It is the mandate of the United Nations High Commissioner for Refugees to protect and assist refugees." (IFRC, 2017)

Transport Accidents

These are used to describe technological transport accidents involving mechanised modes of transport. It comprises four disaster subsets: accidents involving air, boat, rail transport and accidents involving motor vehicles on roads and tracks.

Transport accidents will address issues pertaining to bulk transportation of chemicals both by road, rail or marine means and safe transportation of petroleum products including combustible gases through pipelines. Comprehensive rules and guidelines under various acts provide for safe transportation of hazardous chemicals or dangerous goods. Transportation on land under the Petroleum Rules has laid down safety requirements for tank vehicle, tank capacity, engines, electrical installations etc., and has also highlighted restriction on loading/unloading of tank vehicles (NDMA, 2007).

Industrial Accidents

These accidents include explosions such as chemical explosion, nuclear explosion and mine explosion. Disasters will only be classified as explosions when the explosion is the actual disaster. If the explosion is the cause of another disaster, the event will be classified as the resulting disaster. Such disasters result in subsequent disasters such as:

- Pollution and degradation of one or more aspects in the environment by noxious industrial, chemical or biological wastes, from debris or man-made products and from mismanagement of natural and environmental resources.
- Acid rain: A washout of an excessive concentration of acidic compounds in the atmosphere, resulting from chemical pollutants such as sulphur and nitrogen compounds. When deposited they increase the acidity of the soil and water causing agricultural and ecological damage.

1.6 OTHER CLASSIFICATION OF DISASTERS

Disasters are on a rise throughout the world. Frequency of disasters provides evidence of human ignorance or neglect to certain key developmental issues. It is worth noting that one of the most important decisive factors in any disaster is its disruptive impact that creates pervasive uncertainty, suffering and trauma. Disasters cause severe loss to lives and property, destroy infrastructure and productive capacity, interrupt economic activity and create irreversible changes in a country's natural resource base. Besides, there is an adverse affect of disasters on development process of the society because there is diversion of scarce resources towards relief, reconstruction and rehabilitation activities. Disasters are also classified as compound and complex. Compound disaster is explained as one type of hazard, for example, disaster leading to other contingencies, such as famines followed by civil strife, mass displacement of peoples, etc.

Complex disasters are those that lead to collapse of the political authority or lead to some other complexity where the problems involved/generated are intensely political in nature such as communal bias in distribution of relief, etc.

Check Your Progress 2

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Bring out the difference between Natural and Man-made disasters.

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2) Describe Famines.

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3) Discuss the impact of Industrial Accidents.

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1.7 CONCLUSION

Most disasters that affect our society are often a combination of two or more disasters. For example, earthquakes and volcanic activities can cause an industrial accident; or droughts which can lead up to famine. A major factor which bears upon today's situation is that new disaster threats have developed, particularly since World War II. Increased social violence has drastically affected many nations and communities. Hijacking, terrorism, civil unrest, and conflict with conventional arms have become very common all over the world. These have sometimes inflicted intolerable burden on governments and societies whose existence is already precarious because of poor economic and social conditions. Though we have devised various methods to manage crisis caused due to disasters, many more challenges still persist.

1.8 GLOSSARY

Disaster : A disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. A disaster occurs when a hazard impacts vulnerable people.

Natural Disaster : A natural disaster is caused by natural phenomenon which can cause loss of life or

property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience or ability to recover and also on the infrastructure available.

Man-made Disasters : Technological or man-made disasters are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents.

Compound Disaster : Compound disaster is explained as one type of hazard, for example, disaster leading to other contingencies, such as famines followed by civil strife, mass displacement of peoples etc.

Complex Disasters : Complex disasters are those that lead to collapse of the political authority or lead to some other complexity where the problems involved/generated are intensely political in nature such as communal bias in distribution of relief, etc.

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1.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Your answer should include the following points:

- A disaster is a sudden calamitous event bringing great damage, loss, or destruction.
- Five types of disaster such as Water and Climate Related disasters; Geological disasters; Chemical, Industrial and Nuclear related disasters; Accident related disasters; and Biologically related disasters.

2) Your answer should include the following points:

- Earthquakes are the result of forces deep within the earth's interior. Sudden break within the upper layers of the earth, resulting in the vibration of the ground, which when strong enough cause the collapse of buildings and destruction of life and property.
- Landslide is the movement of soil or rock controlled by gravity and the speed of the movement usually ranges between slow and rapid. It can be superficial or deep, but the materials have to make up a mass that is a portion of the slope or the slope itself.
- It is used in its broad sense to include downward and outward movement of slope forming materials (natural rock and soil).

3) Your answer should include the following points:

- Cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure. Cyclones are characterised by inward spiraling winds that rotate about a zone of low pressure.
- The term "cyclone" refers to the storms' cyclonic nature, with counterclockwise rotation in the Northern Hemisphere and clockwise rotation in the Southern Hemisphere.
- A tropical cyclone is a storm system characterised by a low-pressure center and numerous thunderstorms that produce strong winds and flooding rain.
- Storm surge is a coastal flood or tsunami-like phenomenon of rising water commonly associated with low pressure weather systems (such as tropical cyclones), the severity of which is affected by the shallowness and orientation of the water body relative to storm path, and the timing of tides.
- Most casualties during tropical cyclones occur as the result of storm surges.

Check Your Progress 2

1) Your answer should include the following points:

- Natural disasters are naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical, hydrological, climatological and biological.

- Technological or man-made disasters are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents.

2) Your answer should include the following points:

- Famine is a complex disaster with multiple root causes.
- Severe drought and/or conflict can produce an acute food emergency, whereas chronic food insecurity is often a reflection of poverty.

3) Your answer should include the following points:

- Pollution and degreadation of one or more aspects in the environment by noxious wastes.
- Acid rain.

UNIT 2 HAZARD, RISK AND VULNERABILITY*

Structure

2.0 OBJECTIVES

After reading this Unit, you should be able to:

- Acquire conceptual understanding of relevant disaster terminology;
- Discuss vulnerability factors in brief; and
- Understand vulnerability and risk assessment.

2.1 INTRODUCTION

Throughout the twentieth century, the theory and practice of disaster management had been dominated by the scientific perspective, whereby, disasters were thought of purely as a geological or a climatic problem, the solutions for which lay in engineering and management sciences. In the last two decades, there has been a paradigmatic shift in the understanding of disasters per se the human factor, which had been neglected in the earlier approach, is now in focus. The attempt consequently is to inquire into sociological processes that determine or undermine a community's resilience, coping capacity and response to disasters. Presently, the term disaster is a more inclusive concept, in that it includes man- made, and technological hazards, as also terrorism, which has added a new dimension to its understanding.

* Contributed by Dr. Poonam Rautela, Associate Professor, M B Govt. PG College, Haldwani (Uttarakhand).

There are two important perceptions on disasters. According to one school of thought, disasters are natural, revengeful acts of nature: an opportunity for man to atone for his sins, wherein death and destruction are inevitable. As per the other perspective, disasters are man-made. An event, whether a product of natural phenomena or human activities, turns out to be a catastrophic disaster, if the community or society fails to adequately cope up with it. Natural hazards do not necessarily lead to disasters. Intense, inevitable or unpredictable natural hazards like tsunamis, cyclones and earthquakes prove to be disasters only when the population is affected and more so when it is unprepared to respond to and unable to cope with it.

Disaster sociologist Carr (1932) has endeavoured to understand disasters in terms of social action. Carr indicates that disasters are the collapse (that is, failure or inadequacy) of cultural protection, a result of human activities and not of natural or supernatural forces; therefore, they are essentially human-made. An understanding of causes of disasters and timely appropriate intervention can effectively reduce the disaster threat.

2.2 UNDERSTANDING HAZARDS

Hazard is defined as a potential or a latent/dormant cause, which is activated when the right configuration of factors, natural or man-made or both, present themselves. For example, a chemical plant in a populated area presents a hazard having a potential threat to life and property in that area or within defined vicinity. Disaster is the actual occurrence of the apprehended catastrophe. Hence, disaster is "any occurrence, that causes damage, ecological disruption, loss of human life, deterioration of health and health services, on a scale sufficient to warrant an extraordinary response from outside the affected community or area"(World Health Organisation (WHO)).

A *hazard* technically is not a disaster unless the 'trigger' (natural or man- made) sets it off. Disaster, involving large-scale loss of life and property, is a sudden onset event, on a scale large enough to require outside assistance, which threatens the continuity of social systems and processes. "A disaster should be defined on the basis of its human consequences, not on the phenomenon (hazard) that caused it. Earthquakes, floods and cyclones are 'natural hazards' which cause large-scale loss of life and property (disaster) when the trigger mechanism (natural or man-made) is activated." *Risk* is a technical concept, which is used by engineering and management specialists to arrive at an estimation of losses in the event of a disaster and the expected probability of its occurrence. *'Elements'* are identified as life and property likely to suffer damage in the event of a disaster. *Observation* and *perception* of risk involves ascertaining, specifically, such 'elements' at risk. "*Identification* of risk involves inquiring into the specific natural, technological or chemical, etc., processes that create the vulnerability of the elements identified for risk analysis".

Vulnerability can be natural or man-made. It can be physical, owing to factors such as weak buildings, habitation in hazard prone areas; or socio economic, arising due to poverty or marginalisation of the weaker sections of society who lack the wherewithal of defending themselves in the event of a disaster.

Hazards

"Extreme geophysical events, biological processes and major technological accidents,

characterised by concentrated release of energy or materials, which pose a largely unexpected threat to human life, and can, cause significant damage to goods and the environment" are described as *hazards.*

The difference between a hazard and a disaster is very important and crucial. A disaster takes place when a community is affected by a hazard (usually defined as an event that exceeds the community's capacity to cope). In other words, the impact of the disaster is determined by the extent of a community's vulnerability to the hazard. This vulnerability is not natural. It is the human dimension of disasters, the result of the whole range of economic, social, cultural, institutional, political and even psychological factors that shape people's lives and create the environment that they live in (Twigg, 2001).

Observation and Perception of Hazards

Though hazards could be classified on many criteria; some of the general classifications are as follows (S. Gopalakrishnan). Hazards could be:

- Sudden onset hazards — (geological and climatic hazards) earthquakes, tsunamis, floods, tropical storms, volcanic eruptions, landslides.
- Slow onset hazards — (environmental hazards) drought, famine, environmental degradation, desertification, deforestation, and pest infestation.
- Industrial/technological—system failures/accidents, spillages, explosions, fires.
- Wars and civil strife—armed aggression, insurgency, terrorism, and other actions leading to displaced persons and refugees.
- Epidemics—water and/or food-born diseases, person-to-person diseases (contact and respiratory spread), vector-born diseases and complications from wounds.

Hazards could also be classified as *direct* and *indirect*. For example, earthquake hazard would lead to direct and indirect consequences, tabulated as under (*ibid):*

Direct Hazards

i) Ground shaking;

ii) Differential ground settlement;

iii) Soil liquefaction;

iv) Immediate landslides or mud slides, ground lurching and avalanches;

v) Permanent ground displacement along faults;

vi) Floods from tidal waves, Sea Surges & Tsunamis, etc.

Indirect Hazards

i) Dam failures;

ii) Pollution from damage to industrial plants;

iii) Delayed landslides.

Besides, Hazards can be of both short term and long-term duration, as per the classification proposed by K. Smith (1996).

