CERTIFICATE PROGRAMME IN
DISASTER AND EMERGENCY MANAGEMENT

CDEM 01

FUNDAMENTALS OF DISASTER

GPD School of Interdisciplinary and Vocational Studies

KRISHNAKANTAHANDIQUISTATEOPENUNIVERSITY

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CONTENTS

UNIT 1 : Concept of Disaster **5-13**

Meaning of Hazard and Disasters; Difference between hazards and disasters; Historical perspective; Understanding differenttypes of disasters; Natural and Man-made disasters; Rapid and slow onset disasters; Different phases of Disasters.

UNIT 2 : Natural Disaster **14-25**

Overview of Natural Disaster: Risk of natural disaster; Origin of Natural Disaster: Geological, Hydro-Meteorological and Biological.

UNIT 3 : Geological Disaster **26-34**

Earthquake; Tsunami; Landslide; Volcanic Activity; Avalanche; Mud Flow.

UNIT 4 : Hydro-Meteorological Disaster **35-47**

Flood and river bank erosion; Cyclone; Drought; Desertification; Forest Fire.

UNIT5 : Biological Disaster **48-59**

Understanding Biological Disaster; Outbreak of Avian Flu Epidemic;Outbreak of Swine Flu; Outbreak of Plague;Pandemic and COVID-19.

UNIT 6 : Man-Made Disaster **50-72**

Overview of Man-made Disaster;War and Conflicts; Secondary Disaster.

UNIT 7 : Environmental Degradation **73-87**

Deforestation; Land pollutions; Water pollutions; Air pollutions; Climate Change.

UNIT 8 : Technological Disaster **88-99**

Nuclear accidents; Toxic wastes; Transport accidents; Industrial Accidents, Fire accidents, Oil Spills.

References 100

COURSE INTRODUCTION

"Fundamentals of Disaster" is the first course of the Certificate in Disaster and Emergency Management programme which is designed to provide a holistic view of disasters occurred naturally and by human activities. Our country is prone to natural and man-made disasters. The number has been increased every year due to several factors such as climate change, population growth, urbanization and industrialization.

Any disasters have been taking a huge loss of human and animal lives. Flood, cyclone, earthquake and landslide are the most devastating type of natural disasters that causes a great damage and destruction of property, human life and livestock. Human induced disasters or man-made disasters are not always destructive. Industrialization and technological advancement are the need for human progress and comfort.However, the failure of machineries, fire or explosion at the industry unit, use of hazardous substances etc. are some of the major reasons that may leads to serious impact on human, property and environment.An effort has been made through this Course to understand different types of disaster, their cause of occurrence and their impacts.

The Course is divided into eight units.

The **first unit** covers the meaning of hazard and disaster, difference between hazard and disaster, historical perspective, understanding different types of disasters, natural and man-made disasters, rapid and slow-onset disasters and different phases of disasters

The **second unit** includes the overview of natural disaster and origin of natural disaster.

The **third unit** consists the geological disaster like earth quake, tsunami, landslide, volcanic activity, avalanche and mud flow.

The **fourth unit** covers the flood and bank erosion, cyclone, drought, desertification and forest fires.

The **fifth unit** focuses on the understanding biological disaster, out breaks of epidemic diseases and pandemic.

The **sixth unit** comprises the overview of man-made disaster, war and conflicts and secondary disaster.

The **seven unit** covers the deforestation, desertification, wild fires, pollutions and climate change.

The **eighth unit** includes the nuclear accidents, toxic wastes and other accidents.

While going through a unit, you will notice some boxes, containing such information as would help you to understand some of the difficult, unfamiliar terms. You will find an item called "ACTIVITY' where you will apply your knowledge and thoughts in some questions pertaining to the relevant topic. Again, we have included some relevant concepts in "LET US KNOW" along with the text. And, at the end of each section, you will get "CHECK YOUR PROGRESS" questions. These have been designed to self-check your progress of study. It will be better if you solve the problems put in these boxes immediately after you go through the sections of the units and then match your answers with "ANSWERS TO CHECK YOUR PROGRESS" given at the end of each unit.

UNIT 1 : CONCEPT OF DISASTER

UNIT STRUCTURE

1.1 Learning Objectives

1.2 Introduction

1.3 Meaning of Hazards and Disasters

1.4 Difference Between Hazards and Disasters

1.5 Historical Perspective

1.6 Understanding Different Types of Disasters

1.7 Rapid and Slow-onset Disasters

1.8 Different Phases of Disasters

1.9 Let Us Sum Up

1.10 Further Readings

1.11 Answers to Check Your Progress

1.12 Model Questions

1.1 LEARNING OBJECTIVES

After reading this unit, you will be able to-

- describe the meaning of hazards and disasters
- explain the differences between hazards and disasters
- distinguish about natural and man-made disasters
- discuss the different phases of disasters.