Identification of Hazards

Identification of hazards involves analysis of scientific data to trace the *causal path* of events leading up to a disaster. For example, identification of chemicals causing water pollution; their source, impact on specific 'elements' such as human health, etc.; inquiring into the nature and characteristics of a hazard with a view to distinguish the man-made and natural components thereof; for example, floods, which are caused by both natural and man-made factors. Man-made factors include bad land use management policies such as allowing habitation and locating critical facilities in flood prone areas, etc., which increase the vulnerability of 'exposed' populations. It also entails policy analysis in that the *unintended* consequences of policies have to be examined with a view to framing more environment friendly legislation in the future. Hazard analysis is the basis of 'sustainable development' policies. For example, desertification is a *slow-onset* disaster. Desertification arises from the interaction between a "difficult, unreliable and sensitive dry land environment and the human use and occupation of it in an effort to make a living." Following a hazard analysis of the process of desertification, effective strategies can be devised to address the problem.

Hazards can be of short- term duration. Most of the widely recognised hazards, viz., earthquakes, volcanoes, severe weather conditions, occur naturally in the environment. Another group of hazards is created by the action of human beings. Pollution of water, fire hazard and air frequently fall into the man-made hazards category and include high levels of carbon monoxide (CO) and sulphur dioxide (SO2) in the atmosphere. Other man-made hazards include oil spills, pesticides, etc., which build up in the environment as a result of or due to excessive or repeated application of chemicals by agriculturalists, and flooding and erosions resulting from inappropriate land management practices. Flooding, for example, may be the result of ill-conceived policies, which has allowed construction and intensive land use on flood plains and flood-prone regions.

2.3 UNDERSTANDING RISKS

Risk is precisely defined by the International Strategy for Disaster Reduction (ISDR) as "the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions". Conventionally, risk is expressed by the notation:

Risk = Hazards x Vulnerability.

Some disciplines also include the concept of exposure to refer particularly to the physical aspects of vulnerability. In scenario analysis, *risk* is different from *threat*. Threat is a more abstract concept; risk is an expression of perceived threat in specific terms. Threat is a danger that has an extremely low probability of occurrence. For purposes of public policy, threat has to be articulated objectively in terms of component risks, the probability of their occurrence and damages involved. The difference is most clearly illustrated by the 'precautionary principle', which needs specific articulation of risks involved for development of comprehensive strategy to mitigate risks involved. A set of well-defined risks has to be derived from threat before an action; project, innovation or experiment is allowed to proceed. For example, apprehension of terrorism was a threat. No policy could be devised to meet the threat, which led to September 11 attacks in United States. Threat was not articulated as risk for preventive policy in this regard. Vulnerability is

understood as system faults or weaknesses, which a threat *exploits* to create the negative 'impact.' Risk management involves minimising the vulnerabilities so as to reduce the impact of the threat. Risks, *created,* or *exist,* are both inherent in social systems, due to specific environmental variables in the 'ecology' of a system. The ecological context is therefore significant in understanding of vulnerabilities of people in different cultures as the causes of vulnerability and the level of risk perception in different countries is likely to be different.

Risk contains a probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

Risks are mainly witnessed due to the increased pressure on resources or because of the side effects of external linkages and interventions. Intense use of a resource in mountains exposes them. As a result, it leads to serious degradation. Major forces behind such intensified resource use are rapid population growth, market induced demand, greed of the rich and resource exploitative public policies. Irrespective of the factors behind resource use intensification, invariable consequences are the disruption of conditions conducive to biophysical processes that finally harm the stability and sustainability of mountain environments.

2.3.1 Risk Assessment and Evaluation

Risk assessment is defined as "the methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend".

Such assessment has significant administrative implications in that precise understanding of the underlying process of formulation of targeted risks reduction policies. Precise quantification of risk is often difficult in the absence of adequate data and proper analysis techniques. Moreover, certain areas are multi-hazard prone, which pose another challenge for risk assessment. Risk reduction policy for such areas would require risk assessments regarding each hazard to arrive at an estimation of total loss. Besides, risks are not amenable to simple quantification and cannot be easily either identified or quantified.

Disaster risk is seen as a function of the *hazard, exposure* and *vulnerability, denoted by the mathematical function:*

Disaster Risk = function (Hazard, Exposure, Vulnerability)

Where "Exposure" refers to the element, which is affected by natural disasters; *people* and/or *property.*

To reduce disaster risk, it is important to reduce the level of vulnerability and to keep 'exposure' as far away from hazards as possible by relocating populations and property away from the hazard prone zone"(Wisconsin Disaster Management Center).

"The process of conducting a risk assessment is based on a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking particular account of the coping capabilities pertinent to the risk scenarios…."(ISDR). Risk evaluation entails assessment of

proposed risk reduction measures from the point of view of cost efficiency. Efficiency is examined by means of cost benefit comparisons, which imply assessing benefits procured or expected to be procured from a measure against costs likely to be incurred.

2.3.2 Risk Perception

Risk perception is understood as the 'awareness' of risk, which differs among societies. Poor countries with other pressing problems do not attach too much priority to disaster mitigation. General level of awareness among people regarding the significance of disaster mitigation and preparedness is also quite low. Consequently, there is less interest articulation for policy inputs in this area. On the other hand, risk perception is found to be quite high in the developed world where much effort has been put in disaster mitigation efforts, though vulnerability is low as compared to developing countries. It has been stated that Risk Perception depends on the following four specific factors (Coburn, Sspence & Pomonis., 1994).

Exposure: actual quantitative risk level, as articulated through risk assessments.

Familiarity: personal experience, which makes one alive to the dangers of disasters.

Dread: horror of the disasters' scale and consequences, which makes policy imminent.

Preventability: belief in prevention methods, which leads to disaster mitigation policies.

2.3.3 Risk Identification

The political representatives informally do risk assessments as part of daily governance, which use it to justify legislations in foreign policy, the judicial system, law enforcement, etc. Risk assessments are now being conducted in more sophisticated ways, particularly in the field of environmental legislation. Risk has to be 'empirically' ascertained, for which subjective biases arising due to cultural or ideological inclinations need to be kept out of policy judgments. The best example of risk assessment comes from the insurance industry where "the insurers have well-defined roles of actuary, underwriter, agent, auditor and adjustor." Each of these is an assessor in somewhat different circumstances or stages of the insuring, reinsuring, adjustment, recovery and claims payment processes. Hence, risk assessment is a continuous process of 'articulation', which needs to be undertaken periodically at every stage, or phases in a said activity/process. Objectivity of the risk assessment depends on the availability of adequate and timely data.

Risk, essentially *in the context of disasters*, is the probability that injury to life or damage to property and the environment may happen. However, in disaster management, risk refers to the combined susceptibility and vulnerability of the community to potential damage caused by a particular hazard within a specified time period. Risk is rooted in conditions of physical, social, economic and environmental vulnerability that need to be assessed and managed on a continuing basis.

Further, for understanding the above concepts, a technical evaluation process is usually undertaken, commonly called *hazard assessment, vulnerability analysis,* and *risk analysis*. These are structured analytical procedures for identifying hazards and estimate the probability of their occurrence and consequences given certain conditions. Taken altogether a similar structured analysis of actual or potential vulnerabilities, these estimations are compared with a standard criterion in order

to decide whether or not an action is desirable to reduce the probabilities or to protect the people, property, or environment. Realistically, it is necessary also to consider that to what extent perceived constraints of time and resources may slow down the application of desirable countermeasures.

Hazard and vulnerability are aggregated into risk. Risk can be seen subjectively or objectively analysed or perceived. A subjective risk is the risk perceived by the people affected which determines their willingness to accept a potential hazard and take steps to tackle it.

Check Your Progress 1

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) What do you mean by Hazards?

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2) Explain the concept of Risk.

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3) Discuss the nature of Risk Assessment.

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2.4 UNDERSTANDING VULNERABILITY

Vulnerability gives the *extent to which* a community is affected by a disaster. It involves the measure of 'resilience' and 'coping capacity' of a community in the face of adversity. Resilience and coping capacity develop over time as a result of proactive government policies. Vulnerability is an 'inclusive' concept in which vulnerability of a particular community to a particular type of disaster (flood or earthquake) is a resultant effect of a number of factors, which include physical factors, (geographical perspective) social (sociological perspective) and economic

factors (income and employment, involving micro and macroeconomic policy) besides institutional or administrative, which are essentially governance related issues. The process of vulnerability has been evidenced as proceeding along phases as follows; *root causes*, *dynamic pressures* that translate these into *active problems*, which are a result of a priority decision-making in governance related matters over time, for example, drought in a dry land area, leading to a famine in the absence of disaster mitigation efforts.

Social scientists and climate scientists often interpret vulnerability differently. Social scientists tend to view vulnerability as representing the set of socio-economic factors that determine people's ability to cope with stress or change (Allen, 2003). Climate scientists often view vulnerability in terms of the likelihood of occurrence and impacts of weather and climate related events. Related terms are fragility, stability, resilience and sensitivity of a system. These are the constituents of 'vulnerability'. There are some definitions of vulnerability and vulnerability assessment like: "Vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazard of place (risk and mitigation) with the social profile of communities" (Cutter, 1993). "By vulnerability, we mean the characteristics of a person or a group in terms of their capacity to anticipate, copes with, resists, and recovers from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood are put at risk by a discrete and identifiable event in nature or in society" (Blaikie, et.al, 1994). So, vulnerability is conceived as both physical risk and social response within a specific location and time.

The science of ecology, as Turner and Benjamin have pointed out, lacks a precise/ accepted definition of ecosystem fragility. Ecologists use "fragility" to denote a "system at risk", where the notion of "risk" is linked to ecological concepts of stability/instability and susceptibility. The chain of linkages characterising the system provides the ecological base for the notion of fragility. This complex internal structure of the organic ties of species at risk, is receiving detailed analysis in the emerging field of ecological risk assessment. (Travis & Morris, 1992).

According to Holling (1986), "Stability" is "the propensity of a system to attain and retain the equilibrium condition of a steady state or stable oscillation," where as "resilience" is "the ability of a system to maintain its structure and patterns of behaviour in the face of disturbance".

"Sensitivity" is used to measure the magnitude of negative impacts of environmental change. Change can have both positive and negative impact on human societies. Blaikie and Brookfield (1987) use the terms "sensitivity" and "resilience" to describe the quality of land system. They use "sensitivity" to refer to "the degree to which a given land system undergoes change due to natural forces, following human interference" and "resilience" to refer to " the ability of land to reproduce its capability after interference, and the measure of the need for human artifice to that end". In such manner, we may define sensitivity or susceptibility as "the degree of ecosystem or ecosystem component change associated with a given degree of human induced stress", and resilience as " the ability of a particular ecosystem to maintain the basic structure essential to support human uses during perturbations and to recover from such (and especially damaging) changes".

"Fragility" reflects both of these properties of human ecosystem interactions. This way, fragility is "the sensitivity of a particular ecosystem to human induced perturbations and its resilience to such perturbations."

Green (1990), in reference to flood hazards, expresses vulnerability as a relationship between changing conditions and normal use patterns. He defines vulnerability as a function of "susceptibility (the extent to which the presence of water will affect inputs or outputs of an activity); "dependency" (the degree to which an activity requires a particular good as an input to function normally); and "transferability" (the ability of an activity to response by deferring demand, using substitutes or relocating)"

2.4.1 Vulnerability Identification

Vulnerability is defined as the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the hazards. Vulnerability identification implies examining the root causes of vulnerability that could lie in technological, physical, or socio economic conditions and addressing the same through empirical research and policy. Identification of vulnerability is challenging because in that complex *processes interact* in resultant vulnerability of a system or a specific region/ people(s). Tackling vulnerability involves both short-term and long-term measures in that the problem of vulnerability has essentially come across as a problem of development. The solution therefore lies in policy analyses of developmental planning with a view to making sustainable development measures more precise and 'need based' with respect to reducing of vulnerability.

2.4.2 Types of Vulnerability

Type	Nature
Material/Economic Vulnerability	Inadequate access to resources
Social Vulnerability	Disintegration of local institutions and structures
Ecological Vulnerability	Degradation of environment and inability to protect it
Organizational Vulnerability	Lack of strong central, state and grassroots institutional structures
Educational Vulnerability	Insufficient access to information and knowledge
Attitudinal and Motivational Vulnerability	Low levels of public awareness and desire to change
Political Vulnerability	Limited access to political power and representation
Cultural Vulnerability	Blind faith in beliefs and customs
Physical Vulnerability	Weak building and other infrastructure, as well as physically weak or vulnerable people

Source: IGNOU, 2006.

2.5 VULNERABILITY AND RISK ASSESSMENT

The international community pioneered by the United Nations has attempted to analyse disasters over time and prepare an inventory of causes that lead to them, the extent of damage suffered, what and how mitigation needs to be applied, and where, successfully. Risk assessment is an investigation into the disaster phenomenon through detailed study and investigation of repeat events over time, such as floods or earthquakes, assessment of damage and estimation of future losses possible in the absence of disaster mitigation measures. Vulnerability assessment is a subset of risk assessment, which analyses differential vulnerability of communities in differential areas of disaster impact (such as increasing or decreasing degree of hazard proneness).

Precise quantification of risk, however, is difficult. At best, a gross estimation of risk is possible, for example, number of deaths and the number of people exposed to a hazard. Such crude estimates give only a limited idea of the likely damage from a hazard for different people at different places or even the probability of its occurrence.

Vulnerability Analysis entails assessing the loss of life and property from a *particular hazard* striking at a particular *intensity.* For example, '*x'* number of people are expected to be killed and property worth '*y'* destroyed, if a cyclone strikes with strong winds at 130km/hr.

Disaster vulnerability needs to be studied over time. It does not happen all of a sudden; rather communities gradually slip into a disaster mode. Thus, comprehensively, disaster vulnerability is understood both as 'products' and 'processes' in three main aspects:

- As 'product' of ongoing social-cultural and economic transformation 'processes' within communities;
- As product of normal (under) developmental process; and
- As product of immediate and long term disaster response.

An attempt should be made at redefining disasters in a dynamic and integrated perspective, integrating socio-cultural, developmental and ecological outlook.

The desirable in an academic analysis of vulnerability with the practical perspective of policy design shall include:

- Development of an integrated perspective, integrating socio-cultural, developmental and ecological perspectives to develop a comprehensive framework on disaster mitigation;
- Emphasis on poverty alleviation and community empowerment through local control on land and material resources, cultural continuity and compatibility, sustainability of livelihoods, equitable participation through empowerment, ethics, roles and responsibilities of local governance.

2.6 VULNERABILITY FACTORS

The concept of vulnerability covers risk of hazards and the measure of risk combined with the relative inability to cope with the resulting stress. Timmerman (1981) defined vulnerability at the society or community scale as 'the degree to which a system, or part of a system reacts adversely to a hazardous event.' Most signs of

reducing system scale vulnerability can be seen as expressions of either resilience or reliability. Anderson (2000) showed how the concept of human vulnerability has been refined through time, although there is still no fully acceptable and discipline free, definition available.

'Resilience' is a measure of the rate of recovery from a stressful experience, reflecting the social capacity to absorb and recover from the occurrence of a hazardous event. Traditionally, resilience has been the main weapon against hazard in poverty-dominated areas where disaster is often accepted as a 'normal' part of life. In this situation, community coping strategies are important. For example, nomadic herdsmen in semi-arid areas have tended to accumulate cattle during years with good grazing lands as an insurance against drought.

'Reliability', on the other hand, reflects the frequency with which protective devices against hazards fail. This approach is applicable to developed areas, where technology and engineering design have provided what is perceived to be a high degree of reliability for most urban services. However, extreme stress, for example, from an earthquake, can easily disrupt road networks, electric power lines or water systems.

In Asia and the Pacific, a significant number of people lost their lives from natural disasters over the past 45 years. The region was only hit by around 43 per cent of the disasters experienced globally, but the impact of these disasters in terms of lives lost was notable. Between 1970 and 2014, more than 2 million people died, accounting for 56.6 per cent of the total deaths in the world due to disasters. The impact and susceptibility of Asian and Pacific countries to disasters is evident when considering the total number of people affected. Over 6 billion people in the region have suffered from natural disasters, accounting for 87.6 per cent of the global total (UNESCAP, 2015). Most of these people are in poor regions, where vulnerability arises from poverty, discrimination and lack of democratic functioning hampering the development process. The poorest people often have little choice but to live in unsafe settings, whether it is urban shanties or degraded rural environments. In terms of loss of life and relative economic impact, disasters hit hardest where poverty stricken people are concentrated. In less developed countries, rural inhabitants outnumber people in the urban areas. Even then, now there are more urban dwellers in the third world than in Europe, North America and Japan in total. Metropolitan cities are growing at faster rate. In urban squatter settlements, population densities may reach as high as ten times of present level. Many buildings, without suitable material or construction skills, are erected on steep slopes or flood prone land, exposed to strong winds and landslides. In highly populated rural areas, population density can exceed 1000 per km² and life is a recurrent struggle to secure cultivable land. Many people are landless and disadvantaged by land tenure systems, which deny them access to the means to support themselves.

As has been rightly pointed out, "The study of the vulnerability of human and natural systems to climate change and variability, and of their ability to adapt to changes in climate hazards, is a relatively new field of research that brings together experts from a wide range of fields, including climate science, development studies, disaster management, health, geography, policy development and economics, to name but a few areas. There is need for an integrating framework to bring together diverse traditions in a coherent yet flexible fashion, allowing researchers to assess vulnerability, and the potential for adaptation in a wide variety of different contexts"(IPCC, 2001).

Both natural and man-made factors contribute to vulnerability. Some of the contributing factors are discussed below:

Population Displacement

Population displacement is both a *cause* and a *consequence* of disaster. There is evidence of correlation between poverty and economic inequality and rural to urban migrations, in that more the level of poverty, more is the extent of rural to urban migrations. The phenomenon is most observed in poor third world countries where the poor migrate from rural to urban areas in search of livelihood options. The social order remains basically 'oligarchic' and 'oligopolistic' in that inequality in income and wealth distribution persists. System change through 'soft' democratic options, such as legislation and rhetoric is not successful as entrenched powers are hard to reconcile to socialist philosophy. Result has been corruption and implementation hurdles, more specifically at the implementation level. This largely explains why land reforms and social forestry legislations have not met with expected success. While the size of agricultural holdings has gradually reduced, 'exploitation' at the hands of rich and resourceful farmers has persisted. Frequent droughts have compounded existing problems. The cumulative effect of such conditions has been mass migration of rural folk to urban metropolitan towns.

Urbanisation

Rural to urban migration has led to unmanageable urbanisation and urban congestion that has forced human and physical capital extension in high-risk zones. Consequently, the loss potential of hazards has gone up. Urbanisation has brought in its wake growth of informal settlements, unsafe living conditions, disease, class conflict and social capital depletion as some segments have been socially and economically marginalised. Globalisation has also contributed in many ways to increasing the vulnerability of the urban poor by creating 'uncertain' conditions regarding employment though the obvious impact seems to be betterment of life and better opportunities for all. Though urbanisation is a worldwide phenomenon, it is more pronounced in the third world, because of the above recounted factors. Illustrations to this effect from India substantiate it, as per the 2011 census figures, (provisional) 377 million, that is, 31.16% of the total population lived in 7,935 cities and towns in the country. The number of cities and towns has increased by 2,774 since last Census. Corresponding figures from the first census of India, (the 1901 census) indicate that 25.8 million persons, that is, one-tenth of the total population lived in 1,917 cities and towns. It thus shows vast increase in the number and proportion of total population living in cities and towns since the first census (Census, 2011).

On the other hand, population displacement is also a consequence of disasters. In the event of disasters, large-scale displacement of populations from affected areas takes place, which leads to temporary to permanent loss of livelihood for people. Small-scale industries and micro enterprises are particularly hit. Much work has not been done on providing insurance against disasters to people residing in hazard prone areas. Though some initiatives have been taken, all disasters have not yet been covered properly and resource mobilisation also is far from adequate (Dhar, 2002). Relocation options have also to be carefully weighed so as not to result in unintended consequences that negate the very purpose of the exercise. Unintended consequences as different forms of vulnerability that might be induced because of relocation for example, loss of livelihood for small businessmen because of increased distance from urban commercial centers.

Migration also has significant cultural impact, besides the more obvious, physical

dislocation of populations in that mass migrations introduce communities to alien cultural practices which disturb the cultural homogeneity of a community. In extreme conditions, they can cause civil strife. Different building practices and construction technologies may be introduced, which might be unsuited to the requirements of that particular area. Besides, administrative and political problems are caused due to the influx of refugees, which disturb the political and social matrix of the region, like the influx of Bangladeshi refugees did in India, following the 1971 war. Epidemics and congestion are other administrative problems caused due to mass influx of refugees.

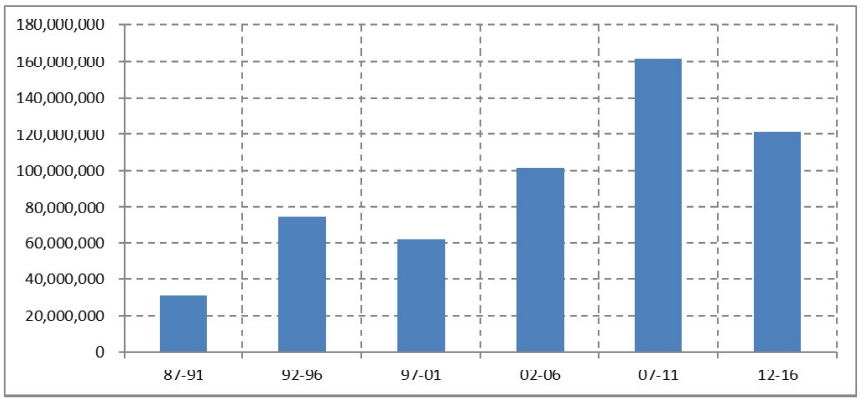
Gender

Gender based vulnerability is an accretion over time which causes disempowerment of women in social economic and political spheres. Gender inequality in social, economic and political spheres results in vast differences between men and women in emergency communication; household decisions about use of relief assets; voluntary relief and recovery work; access to evacuation shelter and relief goods; and employment in disaster planning, relief and recovery programmes, are among other areas of concern in disaster relief. Disaster mitigation as also response policy, particularly concerning control over relief resources, have to factor this component in decision-making with a view to making it more equitable and on the whole, more effective.

Economic Factors

Close correlation has been evidenced between poverty, disasters and environmental degradation. Relative vulnerability of people is comparatively much higher in developing third world countries than in the developed world. As per United Nations estimates, although least developed countries show less physical exposure to hazards (11%), they account for far greater number of casualties, (53%). On the other side, the most developed countries represent more (15%) physical exposure to hazards and account for significantly less (2.8%) victims. The inference drawn is that the magnitude of disaster suffered is directly correlated to the level of development, which explains largely the fact of the third world accounting for significantly more losses than the developed countries. This difference is shown by a list of disaster events and fatalities over 1960-82. Japan suffered 43 earthquakes and other disasters and lost 2,700 people that mean 63 deaths per disaster. Peru suffered 31 disasters with 91,000 dead, the vast majority lost in the single event of the 1970 earthquake.