1.2 INTRODUCTION

This is the first unit of this course where we will explore hazards and disasters. Before delving into these topics, we will define and differentiate between hazards and disasters. This unit will also cover the historical perspective of disasters. Additionally, you will be introduced to various types of disasters, including rapid and slow onset events. The unit will conclude by examining the different phases of disasters.

1.3 MEANING OF HAZARDS AND DISASTERS

A hazard broadly means a threat to human life, the lives of other living things, and property. FEMA 1997 defines hazard as " an event or physical condition that has thepotential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss." Whereas hazard is a threat, disaster is an event that results in the loss of human life, the lives of other living things,and property. Cutter (2001) defines disaster as " a singular event that results in widespread losses to people, infrastructure, or the environment". As any disaster event brings untold misery and hardship, it becomes difficult for a region to cope with the situation with its local resources.

In older times, people used to avoid settling in hazard-prone areas like low-lying flood plains or mountainous regions. However, these days, rapid population growth and the consequent pressure on land mean that people are forced to live in acutely hazard-prone areas, thereby exposing them to different kinds of disasters.

1.4 DIFFERENCE BETWEEN HAZARDS AND DISASTERS

The primary distinction between hazards and disasters is that a hazard is a threat or dangerous situation, whereas a disaster is an extreme event that frequently causes unimaginable suffering for people. A hazard can quickly turn into a disaster, causing people to suffer greatly. A disaster can be a pre-disaster situation. One example is a hanging rock on a slope. That rock is a hazard. Once the rock becomes loose and starts rolling down the slope, and kills people or damages property, it will become a disaster. Therefore, hazards are the origin of disaster, and a hazard prone place always has the danger of disaster. In Assam, flood hazards are present in plain areas, and landslide hazards are present in the hills. When an actual landslide and flood occur, it becomes adisaster. In general, all mountainous areas have landslide hazards, and once an actual landslide takes place, it

becomes a disaster. However, if landslide mitigation measures such as a guard wall or proper drainage systems are built, the landslide hazards on a site will be reduced, and the chances of a landslide disaster will be reduced as a result.



CHECK YOUR PROGRESS

Q.1: What is Hazard?

.....

.....

Q.2: What is Disaster?

.....

.....

Q. 3: What are the difference between hazard and disaster?

.....

.....

1.5 HISTORICAL PERSPECTIVE

Disasters are always a threat to mankind, and they are responsible for the destruction of so many civilizations. They always command a lot of attention from us. Although the detailed study of hazards or disasters is of recent origin, in older times scholars did study the major disasters or 'shocks' which had profound impacts on people. Scholars attempted to explain the causes, consequences, and geographic distribution of major hazards and disasters. Historians have found evidence of how Indian and Greek philosophers tried to study the origin of earthquakes, and Roman philosophers tried to study different aspects of flooding in the Nile Valley.

1.6 UNDERSTANDING DIFFERENT TYPES OF DISASTERS

There are different types of disasters. Disasters are categorised based on different criteria. For example, based on origin or cause, disasters are divided into two types: natural disasters and man-made or anthropogenic

disasters. Again, based on speed, disasters are divided into two types:rapid-onset disasters and slow-onset disasters. Natural disasters used to occur naturally without any human interference. Natural disasters are further subdivided into four types, as shown in the diagram below.