Economic Damage (million USD) in the World (1987-2016)



***Source*:** ADRC, 2017.

The world economy functions and works against the poor who have little opportunity

to process and market what they produce and are dependent on the imports from the industrialized nations for manufactured goods which are quite often unstable. The poor regions have little opportunity to process and market what they produce and are dependent on the import from the industrialised nations of manufactured goods, which are often highly priced or tied to aid packages. The progressive hardship for the small-scale farmer, combined with a foreign debt burden that may be many times the normal annual export earnings, takes resources away from long-term development in a process that has been described as a transfusion of blood from the sick to the healthy. The cycle is reinforced when natural disaster destroys local products and undermines incentives for investment. Major disasters, such as the drought, disrupts and destroys local economies, and brings shortages in neighbouring regions, as a result create innumerable international refugees and stimulate aid programmes to the extent that the consequences of environmental hazards are truly global. The World Meteorological Organisation (WMO) report on "atlas of mortality and economic losses from weather, climate and extreme events" mentioned that around 2,682 extreme events have occurred in Asia during 1970-2012, resulting in 0.92 million deaths and US$ 798.8 billion of economic damages (WMO, 2015). The above diagram shows that the economic damage caused by natural disasters, in the year 2016 sees an increase from the year 2015. By contrast, in the 5-year period average analysis, the 2012-2016 average sees a decrease (ADRC, 2017).

Poverty situation increases vulnerability to disasters and contributes in enabling poverty. In order to facilitate sustainable development, it is essential to eliminate this vicious circle. The sustainable development, with emphasis on the long-term and intergenerational aspects, also enables us to face challenges. Compatibility between economic growth and sustainable development demands a method to measure the kind of growth that encompasses all important aspects pertaining to quality of life, such as human exposure to risk situations and species and lifestyles.

Geographical Factors

Global warming threatens to disrupt agriculture in developing countries though most green house gas emission has taken place from the developed world. Global warming has particularly increased the vulnerability of coastal areas, especially in the Small Island Development States (SIDS) sea level rise will threaten the fragile eco system of these regions, raising the frequency and intensity of natural hazards like tsunamis, cyclones, floods and storm surges. Coastal zones, wetlands and coral reefs are likely to be harmed which act as natural buffers against hazards like cyclones. The magnitude of disasters is also likely to be greater because of the increased pace of infrastructure development that has taken place in these regions in the last few years, owing to population pressure and growing attractiveness of these regions from the point of view of tourism (UNDP, 2002).

Check Your Progress 2

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Define Vulnerability.

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2) What are the types of Vulnerability?

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3) Discuss various factors of Vulnerability.

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2.7 CONCLUSION

Shift of emphasis from disaster response to risk reduction has opened up areas of exploratory research in the subject of disaster management. Vulnerability analysis seeks to preempt disaster management by ensuring timely preparedness on the part of people and institutions and government agencies involved. Disaster management is an imminent administrative task for reduction of disasters through prevention, preparedness, mitigation and response. There has been a paradigmatic shift of emphasis in the last decade from disaster relief and rehabilitation to prevention and mitigation strategies. Post-occurence treatment of disasters has proved an insufficient measure for proper protection of lives and property. There is also an emphasis on mainstreaming disaster management in everyday governmance by treating it as integral to policy formation and implementation process. In keeping with it, the focus in this Unit has been on Hazard, Risk and Vulnerability.

2.8 GLOSSARY

Biological Hazards : Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Examples of biological hazards are outbreaks of epidemic diseases, plant or animal contagion, insect plagues and extensive infestations.

Disaster : Serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of the affected people to cope using its own resources. Disasters are natural and man-made.

Geological Hazards : Geological hazards include internal earth processes or tectonic origin, such as earthquakes, tsunamis, volcanic activity and emissions as well as external processes such as mass movements: landslides, rockslides, rock falls or avalanches, surface collapse, expansive soils and debris or mud flows. Geological hazards can be single, sequential or combined in their origin and effects, for example, floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and wind storms, blizzards and other severe storms; drought, desertification, wild land fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches.

Hazard : A precise definition of hazard is difficult. The International Secretariat of Disaster Reduction has defined hazard as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards have both natural and human components.

Hydro-meteorological Hazards : These hazards are of *atmospheric, hydrological or oceanographic nature.* Hydro-meteorological hazards include: floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and wind storms, blizzards and other severe storms; drought, desertification, wild land fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches. Hydro-meteorological hazards can be single, sequential or combined in their origin and effects.

Risk : Risk is explained as the likelihood or probability of a loss (es). Risk could be voluntary as for example, a game of boxing or bull fighting, or involuntary, which is unforeseen and unprepared for. The word is employed in general usage as also technical usage whereby it denotes the extent of likely damage or the hazard potential of a particular event.

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2.10 ANSWERS TO CHECK YOUR PROGRESS EXCERCISES

Check Your Progress 1

1) Your answer should include the following points:

- Hazard is a potential or a latent/dormant cause, which is activated when the right configuration of factors, natural or man-made or both, present themselves.
- Disaster takes place when a community is affected by a hazard and the, impact of the disaster is determined by the extent of a community's vulnerability to the hazard.

2) Your answer should include the following points:

- Risk is a probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.
- Risk = Hazards x Vulnerability.
- It is as a function of the hazard, exposure and vulnerability.

3) Your answer should include the following points:

- Risk Assessment is a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend.
- It is a continuous process of 'articulation', which needs to be undertaken periodically at every stage, or phases in a said activity/process.

Check your Progress 2

1) Your answer should include the following points:

- Vulnerability is the conditions determined by physical, social, economic,

and environmental factors or processes, which increase the susceptibility of a community to the hazards.

- It is a function of susceptibility, dependency, and transferability.

2) Your answer should include the following points:

- Material/Economic Vulnerability; Social Vulnerability; Ecological Vulnerability; Organizational Vulnerability; Educational Vulnerability; Attitudinal & Motivational Vulnerability; Political Vulnerability; Cultural Vulnerability; and Physical Vulnerability.

3) Your answer should include the following points:

- Population Displacement
- Urbanisation
- Gender
- Economical factors
- Geographical factors.

UNIT 3 NATURAL AND MAN-MADE DISASTERS*

Structure

3.0 OBJECTIVES

After reading this Unit, you should be able to:

- Understand various types of natural disasters; and
- Explain different types of man-made disasters.

3.1 INTRODUCTION

In contemporary academia, disasters are seen as the consequence of inappropriately managed risk. These risks are the product of a combination of both hazards and vulnerability. Hazards that strike in areas with low vulnerability will never become disasters, as in the case of uninhabited regions. A disaster occurs when a hazard impacts vulnerable people, and it can be classified into two broad categories: Natural disasters and Man-made disasters.

A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience or ability to recover and also on the infrastructure available. Man-made disasters are result of human actions. This can include environmental degradation, pollution and accidents. The difference between natural and man-made disasters is the element of human intent or negligence that leads to human suffering and environmental damage.

Though often caused by nature, disasters can have human origins. The combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disaster.

* Contributed by Dr. Poonam Rautela, Associate Professor, M B Govt. PG College, Haldwani (Uttarakhand).

3.2 TYPES OF NATURAL DISASTERS

Natural disasters can be classified into four major categories and several sub-categories categories:

- **Geophysical:** Geophysical disasters are those destructive events that originate within or are caused by the processes of the earth. These disasters include: Earthquakes, Volcanic activity, Landslides and Tsunamis.
- **Hydrological:** Hydrological disaster is a violent, sharp and harmful amendment either in quality of earth's water or in distribution or movement of water ashore below the surface or in atmosphere. These disasters include: Avalanches and floods.
- **Climatological:** Climatological disasters are defined as events caused by long-lived/meso to macro scale processes in the spectrum from intra-seasonal to multi-decadal climate variability. Such events are further classified as: Extreme Temperature; Drought; Wildfire and Cyclones.
- **Biological:** Biological disasters define the devastating effects caused by an enormous spread of a certain kind of living organism – that may cause the spread of a disease, virus, or an epidemic. Biological disasters can also be simply, a sudden growth in the population of a certain kind of plants or animals, e.g., a locust plague.

3.2.1 Geophysical Disasters

Earthquakes

Earthquake has been termed as a devastating phenomenon. It is felt that the key to reduce its toll on human life, livestock and property lies in understanding the causes and mechanisms of earthquake. (Sinvhal, 2010). Earthquakes are the vibrations caused by rupturing of rocks under stress. The underground surface along which the rock breaks and moves is called a fault plane. The size or magnitude of earthquakes is determined by measuring the amplitude of the seismic waves recorded on a seismograph and the distance of the seismograph from the earthquake. These are put into a formula which converts them to a magnitude, which is a measure of the energy released by the earthquake. For every unit increase in magnitude (measured by Richter Scale), there is roughly a twenty three-fold increase in the energy released. The focus of an earthquake is the point where it originated within the Earth. The earthquake epicentre is the point on the Earth's surface directly above the focus. The amplitude of the shaking caused by an earthquake depends on many factors, such as the magnitude, distance from the epicentre, depth of focus, topography, and the local ground conditions.

Earthquake effects, as noted by people, are rated using the Modified Mercalli (MM) intensity scale, which ranges from I (imperceptible) up to XII (total destruction). At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Shaking and ground rupture are the main effects created by earthquakes, principally resulting in more or less severe damage to buildings and other rigid structures. The severity of the local effects depends on the complex combination of the earthquake magnitude, the distance from the epicenter, and the local geological and geomorphological conditions, which may amplify or reduce wave propagation. Earthquakes, along

with severe storms, volcanic activity, coastal wave, and wildfires, can produce slope instability leading to landslides, a major geological hazard. Earthquakes can also cause fires by damaging electrical power or gas lines.

"The Great Chilean Earthquake" – world's largest earthquake with an instrumentally documented magnitude occurred on May 22, 1960 near Valdivia, in southern Chile. It was assigned a magnitude of 9.5 by the United States Geological Survey. It is referred to as the "Great Chilean Earthquake" and the "1960 Valdivia Earthquake" (Geologynat, 2017).

Volcanic Eruption

A volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. Earth's volcanoes occur because its crust is broken into rigid tectonic plates that float on a hotter, softer layer in its mantle. Therefore, on earth, volcanoes are generally found where tectonic plates are diverging or converging and most are found underwater. Volcanic eruptions can generally be characterised as either explosive eruptions, sudden ejections of rock and ash, or effusive eruptions, relatively gentle outpourings of lava.

Large, explosive volcanic eruptions inject water vapor, carbon dioxide, sulfur dioxide, hydrogen chloride, hydrogen fluoride and ash (pulverized rock and pumice) into the stratosphere to heights of 16–32 kilometres above the earth's surface. The most significant impacts from these injections come from the conversion of sulfur dioxide to sulfuric acid, which condenses rapidly in the stratosphere to form fine sulfate aerosols. These aerosols grow and coagulate, they settle down into the upper troposphere where they serve as nuclei for cirrus clouds and further modify the earth's radiation balance. Most of the hydrogen chloride and hydrogen fluoride are dissolved in water droplets in the eruption cloud and quickly fall to the ground as acid rain. Ash thrown into the air by eruptions can present a hazard to aircraft, especially jet aircraft where the particles can be melted by the high operating temperature; the melted particles then adhere to the turbine blades and alter their shape, disrupting the operation of the turbine. Erupting volcanoes can pose many hazards, not only in the immediate vicinity of the eruption. Large eruptions can affect temperature as ash and droplets of sulfuric acid obscure the sun and cool the earth's lower atmosphere (causing volcanic winters); however, they also absorb heat radiated from the earth, thereby warming the upper atmosphere (or stratosphere). Historically, volcanic winters have caused catastrophic famines. While many eruptions only pose dangers to the immediately surrounding area, Earth's largest eruptions can have a major regional or even global impact, with some affecting the climate and contributing to mass extinctions.

The massive Tambora Strato Volcano forms the entire 60-km-wide Sanggar Peninsula on northern Sumbawa Island. On 10 April 1815, Tambora produced the largest eruption known on the planet during the past 10,000 years. The volcano erupted more than 50 cubic kilometers of magma and collapsed afterwards to form a 6 km wide and 1250 m deep caldera. The eruption produced global climatic effects and killed more than 100,000 people, directly and indirectly (Klingaman, W.K. & Klingaman, N.P., 2013).

Landslides

A landslide is the slope down movement of rock, debris or earth. They result from the failure of the materials which make up the hill slope and are driven by

the force of gravity. Landslides are also known as landslips, slumps or slope failure. It has been pointed out by Crozin and Glade (2005) that "In general terms, landslides generate a small but important component of the spectrum of hazard and increasing the risk that faces mankind. Landslides present a threat to life and livelihood throughout the world ranging from minor disruption to social and economic catastrophe". Some of the most common types of landslide are earth slides, rock falls and debris flows. The movement of landslide material can vary from abrupt collapses to slow gradual slides and ranges from almost undetectable to extremely rapid. Sudden and rapid events are the most dangerous because of a lack of warning and the speed at which material can travel down the slope as well as the force of its resulting impact. Extremely slow landslides might move only millimeters or centimeters a year and can be active over many years. Although this type of landslide is not a threat to people, however, they can cause considerable damage to property.

Landslides can be triggered by natural causes or by human activity. They range from a single boulder in a rock fall or topple to tens of millions of cubic meters of material in a debris flow. They can also vary in their extent, with some occurring very locally and impacting a very small area or hill slope while others affect much larger regional areas. The distance travelled by landslide material can also differ significantly with slides travelling from a few centimetres to many kilometres depending on the volume of material, water content and gradient of the slope. Slope material that becomes saturated with water may develop into a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses and cars, thus blocking bridges and tributaries causing flooding along its path.

Landslides occur when the slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone.

Natural causes of landslides include:

- increase in groundwater (pure water) pressure destabilizing the slope;
- loss or absence of vertical vegetative structure, soil nutrients, and soil structure (for example, after a wildfire – a fire in forests lasting for 3–4 days);
- erosion of the toe of a slope by rivers or ocean waves;
- weakening of a slope through saturation by snow melting, glaciers melting, or heavy rain;
- earthquakes adding loads to barely stable slope;
- earthquake-caused liquefaction resulting into destabilize slopes;
- volcanic eruptions.

Landslides are aggravated by human activities, such as

- deforestation, faulty cultivation and ill-conceived construction, which destabilize the already fragile slopes.
- vibrations from machinery or traffic or blasting
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope

- construction, agricultural or forestry activities (logging) which change the amount of water infiltrating the soil.

Tsunamis

Tsunamis are giant waves caused by earthquakes or volcanic eruptions under the sea. Out in the depths of the ocean, tsunami waves do not dramatically increase in height. But as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. When a tsunami travels over a long and gradual slope, it allows time for the tsunami to grow in wave height. This is called shoaling and typically occurs in shallow water less than 100 m. Successive peaks can be anywhere from five to 90 minutes apart. In the open ocean, even the largest tsunamis are relatively small with wave heights of less than one meter. The shoaling effect can increase this wave height to a degree such that the tsunami could potentially reach an onshore height of up to 30 meters above sea level. The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Tsunami waves may travel as fast as jet planes over deep waters, only slowing down when reaching shallow waters. While tsunamis are often referred to as tidal waves, this name is discouraged by oceanographers because tides have little to do with these giant waves.

The 2004 Indian Ocean earthquake occurred on 26 December with the epicenter off the west coast of Sumatra, Indonesia. The shock had a moment magnitude of 9.1–9.3 and a maximum Mercalli intensity of IX (Violent). The undersea megathrust earthquake was caused when the Indian Plate was subducted under the Burma Plate and triggered a series of devastating tsunamis along the coasts of most landmasses bordering the Indian Ocean, killing 230,000–280,000 people in 14 countries, and inundating coastal communities with waves up to 30 meters (100 ft) high. It was one of the deadliest natural disasters in recorded history. Indonesia was the hardest-hit country, followed by Sri Lanka, India, and Thailand (Government of India, 2016).

3.2.2 Hydrological Disasters

Avalanches

An avalanche is considerable amount of snow sliding down a mountainside. It can be compared to a landslide, only with snow instead of earth. Another common term for avalanche is “snowslide”. As an avalanche reaches nearer to the bottom of the slope, it gains speed and power, this can cause, even the smallest of snowslides, to be a major disaster.

There are two common types of avalanches, a surface avalanche that occurs when a layer of snow with different properties slides over another layer of snow, for example, when a layer of dry loosely packed snow slides over a dense layer of wet snow. The other common avalanche is known as a Full-Depth Avalanche which occurs when an entire snow cover, from the earth to the surface, slides over the ground. Although primarily composed of flowing snow and air, large avalanches have the capability to entrain ice, rocks, trees, and other surface material. Avalanches happen on mountains with extreme amounts of slow fall and build-up. Wherever snow is lying on ground on an extreme and sufficient angle there is potential for a sleeping avalanche. Three main factors effect whether or not avalanches are probable to occur. These three factors are the weather, the snow pack and the terrain. The weather is the most important factor when deciding whether avalanches

are likely to happen or not. For example, if the temperature were to have a rapid increase then a wet slab avalanche is likely to occur. The height of the snow pack is also dependent on the weather.

Avalanches are not rare or random events and are endemic to any mountain range that accumulates a standing snowpack. Avalanches are most common during winter or spring but glacier movements may cause ice and snow avalanches at any time of year. In mountainous terrain, avalanches are among the most serious objective natural hazards to life and property, with their destructive capability resulting from their potential to carry enormous masses of snow at high speeds.

Floods

A flood occurs when water overflows or inundates land, that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. Coastal flooding occurs when a large storm or tsunami causes the sea to surge inland. Moving water has awesome destructive power. When a river overflows its banks or the sea drives inland, structures poorly equipped to withstand the water's strength are no match. Bridges, houses, trees, and vehicles can be picked up and carried off. The erosive force of moving water can drag soil from under a building's foundation, causing it to crack and tumble.

When floodwaters recede, affected areas are often blanketed in silt and mud. The water and landscape can be contaminated with hazardous materials, such as sharp debris, pesticides, fuel, and untreated sewage. Potentially dangerous mold blooms can quickly overwhelm water-soaked structures. Residents of flooded areas can be left without power and clean drinking water, leading to outbreaks of deadly waterborne diseases like typhoid, hepatitis A, and cholera.

3.2.3 Climatological Disasters

Extreme Temperature

Heat Waves: A heat wave is a prolonged period of excessively hot and sometimes also humid weather relative to normal climate patterns of a certain region. Heat kills people by stressing the human body beyond its limits. In extreme heat and high humidity, evaporation is slowed and the body must work extra hard to maintain a normal temperature. Most heat disorders occur because the victim has been overexposed to heat or has over-exercised for his or her age and physical condition. Older adults, young children, and those who are sick or overweight are more likely to succumb to extreme heat. Conditions that can induce heat-related illnesses include stagnant atmospheric conditions and poor air quality. Consequently, people living in urban areas may be at greater risk from the effects of a prolonged heat wave than those living in rural areas. Also, asphalt and concrete store heat longer and gradually release heat at night, which can produce higher nighttime temperatures known as the "urban heat island effect."

Cold waves, winter storms and extreme winter conditions: A cold wave can be both a prolonged period of excessively cold weather and the sudden invasion of very cold air over a large area. Along with frost, it can cause damage to agriculture, infrastructure, and property. Cold waves, heavy snowfall and extreme cold can immobilise an entire region. Even areas that normally experience mild winters can

be hit with a major snowstorm or extreme cold. Winter storms can result in flooding, storm surge, closed highways, blocked roads, downed power lines and hypothermia.

Droughts

A drought is a period of below-average precipitation in a given region; resulting in prolonged shortages in the water supply, whether atmospheric, surface water or ground water. A drought can last for months or years, or may be declared after as few as 15 days. It can have a substantial impact on the ecosystem and agriculture of the affected region and harm to the local economy. Periods of heat can significantly worsen drought conditions by hastening evaporation of water vapor.

Many plant species, such as those in the family Cactaceae (or cacti), have drought tolerance adaptations like reduced leaf area and waxy cuticles to enhance their ability to tolerate drought. Some others survive dry periods as buried seeds. Semi-permanent drought produces arid biomes such as deserts and grasslands. Prolonged droughts have caused mass migrations and humanitarian crises. Droughts can be categorised into:

- Meteorological drought is specific to different regions.
- Agricultural drought accounts for the water needs of crops during different growing stages. For instance, not enough moisture at planting may hinder germination, leading to low plant populations and a reduction in yield.
- Hydrological drought refers to persistently low water volumes in streams, rivers and reservoirs. Human activities, such as drawdown of reservoirs, can worsen hydrological droughts. Hydrological drought is often linked with meteorological droughts.
- Socio-economic drought occurs when the demand for water exceeds the supply. Examples of this kind of drought include too much irrigation or when low river flow forces hydroelectric power plant operators to reduce energy production.

Wildfires

A wildfire is a fire in an area of combustible vegetation that occurs in the countryside or rural areas. Depending on the type of vegetation where it occurs, a wildfire can also be classified more specifically as a brush fire, bush fire, desert fire, forest fire, grass fire, hill fire, peat fire or vegetation fire. Earth is an intrinsically flammable planet owing to its cover of carbon-rich vegetation, seasonally dry climates, atmospheric oxygen, and widespread lightning and volcano ignitions.

Wildfires can be characterised in terms of the cause of ignition, their physical properties, the combustible material present, and the effect of weather on the fire. Wildfires can cause damage to property and human life, but they have many beneficial effects on native vegetation, animals, and ecosystems that have evolved with fire. Many plant species depend on the effects of fire for growth and reproduction. However, wildfire in ecosystems where wildfire is uncommon or where non-native vegetation has encroached may have negative ecological effects. Wildfire behaviour and severity result from the combination of factors such as available fuels, physical setting, and weather.

The most noticeable adverse effect of wildfires is the destruction of property. However, the release of hazardous chemicals from the burning of wildland fuels

also significantly impacts human health. Wildfire smoke is composed primarily of carbon dioxide and water vapor. Other common smoke components present in lower concentrations are carbon monoxide, formaldehyde, acrolein, polyaromatic hydrocarbons, and benzene. Despite carbon dioxide's high concentration in smoke, it poses a low health risk due to its low toxicity. Rather, carbon monoxide and fine particulate matter have been identified as the major health threats.

The degree of wildfire smoke exposure to an individual is dependent on the length, severity, duration, and proximity of the fire. People are exposed directly to smoke via the respiratory tract though inhalation of air pollutants. Indirectly, communities are exposed to wildfire debris that can contaminate soil and water supplies.