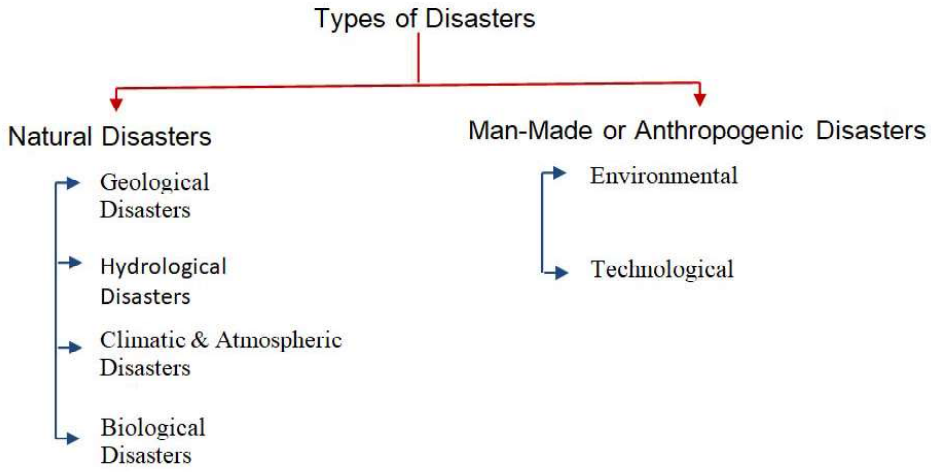


Figure 1.1: Types of disasters

A geological disaster or terrestrial disaster or tectonic disaster is an adverse geologic event that causes widespread destruction. Earthquakes, volcanic eruptions, landslides, avalanches, etc. are some examples of geological disasters. As geologicaldisastersoriginate inside the earth, they are often unpredictable and inflict huge death and destruction. A hydrological disaster is an adverse event related to the quality, distribution, or movement of water. Hydrological disasters include floods, tsunamis, and other natural disasters related to water. Hydrological disasters are the most common and cause the most casualties and property destruction of the three major types of disasters— geological, hydro-metrological, and biological. A climatic or atmospheric disaster is an adverse event in a weather cycle. Cyclones, drought, high winds, etc. are some of the examples. Biological disasters are adverse events caused by the spread of diseases, viruses, or infestations of plants and animals on an epidemic or pandemic level. Biological disasters can be extremely deadly and kill a huge number of humans, other animals, or plants. Sometimes biological disasters can even cause the extinction of a plant or animal species. When a biological disaster is limited to a local area, it is called an “epidemic,” and once it spreads to a larger area, it is

called a pandemic. The recent COVID-19 disaster is an excellent example of a global pandemic that affected all countries. Biological disasters are further subdivided into two types, namely primary and secondary, which are further subdivided into two subtypes:epidemics and infestations. Secondary disasters include different diseases after a disaster. For example, cases of malaria and other mosquito-borne diseases after floods or water-borne diseases after an earthquake.

Man-made or anthropogenic disasters are further subdivided into two types, as shown in the figure above. An environmental disaster is man-made damage to our natural environment, for which all living beings used to suffer. Environmental disasters include deforestation, pollution, forest fires, biodiversity loss, oil spills, etc. A technological disaster is an adverse event that is detrimental to our environment and is caused by human error in controlling technology or a malfunction in a system. Technological disasters are sometimes very serious and have a catastrophic impact over a large geographical area. Technological disasters include industrial accidents, the meltdown of nuclear power stations, structural collapse, mining disasters, transport accidents, etc.



CHECK YOUR PROGRESS

Q 4: State true or false:

i) A Landslide is a geological disaster.

ii) The Covid-19 pandemic was a biological disaster.

iii) Flooding is a climatic disaster.

iv) A Tsunami is a hydrological disaster.

1.7 RAPID AND SLOW-ONSET DISASTERS

Rapid-onset disasters are dangerous as they tend to occur rapidly. Rapid-onset disasters used to have clearly identifiable start and endpoint. They are also less predictable due to their intensity and their frequency. Many rapid-onset disasters like earthquakes don’t give any prior warning, and so their effects are often devastating as people don’t get any time for evacuation. Examples of rapid-onset disasters are given in the figure below.

With the development of science and technology, nowadays scientists can predict a volcanic eruption, cyclone, flood, landslide, avalanche, or blizzard with a high degree of accuracy, but until now they could not predict an earthquake or tsunami, which is why they are so dangerous.

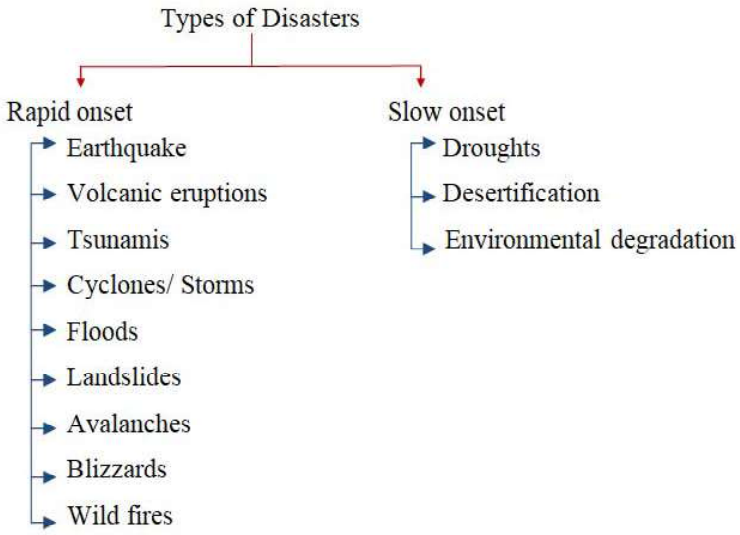


Figure 1.2 Types of Disasters

A slow-onset disaster used to occur gradually over time. As slow-onset disasters are slow, their effects may be visible after a considerable period of time. Examples of slow-onset disasters are given in the figure above. Although slow-onset disasters occur slowly, their ill effects are as deadly as those of rapid-onset disasters. Slow-onset disasters like drought can lead to crop failure and,consequently, famine and starvation. Similarly, the ill effects of environmental degradation may not be discernible immediately, but over time, they can kill thousands of humans and animals. The economic impact of slow-onset disasters like sea level rise and air pollution can be disastrous over a long period of time.