Cyclones

In meteorology, a cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure. The term "cyclone" refers to the storms' cyclonic nature, with counterclockwise rotation in the northern hemisphere and clockwise rotation in the southern hemisphere. Cyclones are characterised by inward spiraling winds that rotate about a zone of low pressure. The largest low-pressure systems are polar vortices and extra tropical cyclones of the largest scale (the synoptic scale). Warm-core cyclones such as tropical cyclones and subtropical cyclones also lie within the synoptic scale. Mesocyclones, tornadoes and dust devils lie within the smaller mesoscale Cyclogenesis is the development or strengthening of cyclonic circulation in the atmosphere. Cyclogenesis is an umbrella term for several different processes that all result in the development of some sort of cyclone. It can occur at various scales, from the microscale to the synoptic scale.

Tropical cyclones are formed as a result of significant convective activity, and have warm core. Mesocyclones are formed as warm core cyclones over land, and can lead to tornado formation. There are six main requirements for tropical cyclogenesis:

- sufficiently warm sea surface temperatures
- atmospheric instability
- high humidity in the lower to middle levels of the troposphere
- enough Coriolis force to develop a low-pressure center
- a preexisting low-level focus or disturbance
- low vertical wind shear.

Tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and a damaging storm surge. The winds increase the wave size, and in so doing they draw more heat and moisture into their system, thereby increasing their strength. They develop over large bodies of warm water, and hence lose their strength if they move over land. This is the reason coastal regions can receive significant damage from a tropical cyclone, while inland regions are relatively safe from strong winds. Heavy rains, however, can produce significant flooding inland. Storm surges rise in sea level, caused by the reduced pressure of the core that in effect "sucks" the water upward and from winds that in effect "pile" the water up. Storm surges can produce extensive coastal flooding up to 40 kilometres from the coastline. Although their effects on human populations can be devastating, tropical cyclones can also relieve drought

conditions. They also carry heat and energy away from the tropics and transport it toward temperate latitudes, which make them an important part of the global atmospheric circulation mechanism. As a result, tropical cyclones help to maintain equilibrium in the Earth's troposphere as well.

3.2.4 Biological Disasters

Disease epidemics

An epidemic is the rapid spread of infectious disease to a large number of people in a given population within a short period of time, usually two weeks or less. For example, in meningococcal infections, an attack rate in excess of 15 cases per 100,000 people for two consecutive weeks is considered an epidemic (CTI Reviews, 2017).

Epidemics of infectious disease are generally caused by several factors including a change in the ecology of the host population (for example, increased stress or increase in the density of a vector species), a genetic change in the pathogen reservoir or the introduction of an emerging pathogen to a host population (by movement of pathogen or host). Generally, an epidemic occurs when host immunity to either an established pathogen or newly emerging novel pathogen is suddenly reduced below that found in the endemic equilibrium and the transmission threshold is exceeded.

An epidemic may be restricted to one location; however, if it spreads to other countries or continents and affects a substantial number of people, it may be termed a pandemic. The conditions which govern the outbreak of epidemics include infected food supplies such as contaminated drinking water and the migration of populations of certain animals, such as rats or mosquitoes, which can act as disease vectors. Certain epidemics occur at certain seasons.

Check Your Progress 1

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Discuss Geophysical disasters.

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2) Explain Climatological disasters with special reference to cyclone.

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3) Write a note on Biological disasters.

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3.3 TYPES OF MAN-MADE DISASTERS

Complex emergencies and conflicts

"Complex emergencies" are typically characterised by:

- extensive violence and loss of life;
- displacements of populations;
- widespread damage to societies and economies;
- the need for large-scale, multi-faceted humanitarian assistance ;
- the hindrance or prevention of humanitarian assistance by political and military constraints;
- significant security risks for humanitarian relief workers in some areas.

Famine

A famine is a widespread scarcity of food, caused by several factors including crop failure, population imbalance, or government policies. This phenomenon is usually accompanied or followed by regional malnutrition, starvation, epidemic, and increased mortality. Every inhabited continent in the world has experienced a period of famine throughout history.

According to the United Nations humanitarian criteria, even if there are food shortages with large numbers of people lacking nutrition, a famine is declared only when certain measures of mortality, malnutrition and hunger are met.

The criteria are:

- At least 20% of households in an area face extreme food shortages with a limited ability to cope
- The prevalence of acute malnutrition in children exceeds 30%
- The death rate exceeds two persons per 10,000 persons per day.

Food shortages in a population are caused either by a lack of food or by difficulties in food distribution; it may be worsened by natural climate fluctuations and by extreme political conditions related to oppressive government or warfare.

Transport and industrial accidents

Transport disaster is a term used to describe technological transport accidents involving mechanised modes of transport. It comprises of four disaster subsets:

accidents involving air, boat, rail transport and accidents involving motor vehicles on roads and tracks.

Industrial disasters are non-natural disastrous occurrences that include:

- Accident release occurring during the production, transportation or handling of hazardous chemical substances.
- Explosions disasters (only be classified as explosions when the explosions is the actual disaster). If the explosion is the cause of another disaster, the event will be classified as the resulting disaster.
- Chemical explosion: violent destruction caused by explosion of combustible material, nearly always of chemical origin.
- Nuclear explosion/Radiation accidental release of radiation occurring in civil facilities, exceeding the internationally established safety levels.
- Mine explosion accidents which occur when natural gas or coal dust reacts with the air.
- Chemical pollution: A sudden pollution of water or air near industrial areas, leading to internal body disorders with permanent damage of the skin.
- Atmosphere pollution: Contamination of the atmosphere by large quantities of gases, solids and radiation produced by the burning of natural and artificial fuels, chemicals and other industrial processes and nuclear explosions.
- Pollution or degradation of atmosphere.
- Acid rain.

Check Your Progress 2

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Discuss the types of man-made disasters?

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2) Write a note on famines.

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3) Discuss transport and industrial accidents.

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3.4 CONCLUSION

In recent years, disasters took toll of thousands of lives and caused massive destruction of property. These have adversely affected the vital sectors of our development as agriculture, communication, irrigation, power projects and rural and urban settlements. The time and cost overrun in some cases have been enormous but their indirect impact on our economy has never been calculated. India is among the world's most disaster prone areas and a large part of the country is exposed to natural hazards, which often turn into disasters causing loss of life and property. The unique geo-climatic conditions have exposed this country to natural catastrophes. They are sudden, drastic and normally occur without any alarm or warning. Some disasters may be short lived such as earthquakes and some other may be of long duration, such as drought. However, irrespective of the duration of a disaster, the damage in the form of deaths, injuries and losses of property is immense. The magnitude of the disasters can be judged by the fact that only during the past two decades; occurrences of floods, earthquakes, landslides, cyclones, etc. have killed several million people. Though most of the disasters have a natural origin, man-made disasters are also becoming significant. Since we cannot control the natural disasters, it is necessary to keep a check on human activities so as to reduce the possibilities of occurrences of man-made disasters. Furthermore, we can mitigate the suffering caused by disasters by following an effective disaster management plan for reduction of disasters through prevention, preparedness, mitigation and response.

3.5 GLOSSARY

Natural Disaster : A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience or ability to recover and also on the infrastructure available.

Man-made Disaster : Man-made disasters are events that are caused by humans and occur in or close to human settlements. This can include environmental degradation, pollution and accidents.

Geophysical Disaster : Geophysical disasters are those destructive events that originate within or are caused by the processes of the earth. These disasters include: earthquakes, volcanic activity, landslides and tsunamis.

Hydrological Disasters : Hydrological disasters are violent, sharp and harmful amendment either in quality of earth's water or in distribution or movement of water ashore below the surface or in atmosphere. These disasters include: avalanches and floods.

Climatological Disasters : Climatological disasters are defined as events caused by long-lived/meso to macro scale processes in the spectrum from intra-seasonal to multi-decadal climate variability. Such events are further classified as: extreme temperature; drought; wildfire and cyclones.

Biological Disasters : Biological disasters define the devastating effects caused by an enormous spread of a certain kind of living organism – that may the spread a disease, virus, or an epidemic. Biological disasters can also be simply, a sudden growth in the population of a certain kind of plants or animals, e.g., a locust plague. These disasters include: Disease epidemics.

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3.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Your answer should include the following points:

   - Geophysical disasters are destructive events that originate within or are caused by the processes of the earth.
   - Earthquakes, Volcanic activity, Landslides and Tsunamis.

2) Your answer should include the following points:

   - Climatological disasters are events caused by long-lived/meso to macro scale processes in the spectrum from intra-seasonal to multi-decadal climate variability.
   - Extreme Temperature; Drought; Wildfire and Cyclones are considered as climatological disasters.

- Cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure.
- Based on the intensity the tropical cyclones are referred as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, or simply as a cyclone

3) Your answer should include the following points:

- Biological disasters is the outcome of devastating effects caused by an enormous spread of a certain kind of living organism – that may the spread a disease, virus, or an epidemic.
- It may be called disaster epidemics.
- Epidemic is the rapid spread of infectious disease to a large number of people in a given population within a short period of time.
- It occurs when host immunity to either an established pathogen or newly emerging novel pathogen is suddenly reduced below that found in the endemic equilibrium and the transmission threshold is exceeded.

Check Your Progress 2

1) Your answer should include the following points:

- Complex emergencies and conflicts.
- Famine.
- Transport and Industrial Accidents.

2) Your answer should include the following points:

- Famine is a scarcity of food, caused by several factors including crop failure, population imbalance, or government policies.
- It is usually accompanied or followed by regional malnutrition, starvation, epidemic, and increased mortality.

3) Your answer should include the following points:

- Transport disaster is a technological transport accident involving mechanised modes of transport. Accidents involving air, boat, rail transport and accidents involving motor vehicles on roads and tracks are come under the category of Transport and Industrial Accidents.
- Chemical/Nuclear/Mine Explosion, Pollution degradation, Acid rain and Chemical/Atmospheric Pollution are considered as industrial accident related disasters.

UNIT 4 DISASTER PROFILE OF INDIA*

Structure

4.0 OBJECTIVES

After reading this Unit, you should be able to:

- Discuss the disasters that occur in India;
- Understand the statistics of natural disasters in India; and
- Know the Disaster Profile of India.

4.1 INTRODUCTION

The Indian sub-continent is among the world's most disaster prone areas. Almost 85% of India's area is vulnerable to one or multiple hazards. Of the 29 states and 7 union territories in India, 22 are multi-disaster prone. It is vulnerable to wind storms spawned in the Bay of Bengal and the Arabian Sea; earthquakes caused by active crustal movement in the Himalayan mountains; floods brought by monsoons, and droughts in the country's arid and semi-arid areas. India is vulnerable, in varying degrees, to a large number of disasters. More than 58.6 per cent of the landmass is prone to earthquakes (high seismic zones III–V) of moderate to very

* Contributed by Dr. Poonam Rautela, Associate Professor, M B Govt. PG College, Haldwani (Uttarakhand).

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. Moreover, India is also vulnerable to Chemical, Biological, Radiological and Nuclear (CBRN) emergencies and other man-made disasters (NDMA, 2016).

Disaster risks in India are further compounded by increasing vulnerabilities related to changing demographics and socio-economic conditions, unplanned urbanisation and development within high-risk zones, environmental degradation, climate change, geological hazards, epidemics and pandemics. Clearly, all these contribute to a situation where disasters seriously threaten India's economy, its population and sustainable development.

4.2 VULNERABILITY PROFILE OF INDIA

India, due to its, physiographic and climatic conditions is one of the most disaster prone areas of the world. It is vulnerable to windstorms from both the Arabian Sea and Bay of Bengal. Floods brought about by heavy rains and drought in arid and semi-arid areas also contribute in making hostile environment of this sub-continent. The western region of the country, represented by the Thar Desert and the central India by the Deccan Plateau, face recurring droughts due to acute shortage of rainfall. India has increasingly become vulnerable to Tsunamis since the 2004 Indian Ocean Tsunami. India has a coastline running 7600 km long; as a result is repeatedly threatened by cyclones.