1.8 DIFFERENT PHASES OF DISASTERS

As disasters are highly destructive, proper planning is an absolute necessity to mitigate any disaster. Generally, a disaster management plan involves three phases: pre-disaster, during disasters, and post-disaster. The “pre-disaster phase” is a period before the occurrence of a disaster. During this phase, the adverse effects of a disaster are attempted to be

minimised and, if possible, eliminated through prevention, mitigation, and preparedness. In the pre-disaster phase, a community or society needs to assess the risks of different types of disasters, train people to be prepared, and properly plan a programme to avert or reduce the impact of disaster. In countries like Japan, pro-active pre-disaster policy has seen a considerable reduction in deaths and destruction from different disasters like earthquakes, tsunamis, volcanic eruptions, etc. In India, due to a proper pre-disaster policy, a huge reduction in causality from disasters like cyclones and floods is seen.

The "during disaster" phase is a period when a particular disaster takes place. The duration of this phase varies from a few seconds to several months and depends on the type of disaster. For example, for earthquakes, the duration may be a few seconds to a few minutes, on the other hand, for droughts or floods, this phase is considerably longer. In this phase, the response of the community depends on the kinds of disasters and the degree of preparedness. Rapid onset disasters like earthquakes or tsunamis are always dangerous, even for a well-prepared community, as the response time is so short. Again, the intensity of the disaster is another aspect that determines the level of destruction. Slow-onset disasters have a long "during disaster" phase, and for disasters like drought, it may cover several years.

The "post-disaster" phase is extremely important in any disaster management plan. The duration of this phase depends on the type and intensity of a particular disaster. This phase involves evacuating the survivors, providing shelter to the homeless, food, water, and medicine to affected people, etc. The success of this phase will ensure the prevention of epidemic outbreaks, famine, etc.



CHECK YOUR PROGRESS

Q 5: State true or false:

i) Blizzard is a slow-onset disaster

ii) Landslide is a rapid onset disaster

iii) Drought is a slow onset disaster

iv) Slow-onset disasters have a long "during disaster" phase



1.9 LET US SUM UP

- Hazard is a threat whereas disaster is an event that results in the loss of human life, the lives of other living things,and property.
- Based on origin or cause, disasters are divided into two types- natural disasters and man-made or anthropogenic disasters.
- A hydrological disaster is an adverse event related to the quality, distribution, or movement of water.
- Biological disasters are adverse events caused by the spread of diseases, viruses, or infestations of plants and animals on an epidemic or pandemic level.
- Man-made or anthropogenic disasters are further subdivided into two types-environmental disasters and technological disaster.
- Slow-onset disasters are slow and their effects may be visible after a considerable period of time.
- A disaster management plan involves three phases: pre-disaster, during disasters, and post-disaster.



1.10 FURTHER READINGS

1) Disaster Management and Preparedness by Dhawan N.G. and Khan A.S.
2) Disaster Management by Pandey M.
3) Disaster Management by Kumar P.
4) Text Book of Disaster Management by Srivastava A. K.



1.11 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No 1: A hazard means a threat to human life, the lives of other living things, and to property.

Ans to Q No 2: A disaster is an event that results in widespread losses to people, infrastructure, or the environment.

Ans to Q No 3: Hazard is a threat or dangerous situation, whereas a disaster is an event that frequently causes unimaginable suffering to people.

Ans to Q No 4: i) True ii) True iii) False iv) True

Ans to Q No 5: i) False ii) True iii) True iv) True



1.12 MODEL QUESTIONS

Q.1: What is a disaster? Give some examples of disasters in India.

Q.2: What are the common natural disasters in Assam?

Q.3: Distinguish between hazard and disaster?

Q.4: Give a classification of different types of disasters.

Q.5: Describe natural and man-made disasters.

Q.6: Distinguish between rapid onset and slow onset disasters.

Q.7: Classify man-made disasters with examples of each.

*** ***** ***

UNIT 2 : NATURAL DISASTER

UNIT STRUCTURE

2.1 Learning Objectives

2.2 Introduction

2.3 Overview of Natural Disaster

2.3.1 What is the risk of a natural disaster?

2.4 Origin of Natural Disaster

2.4.1 Geological

2.4.2 Hydro-Meteorological

2.4.3 Biological

2.5 Let us Sum up

2.6 Further Readings

2.7 Answers to Check Your Progress

2.8 Model Questions

2.1 LEARNING OBJECTIVES

After reading this unit, you will be able to-

- explain the natural disasters
- estimate the origin of natural disasters
- discuss various type of natural disasters.

2.2 INTRODUCTION

The previous unit deals with the basic understanding of the concept of disasters. This unit highlights the significance of understanding natural disasters.A natural disaster is a significant event that leads to environmental degradation, as well as loss of life and property.Natural disasters generally occur due to sudden changes in the environment. They take lives both human and animal cause destruction, inhibit development, and contribute to political instability.Based on intensity or magnitude, natural disasters can be major or minor. Major natural disasters cause widespread destruction over a very large area, and their ill effects used to be felt long after their

occurrence. On the other hand, minor natural disasters are less destructive, and a region can overcome their ill effects within a short period of time. In this unit, you will be exposed to the risks associated with natural disasters.This unit will also explain the origins of natural disasters such as earthquakes, floods, droughts, and more.

2.3 OVERVIEW OF NATURAL DISASTER

With the rapid increase in population in most parts of the world, natural disasters are becoming increasingly deadly, especially in urban areas where population density used to be very high.A natural disaster is caused by the earth's endogenic and exogenic processes. Endogenic forces cause natural disasters like earthquakes, volcanic eruptions, tsunamis, etc. On the other hand, exogenic or external forces are responsible for natural disasters like firestorms, dust storms, floods, hurricanes, tornadoes, etc. Our earth has experienced numerous natural disasters in its 4.5 billion-year history. Many such natural disasters were responsible for mass extinctions like the one that caused the extinction of dinosaurs around 65 million years ago. Different types of natural disasters can take place in every part of the world. But by adapting preventive measures, it is possible to lessen the impact of disasters. For example, by building constructive seismic-resistant structures, we can reduce the impact of earthquakes to a large extent, as seen in Japan.

There are natural processes like earthquakes, cyclones, volcanic eruptions, andlandslides that have been used to sculpt the earth since time immemorial. Whenever these natural processes destroy human-made features like roads, buildings, or industries, disaster happens. Every year, different types of disasters strike the earth, causing significant damage. Disaster often inhabits development and contributes to forced migration.

A natural hazard may precede a natural disaster. For example, the Great San Francisco Earthquake of 1906 was a huge natural disaster, and the natural hazard is to live under the active fault line of the San Andreas Fault, present on the western coast of the USA. Although most natural disasters don't have any ***anthropogenic*** influence***,*** some, like floods or



Anthropogenic: It refers to the environmental change caused by people either directly or indirectly.

landslides, may be affected by human actions like deforestation or construction activity.

2.3.1 What is the risk of a natural disaster?

The risk of a natural disaster in a particular place depends on the severity of the hazards present and the vulnerability of the population at risk in that place. According to Ansell and Wharton (1992), "riskis the likelihood of an event's occurrence multiplied by the consequences of that event, if it occurs," and can be stated as follows:

Risk (R) = Hazard (H) × Vulnerability (V)

Risk depends on the combination of hazards, vulnerabilities, and exposure. Risk is the estimated impact that a hazard would have on people, services, infrastructure, and physical assets in a community. It refers to the likelihood of a hazardous event becoming a disaster.

Vulnerability is a concept defined by the UNDRR, 2017, as "the characteristics determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards." An example of vulnerability could be a population residing close to an active volcano on an isolated island. This population is vulnerable as volcanic hazards exist and the population lives in an isolated place where relief and rescue measures are lacking. Some factors can increase or decrease vulnerability, e.g., the financial condition of the residents, the level of infrastructure development in a place, etc.



CHECK YOUR PROGRESS

Q.1: State true or false:

I. A natural disaster is caused by the earth's endogenic and exogenic processes.

ii. Using renewable energy sourcesthe impact of earthquakes can be mitigated.
iii. Activities such as mining and drilling have the potential to impact natural disasters such as floods or landslides.
iv. Risk in the context of natural disasters is determined by the combination of hazards, vulnerabilities and exposure.
v. According to Ansell and Wharton (1992), risk (R) can be mathematically expressed as Risk (R) = Hazard (H) + Vulnerability (V).