India has been classified into three main geological divisions, that is, Himalayas, also known as the Extra-Peninsula; Indo-Gangetic Plains and the Peninsula. The Himalayan is sub-classified by two methods. In method-1, the Himalaya is divided from west to east, into four regions. They are Punjab Himalaya-the area between Indus and Sutlej rivers, Kumaon Himalaya-area between Sutlej and Kali Rivers, Nepal Himalaya- area between Kali and Tista Rivers and Assam Himalaya-area between Tista and Brahmaputra Rivers. As per method-2, the Himalaya is divided in to three regions only. These are the Nepal Himalaya that constitutes the Central Himalayas, the mountainous area on its west and east as western and eastern Himalayas. Every region has its own risk of disaster. The region and risk wise classification will be explained in subsequent paragraphs.

4.2.1 The Himalayan Region

As per Hindu mythology, the Himalayas are the place of abode for Gods and thus every year, thousands of pilgrims religiously visit the important sacred places in this region. However, the young Himalayan mountain range on the north still shows focal signs of neo-tectonism. High atmospheric precipitation concentrated to the monsoon season, together with high relative relief and highly trusted, folded, faulted, metamorphosed and weathered rocks make this region highly prone to landslides and flash floods. Landslides are a routine phenomenon in the region. The Malpa slide (1998), Okhimath (1998), Uttarkashi (2003 & 2012) Uttarakhand flash flood (2013) represent the extreme events. The entire Himalayan region is seismically highly active and marked in Zones V and IV on earthquake risk map. The seismic hazard in the Himalayan region is very high. It doesn't mean the other regions are safe from the threat of earthquakes. No part of the country that falls in the least affected Zone I of the seismic risk map. The Uttarkashi earthquake

(1991), Killari earthquake (1993), Koyana earthquake (1997), Chamoli earthquake (1999), Bhuj earthquake (2001), Jammu and Kashmir earthquake (2005), Sikkim earthquake (2011) are some of the recent ones.

In mountainous region, the area above 3500 meters is devoid of vegetation and normally snow bound. These areas are considered as high altitude areas. The weather is much unpredictable. There is shortage of oxygen in the atmosphere. The steep mountainous peaks, permanent glaciers, moraines, and cold water lakes are common. Area is cold, windy and prone to crevasses; fresh snow falls and avalanches. In summer due to melting of snow and glacier, the water inflow increases in lakes and stream, which may cause flood. The hilly area below 3500 feet, depending up on the geographical and climatic condition, is more prone to heavy rain, cloud burst, flash flood, landslide and mudflow. The major natural risks in this region are: Earthquake, Landslides, Forest fires, Soil erosion, Snow avalanches and Flash floods.

4.2.2 The Gangetic Plain

The Indo-Gangetic plain that is densely populated and is drained by the Himalayan river is prone to both floods and droughts. Floods in the Indo–Gangetic–Brahmaputra plains are an annual feature. On an average, a few hundred lives are lost, millions are rendered homeless and several hectares of crops are damaged every year. Nearly 75% of the total rainfall occurs over a short monsoon season (June – September). 40 million hectares, or 12% of Indian land, is considered prone to floods. Floods are a perennial phenomenon in at least 5 states – Assam, Bihar, Odisha, Uttar Pradesh and West Bengal. In the other extreme, about 50 million people are affected annually by drought. Of approximately 90 million hectares of rain-fed areas, about 40 million hectares are prone to draught (Rajan, 2018).

4.2.3 Arid and Semi Arid Regions

Arid and semi-arid regions are characterised by a climate with no or insufficient rainfall to sustain agricultural production. Within India, almost 53.4 per cent land area comprises arid and semi-arid region (Patra, 2016). The rains are erratic and often come in a few heavy storms of short duration, resulting in high run-off, instead of replenishing the ground water. Protective vegetation cover is sparse and there is very little moisture for most part of the year. In these regions, cultivation is restricted to more productive but limited land, while a large animal population depends on native vegetation. Irrigation with surface or ground water is inevitable for growing crops in the arid and semi-arid zones. The rainfall pattern roughly reflects the different climate regimes of the country, which vary from humid in the northeast (about 180 days rainfall in a year), to arid in the Thar deserts of Rajasthan (20 days rainfall in a year) (Pechlivanidis & Arhemer, 2015).

4.2.4 Deccan Plateau

The Deccan is a peninsular plateau located in central India that includes inland sections of the states of Andhra Pradesh, Maharashtra and Karnataka. The Deccan is delineated by the Western Ghats on the west, the Nilgiri Hills on the south, the Eastern Ghats on the east, and the Aravalli and Chota Nagpur hills on the north. The Deccan Plateau also faces acute scarcity of water though there are Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Cauvery rivers flowing in this area. These rivers have mostly well defined stable courses. They have adequate capacity within the natural banks to carry the flood discharge

except in the delta area. The lower reaches of the important rivers on the East Coast have been embanked, thus largely eliminating the flood problem.

4.2.5 Western and Eastern Ghats

The Western and Eastern Ghats running parallel to the coastline face the problem of landsliding and droughts in the rain shadow areas. The Western Ghats extend from the Satpura Range in the north, to south past Maharashtra, Goa, through Karnataka and into Kerala and Tamil Nadu. Western Ghats is one of the 33 recognised ecologically sensitive zones in the World. The Western Ghats and Nilgiris are geologically stable but still prone to landslide in rainy season. The environmental degradation rising out of population pressure, illegal mining, curies, deforestation has made both ghats very vulnerable from natural disasters. The Eastern Ghat is not a continuous range of scrap lands as the Western Ghat. Also scraps are nearly absent here. The range is actually cut up into a number of separate circumdenudation hills. The only compact mountainous region is found in Orissa. Mahanadi, Godavari and Krishna that have cut gaps through Eastern Ghat and have completely broken its continuity. The mountains are much more away from the sea than the Western Ghat. The mountain ranges run parallel to the Bay of Bengal. The Deccan Plateau lies to the west of the range, between the Eastern Ghats and Western Ghats. The coastal plains, including the Coromandel Coast region, lie between the Eastern Ghats and the Bay of Bengal. The Eastern Ghats are not as high as the Western Ghats. The structure of the Eastern Ghats includes thrusts and strike-slip faults.

4.2.6 Coastal Region

The Indian subcontinent is one of the worst affected regions in the world. The subcontinent with a long coastline of 7,500 KM is exposed to nearly 10 per cent of the world's tropical cyclones. Of these, the majority has their initial formulation over the Bay of Bengal and strike the east coast of India. On an average, five to six tropical cyclones form every year, of which two or three could be severe. More cyclones occur in the Bay of Bengal than the Arabian Sea and the ratio is approximately 4:1. Cyclones occur frequently on both the coasts (The west coast – Arabian Sea; and the east coast – Bay of Bengal). An analysis of the frequency of cyclones on the east and west coasts of India between 1877 and 2005 shows that nearly 283 cyclones occurred (106 Severe) in a 50 km wide strip on the east coast. Less severe cyclonic activity has been noticed on the west coast, with 35 cyclones occurring in the same period, out of which 20 of them were severe. Tropical cyclones occur in the months of May-June and October-November (NDMA, 2016).

4.3 NATURAL DISASTER PROFILE

4.3.1 Earthquakes

Earthquakes are a sudden violent shaking of the ground, typically causing great destruction, as a result of movements within the earth's crust or volcanic action. Of the total earthquake-prone areas, 12% is prone to very severe earthquakes, 18% to severe earthquakes and 25% to damageable earthquakes. The biggest quakes have occurred in the Andaman and Nicobar Islands, Kutch, Himachal and the North-East. The Himalayan regions are particularly prone to earthquakes. The last three major earthquakes shook Gujarat in January 2001; Jammu and Kashmir in October 2005; and Sikkim in 2011. Many small-scale quakes have

occurred in other parts of India in 2006. 7 North-East States of India (Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya), Andaman & Nicobar Islands; and parts of 6 other states in the North/North-West (Bihar, Jammu and Kashmir & Uttarakhand) and West (Gujarat), are in Seismic Zone V (Government of India, 2016). Table-4.1 below brings to light the location and magnitude of earthquakes in India during the past 200 years.

Table 4.1: Major Earthquakes in India

Date	Location	Magnitude
16 Jun 1819	Kutch, Gujarat	8
10 Jun 1869	Near Cachar, Assam	7.5
30 May 1885	Sopor, J&K	7
12 Jun 1897	Shilong Plateau	8.7
04 Apr 05	Kangra, HP	8
08 Jul 18	Srimangal, Assam	7.6
02 Jul 30	Dhubri, Assam	7.1
15 Jan 34	Bihar- Nepal Border	8.3
26 Jun 41	Andaman Island	8.1
23 Oct 43	Assam	7.2
15 Aug 50	Arunachal Pradesh- China Border	8.5
21 Jul 56	Anjar, Gujarat	7
10 Dec 67	Koyna, Maharashtra	6.5
19 Jun 75	Kinnuar, HP	6.2
06 Aug 88	Manipur-Myanmar Border	6.6
21 Aug 88	Bihar- Nepal Border	6.4
20 Oct 91	Uttarkhashi, Uttarakhand	6.6
30 Sep 93	Latur- Osmanabad, Maharashtra	6.3
22 May 97	Jabalpur, MP	6
29 Mar 99	Chamoli Dist, UK	6.8
26 Jan 01	Bhuj, Gujarat	7.7
08 Oct 05	Kashmir	7.6
18 Sep 2011	Sikkim	6.9

***Source*:** Government of India, 2011.

The Indian sub-continent has a history of devastating earthquakes. The major reason for the high frequency and intensity of the earthquakes is that the Indian plate is driving into Asia at a rate of approximately 47 mm/year. Geographical statistics of India show that almost 54% of the land is vulnerable to earthquakes. A World Bank & United Nations Report estimates that around 200 million city dwellers in India will be exposed to storms and earthquakes by 2050. The latest version of seismic zoning map of India given in the earthquake resistant design code of India assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version, which consisted of five or six zones for the

country. According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity.

4.3.2 Tsunami

A tsunami (in Japanese "tsu" means harbor and "nami" means wave) is a series of water waves caused by the displacement of a large volume of a body of water, usually an ocean. Seismicity generated tsunamis are the result of abrupt deformation in the sea floor resulting vertical displacement of the overlying water. Earthquakes occurring beneath the sea level displace the water above the reformed area from its equilibrium position. Tsunamis are giant waves caused by earthquakes or volcanic eruptions under the sea. Out in the depths of the ocean, tsunami waves do not dramatically increase in height. But as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Tsunami waves may travel as fast as jet planes over deep waters, only slowing down when reaching shallow waters. While tsunamis are often referred to as tidal waves, this name is discouraged by oceanographers because tides have little to do with these giant waves. The sudden release of energy produces tsunami waves which have small amplitude but a very long wavelength (often hundreds of kilometer long). It may be caused by non-seismic event also such as marine landslides or impact of a meteor. The Tsunami in Indian Ocean on 26 December 2004 had devastating effects on India. Many people died and millions were displaced. The hardest hit areas were on Southern coast and the Andaman and Nicobar Island (Government of India, 2016).

4.3.3 Landslides

A landslide is the movement of rock, debris or earth down a slope. They result from the failure of the materials which make up the hill slope and are driven by the force of gravity. Landslides are also known as landslips, slumps or slope failure. India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 6 cm/year accumulates stress to which natural disasters are attributed. Some landslides make devastating and unparalleled catastrophes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India. Besides the Himalayas, the northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans, covering about 15 % of the landmass, are some other potential landslide zones. The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterised by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.

Some spectacular events of tragedies are reported as Chamoli Garhwal landslide (1868), Nainital landslide (1880), Malpha landslide (1998) Pithoragarh district, Ukhimath landslide (2001) in Chamoli district, Varnavat landslide(2003) Uttarkashi

District, Dasgaon landslide (2005) Raigad district and Paglajhora (2010) in Darjeeling district as well as in Sikkim, Aizawl sports complex, Mizoram (Parkash & Kathait, 2014). The problem, therefore, needs to be tackled for mitigation and management for which hazard zones have to be identified and specific slides to be stabilised and managed in addition to monitoring and early warning systems to be placed at selected sites. Landslides occur in the hilly regions such as the Himalayas, North-East India, the Nilgiris, and Eastern and Western Ghats. Landslides in India are another recurrent phenomenon. Landslide-prone areas largely correspond to earthquake-prone areas, that is, North-west and North-East, where the incidence of landslides is the highest (NDMAa, 2016).

Check Your Progress 1

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Bring out the Vulnerability Profile of India.

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2) Write a short note on Earthquakes in India.

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3) Discuss the nature of Tsunami and Landslide with reference to India.

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4.3.4 Floods

Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries. It may also occur due to the accumulation of rainwater on saturated ground. On an average, in India, about 30 million people are affected annually. Floods in the Indo–Gangetic–Brahmaputra plains are an annual feature. On an average, a few hundred lives are lost, millions are rendered homeless and several hectares of crops are damaged every year. 40 million hectares, or 12% of Indian land, is considered prone to floods. Floods are a perennial phenomenon in at least 5 states – Assam, Bihar, Orissa, Uttar Pradesh and West Bengal (Rao, 2018). On account of climate change, floods have also occurred in recent years in areas that are normally not flood prone. The principal reasons for

flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm (ADRC, 2015). Table 4.2 brings about the major floods in India from 2008 to 2018.

Table 4.2: States hit by Flood from 2008 to 2018

Year	Location	Killed
2008	Tamil Nadu, Karnataka	37
2008	West Bengal, Orissa	1063
2008	Assam, Bihar, Gujarat	NA
2008	Assam	142
2008	Bihar	47
2008	Bihar	245
2008	Assam, Tamil Nadu	54
2009	Bihar, Orissa, West Bengal	992
2009	Bihar, West Bengal	52
2009	Karnataka	300
2009	Tamil Nadu	70
2010	Andhra Pradesh	27
2010	Bihar	98
2010	Haryana	53
2010	New Delhi	11
2010	Jammu and Kashmir	196
2010	Assam	NA
2010	Punjab, Haryana, Uttar Pradesh	NA
2010	Uttarakhand	200
2010	Tamil Nadu	203
2011	Uttar Pradesh, Uttarakhand	50
2011	Uttar Pradesh	19
2011	West Bengal	47
2011	Assam	204
2011	Assam	7
2011	Odisha	42
2011	Odisha	239
2012	Assam	120
2012	Uttarakhand, Uttar Pradesh	30
2012	Himachal Pradesh	26
2012	Rajasthan	37
2012	Uttarakhand	45
2012	Assam, Sikkim, Arunachal Pradesh	21
2013	Uttarakhand, Himachal Pradesh	580; 5,474
2015	Gujarat	70
2016	Assam	1.8 million People affected
2017	Gujarat	200
2018	Kerala	NA

***Source*:** Government of India, 2011 & www.emdat.de.

4.3.5 Cyclones

Any large system of winds that circulates about a centre of low atmospheric pressure in a counter clockwise direction north of the Equator and in a clockwise direction to the south is known as cyclone. Cyclonic winds move across nearly all regions of the earth except the equatorial belt and are generally associated with rain or snow. Also occurring in much the same areas are anticyclones, wind systems that rotate about a high-pressure centre. Anticyclones are so called because they have a flow opposite to that of cyclones — that is, an outward-spiraling motion, with the winds rotating clockwise in the northern hemisphere and counterclockwise in the southern. These winds are usually not as strong as the cyclonic system and commonly produce no precipitation.

About 8% of the land in India is vulnerable to cyclones of which coastal areas experience two or three tropical cyclones of varying intensity each year. Cyclonic activities on the east coast are more severe than on the west coast. The Indian continent is considered to be the worst cyclone-affected part of the world, as a result of low-depth ocean bed topography and coastal configuration. The principal threats from a cyclone are in the form of gales and strong winds; torrential rain and high tidal waves/storm surges. Most casualties are caused due to coastal inundation by tidal waves and storm surges. Cyclones typically strike the East Coast of India, along the Bay of Bengal, that is, the states of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu, but also parts of Maharashtra and Gujarat in the West Coast in front of Arabian Sea. Table 4.3 reveals the number of causalities due to cyclones in India is over the years.

Table 4.3: Major Cyclones in India

Year	Name of the Place	No. of Death
1737	Hoogli, West Bengal (India)	3,00,000
1876	Bakerganj (Bangladesh)	2,50,000
1885	False point (Orissa)	5,000
1971	Paradeep, Orissa (India)	10,000
1977	Chirala, Andhra Pradesh	10,000
1990	Andhra Pradesh	990
1998	Porbander Cyclone, Gujarat	1,173
1999	Paradeep, Orissa	9,885
2011	Thane Cyclone, Tamil Nadu & Puducherry	47
2013	Phailin Cyclone, Odisha & Andhra Pradesh	45
2014	Hudhud Cyclone, Andhra Pradesh	124
2016	Vardah Cyclone, Tamil Nadu & Andaman and Nicobar Islands	38
2017	Ockhi Cyclone, Kerala, Tamil Nadu & Gujarat	282

***Source*:** Government of India, 2011 & www.emdat.de.

4.3.6 Droughts

A drought is a period of below-average precipitation in a given region; resulting in prolonged shortages in the water supply, whether atmospheric, surface water or ground water. A drought can last for months or years, or may be declared after as few as 15 days.

About 50 million people are affected annually by drought in India. Of approximately 90 million hectares of rain-fed areas, about 40 million hectares are prone to scanty or no rain. The primary cause of any drought is deficiency of rainfall and in particular, the timing, distribution and intensity of this deficiency in relation to existing reserves. Drought is not uncommon in certain districts of Uttar Pradesh, Madhya Pradesh, Orissa, Andhra Pradesh, etc. Although a slow onset emergency, and to an extent predictable emergency, drought has caused severe suffering in the affected areas in recent years, including effects on poverty, hunger, and unemployment. A prolonged period of relatively dry weather leading to drought is a widely recognized climate anomaly. Drought can be devastating as water supplies dry up, crops fail to grow, animals die, and malnutrition and ill health become widespread The environmental effects of drought, include salinisation of soil, groundwater decline, increased pollution of freshwater ecosystems and regional extinction of animal species.

4.3.7 Heat Waves and Cold Waves

A heat wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the north-western parts of India. Heat waves typically occur between March and June, and in some rare cases they even extend till July. The extreme temperatures and resultant atmospheric conditions adversely affect people living in these regions. Extreme positive departures from the normal maximum temperature result in a heat wave during the summer season. The rising maximum temperature during the pre-monsoon months often continues till June, in rare cases till July, over the northwestern parts of the country.

The Indian Meteorological Department (IMD) has given the following criteria for heat waves:

- Heat wave need not be considered till maximum temperature of a station reaches at least 40^0C for plains and at least 30^0C for hilly regions;
- When normal maximum temperature of a station is less than or equal to 40^0C, heat wave departure from normal is 5^0C to 6^0C. Severe heat wave departure from normal is 7^0C or more;
- When normal maximum temperature of a station is more than 40^0C heat wave departure from normal is 4^0C to 5^0C. Severe heat wave departure from normal is 6^0C or more; and
- When actual maximum temperature remains 45^0C or more irrespective of normal maximum temperature, heat waves should be declared. Higher daily peak temperatures and longer, more intense heat waves are becomingly increasingly frequent globally due to climate change. India too is feeling the impact of climate change in terms of increased instances of heat waves which are more intense in nature with each passing year, and have a devastating impact on human health thereby increasing the number of heat wave casualties.

A cold wave is a weather phenomenon that is distinguished by cooling of the air. Cold waves are recurrent phenomenon in North India. Hundreds of people die of cold and related diseases every year, most of them from poor urban areas in northern parts of the country.

Check Your Progress 2

Note: i) Use the space given below for your answers.

ii) Check your answers with those given at the end of the Unit.

1) Discuss the nature of Floods in India.

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2) 'India is much prone to Cyclones'. Discuss.

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3) Explain Heat Waves and Cold Waves.

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4.4 CONCLUSION

India is much prone to multi-disasters. Major natural disasters, over the years, in India have been discussed in the Unit. These disasters have been causing great loss of life and property in the country. These disasters are droughts, floods, tsunami, landslides, cyclones among others.There is much felt need for concerted and coordinated endeavours for effective disaster management.

4.5 GLOSSARY

Hills of Circumdenudatioin : Denudation around or in hills which have been produced by surface erosion. These are the elevators which have been left after denudation of a mass of high ground.

Seismic Zone : A seismic zone is an area of seismicity probably sharing a common cause.

Richter scale : The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes.

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4.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Your answer should include the following points:

- India's 57% of the land is vulnerable to earthquake (high seismic zones III–V) and 68% is to drought.
- 12% of land is vulnerable to floods and river erosion.
- Out of 7,516 KM coastline, 5700 KM are vulnerable to Cyclone.

2) Your answer should include the following points:

- Earthquakes are a sudden violent shaking of the ground, typically causing great destruction, as a result of movements within the earth's crust or volcanic action.
- Reason for the high frequency and intensity of the earthquakes is that the Indian plate is driving into Asia at a rate of approximately 47 mm/year.

- 12% is prone to very severe earthquakes,18% to severe earthquakes and 25% to damageable earthquakes.

3) Your answer should include the following points:

- A tsunami is a series of water waves caused by the displacement of a large volume of a body of water in the ocean.
- It's a giant waves caused by earthquakes or volcanic eruptions under the sea.
- Landslide is the movement of rock, debris or earth down a slope. It's the failure of the materials which make up the hill slope and are driven by the force of gravity.
- It may be called as landslips, slumps or slope failure.
- The Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans are vulnerable to the Landslides.

Check Your Progress 2

1) Your answer should include the following points:

- Flood is occurring due to overflow of water from water bodies.
- Floods in the Indo–Gangetic–Brahmaputra plains are an annual feature. On an average, a few hundred lives are lost, millions are rendered homeless and several hectares of crops are damaged every year 40 million hectares, or 12% of Indian land, is considered prone to floods. Floods are a perennial phenomenon in at least 5 states – Assam, Bihar, Orissa, Uttar Pradesh and West Bengal.

2) Your answer should include the following points:

- Cyclone is a large system of winds that circulates about a centre of low atmospheric pressure in a counterclockwise direction north of the Equator and in a clockwise direction to the south.
- Indian sub continent is considered to be the worst cyclone-affected part of the world, as a result of low-depth ocean bed topography and coastal configuration. The principal threat from a cyclone is in the form of gales and strong winds; torrential rain and high tidal waves/storm surges. Most casualties are caused due to coastal inundation by tidal waves and storm surges.

3) Your answer should include the following points:

- Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the North-Western parts of India.
- It typically occurs between March and June, and in some rare cases even extends till July.
- Cold wave is a weather phenomenon that is distinguished by a cooling of the air and which are recurrent phenomenon in North India.
- Uttarpradesh and Bihar rank the highest in terms of casualties from cold wave.