2.4 ORIGIN OF NATURAL DISASTERS

Natural disasters are destructive events that occur naturally and result in loss of life and damage to property. They originate from dynamic and complex natural processes within the Earth's geosphere, hydrosphere, and atmosphere. These processes are driven by the planet's internal heat, solar energy and gravitational forces, interacting in ways that can occasionally result in extreme and destructive events.Exploring the various natural processes within the earth and its atmosphere is essential to understand their origins.

Natural disasters can be of various types, and they are classified as follows.

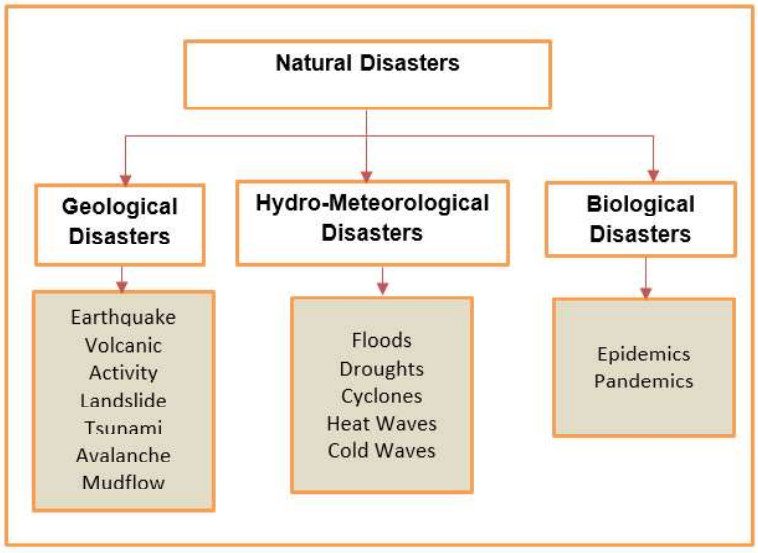


Fig. 1.1: Block diagram representation of natural disasters

2.4.1 Geological Disasters

A geological disaster is sometimes also referred to as a geophysical disaster, and it originates from the interior of the earth. It originates when natural geological processes affect humans by causing death and destruction. The primary cause of geological disaster is the movement of tectonic plates. As geological disasters originate inside the earth, they are often unpredictable and inflict huge death and destruction. The 2004 Indian Ocean earthquake and accompanying tsunami killed at least 225,000 people and destroyed property worth several billion (US) dollars. Different geological disasters include earthquakes, volcanic eruptions, landslides, avalanches, and mud flows.

Earthquake

An earthquake is a sudden shaking of the surface of the earth caused by the passage of seismic waves. Seismic waves are generated inside the earth when stored energy is suddenly released. In most cases, this energy release is due to masses of rock straining against one another along geologic faults. As most of these faults are found at the fringes of tectonic plates, most earthquakes used to occur along the boundaries of tectonic plates. The earth's lithosphere is divided into several tectonic plates. The interaction between these plates, such as collision, sliding past each other, or pulling apart, generates stress. When this stress is released, it causes seismic waves, resulting in an earthquake.Earthquakes often occur along fault lines, where tectonic plates meet or where there are fractures in the earth's crust.

Earthquakes used to occur frequently, and fortunately most of them are mild and do not cause significant damage. Sometimes, however, an earthquake can be very powerful, leading to wild shaking of the ground, resulting in widespread destruction and death. Unlike a cyclone or volcanic eruption, an earthquake's occurrence cannot be predicted, making it very deadly.

Volcanic activity

A volcanic eruption is the expulsion of molten lava, rock fragments,dust, and hot gases through a vent onto the earth's surface. Most of the eruption occurs from the top of the volcano, but sometimes lava is also thrown out from the side branches. Volcanic eruptions can be quite outflowing or they may be terrible explosionsthat release huge amounts of energy, thereby causing immense destruction. Explosive volcanic eruptions cause powerful earthquakes, and ifthe volcano is located on an island or in coastal areas, a destructive tsunami may be generated, thereby causing immense destruction. Like earthquakes, distribution of volcanoes is highly uneven, and most of the volcanoesarefound near tectonic plate boundaries. In India, its only active volcano is located on Barren Island in the union territory of Andaman and Nicobar.

Landslide

A landslide is the downward movement of a mass of rock, debris, or soil. It is a type of mass waste or mass movement. Although landslides are primarily caused by gravity, heavy rainfall and earthquakes can also trigger them. It occurs when the ground on a slope becomes unstable due to various reasons. Landslide events are commonly found on hills, plateaus, and mountains because as the slope becomes steeper, the probability of a landslide occurring increases. Beside slope, other natural factors affecting landslide events are local geology, vegetation cover, rainfall patterns, etc. Landslides also occur under water, and they are called submarine landslides. The occurrence of landslides is often influenced by various human actions like deforestation, mining, road and railway line construction, and urban development. In the recent decade, a marked increase in landslide events has been seen, and it is primarily due to human action, as various human activities like blasting for construction and deforestation often lead to instability of hill slopes and consequent landslides.

Tsunami

A tsunami is a series of large ocean waves created by sudden disturbances in or near a body of water. These disturbances are usually caused by undersea earthquakes, volcanic eruptions, underwater landslides, or meteorite impacts. When these waves reach the shore, they can cause significant destruction and loss of life due to their immense energy and height.Tsunami waves can travel at speeds of up to 500-800 kilometers per hour in deep water. When they approach shallow coastal areas, their height can increase dramatically, sometimes reaching heights of over 30 meters. One of the deadliest tsunamis occurred in 2004, triggered by a massive undersea earthquake off the coast of Sumatra, Indonesia. This event caused widespread devastation and loss of life in several countries around the Indian Ocean.

Avalanche

An avalanche is the downward movement of loose snow from a hill or a mountain. An avalanche has a rapid flow down a slope; it is always unpredictable, and escaping from an avalanche is always difficult. An avalanche can be triggered by multiple factors, like an earthquake, increased precipitation, or human or animal movement. On average, humans are responsible for more than 80 percent of avalanches. An avalanche is of two types: a slab avalanche and a loose snow avalanche. Whereas the first one is composed of tightly packed snow, the second one is composed of loose snow. A slab avalanche is generally more deadly as it is composed of a thick slab of snow that may act as broken glass as it moves downhill. A fast-moving avalanche, often mixed with air, forms a powder snow avalanche that rapidly engulfs a large area, endangering human and animal life.

Mudflow

A mudflow involves the fast-moving flow of mud down a slope. It is also known as a mudslide. Heavy rainfall in a short period of time often triggers mudflow, especially in clayey, rich soil. Besides

rainfall, snowmelt, groundwater flowing through cracked bedrock,and volcanic eruptions, other factors can also trigger mudflows. Mudflows move at speeds ranging from 3 metres per minute to 60 metres per minute, and higher speeds increase their destructive power.

2.4.2 Hydro-Metrological Disasters

Hydro-metrological disasters are processes or phenomena that are concerned with the earth's atmosphere or water bodies and cause loss of life and destruction of property. Hydro-metrological disasters are the most common and cause the most casualties and property destruction of the three major types of disasters—geological, hydro-metrological, and biological. Hydro-meteorological disasters include floods, droughts, cyclones, heat waves, and cold waves. Although earthquakes can cause landslides, heavy rainfall is the most common cause of landslides. As a result, most landslides are classified as hydro-meteorological disasters.

Floods

Among different types of hydro-meteorological disasters, floods cause the most damage. Although floods primarily affect flat areas, hills and plateaus are not immune to flooding, and devastating floods can occur in high-altitude areas. The widespread adaptation of structural flood control measures in developed countries results in significantly less damage, but developing and underdeveloped countries in Asia, Africa, and South America, which lack the resources and technology to adapt flood control measures, suffer greatly from floods.

Drought

Drought is a prolonged dry period that occurs due to a lack of rainfall, resulting in a severe water shortage. Generally, drought occurs when a region receives consistently below-average rainfall for several years. Drought is a slow-onset disaster, and it used to have a severe impact on agriculture, energy, animal husbandry, and other sectors of the economy. Historically, drought has been

associated with famine and starvation all over the world. A drought can last from a few months to several years, and the longer it lasts, the more misery it brings to people and other living creatures. Some human activities, like deforestation, over-farming, or over-irrigation, can cause drought in a region.

Cyclones

A cyclone is an air mass that circulates around a centre of low atmospheric pressure in a clockwise direction in the north of the equator and anticlockwise in the south of the equator. Cyclones can cause significant loss of life and property as they are associated with high speeds, heavy rainfall, thunder, lightning, and storm surge. Every year, cyclones bring death and destruction to coastal areas and islands in many countries around the world. Cyclones have different names in various parts of the world. In India, it is called a cyclone, ahurricane in North and South America, and a typhoon in Japan.

Heat Waves

A heat wave is a condition of very high temperature that is far above the normal maximum temperature, and it occurs in the summer season in tropical and subtropical regions of the world. A heat wave can cause dehydration, exhaustion, and cramps, and sometimes it is fatal to humans and animals. A heat wave can increase the risk of other disasters as it can exacerbate drought and also cause wildfire conditions. According to many scientists, global warming will result in an increase in the frequency and intensity of heat waves across the world in the coming years.

Cold Waves

A cold wave is an atmospheric condition that is characterised by cooling of the air and a temperature that falls far below the average minimum temperature. A cold wave used to have a negative impact on people, agriculture, and services. As cold waves bring frost, crops die before harvest, thereby bringing misery to farmers. Besides humans, wildlife and livestock also face great trouble during a cold

wave as snow engulfs grass and plants, thereby denying them food. Cold waves often kill people and animals by causing hypothermia and starvation.

2.4.3 Biological Disasters

A biological disaster is a natural event characterized by the rapid spread of disease among humans, animals, and plants.It is caused by microorganisms like viruses, bacteria, or toxins. Biological disasters can be extremely deadly and kill a huge number of humans, other animals, or plants. Sometimes, a biological disaster can even cause the extinction of a plant or animal species. When a biological disaster is limited to a local area, it is called an “epidemic,” and once it spreads to a larger area, it is called a pandemic. The COVID-19 disaster is an excellent example of a global pandemic that affected all countries.

Source of occurrence

The pathogens that cause an epidemic or pandemic may spread from various places. That place can be a hospital, a medical facility, a research laboratory, or even a jungle or wetland. However, identifying the source of a pathogen for a particular disease is not easy, and only determined action by governments or international bodies like the World Health Organization can help in identifying the source of a particular pathogen.

Prevention of Biological Disasters

Biological disasters can be prevented or controlled with proper planning and management. Through environmental management, epidemics can be controlled or prevented. A safe water supply can control water-borne diseases like cholera and dysentery. Similarly, by checking for rodents and mosquitoes, various diseases can be controlled. Integrated disease surveillance systems are a must for any country to prevent biological disasters.



CHECK YOUR PROGRESS

Q.2: State true or false

i. Volcanic eruption can cause earthquake.

II. Flood is a geological disaster.

III. Drought is a slow-onset disaster.

IV. Cyclones have different names in different parts of the world.

V. Cold waves are associated with hyperthermia.



2.5 LET US SUM UP

- A natural disaster is caused by the earth's endogenic and exogenic processes.
- Risk depends on the combination of hazards, vulnerabilities, and exposure.
- Natural disasters can be classified as geological disaster, Hydro-metrological disasters and biological disaster.
- Different geological disasters include earthquakes, volcanic eruptions, landslides, avalanches, and mud flows.
- Hydro-meteorological disasters include floods, droughts, cyclones, heat waves, and cold waves.
- An avalanche is the downward movement of loose snow from a hill or a mountain.
- Cyclones have different names in various parts of the world.
- Biological disaster is caused by microorganisms like viruses, bacteria, or toxins.



2.6 FURTHER READINGS

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2.7 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No 1: i. True ii. False iii. Trueiv. Truev. False

Ans to Q No 2: I. True II. False III. True IV. True V. False



2.8 MODEL QUESTIONS

Q 1: Discuss briefly the major types of natural disasters.

Q 2: What **are biological disasters?**

Q 3: What are the different types of geological disasters?

Q 4: What are hydro-meteorological disasters? Discuss its various types.

*** ***** ***

UNIT 3 : GEOLOGICAL DISASTERS

UNIT STRUCTURE

3.1 Learning Objectives

3.2 Introduction

3.3 Earthquake

3.4 Tsunami

3.5 Landslide

3.6 Volcanic activity

3.7 Avalanche

3.8 Mudflow

3.9 Let Us Sum Up

3.10 Further Readings

3.11 Answers to Check Your Progress

3.12 Model Questions

3.1 LEARNING OBJECTIVES

After reading this unit, you will be able to-

- Clarify the origin of geological disasters
- Distinguish different type of geological disasters
- Highlight the aggravating factors of disasters.

3.2 INTRODUCTION

In the previous unit, we discussed natural disasters. In this unit, we will explore various types of geological disasters. This unit will cover the causes and impacts of earthquakes along with its significance in India. It will also focus on tsunamis and their causes. Additionally, the occurrence of landslides and volcanic activity, along with their impacts, will be discussed. The unit will conclude with a discussion on geological disasters such as avalanches and mudflows.

3.3 EARTHQUAKE

An earthquake is the sudden shaking of the Earth's surface resulting from the movement of seismic waves. These waves are produced when energy stored within the Earth's crust is abruptly released. This release typically occurs when large masses of rock, under stress, slip or fracture along geological faults. Because many of these faults are located at the edges of tectonic plates, the majority of earthquakes happen along these plate boundaries. Sometimes, however, an earthquake can be very powerful, leading to wild shaking of the ground, resulting in widespread destruction and death. Unlike a cyclone or volcanic eruption, an earthquake's occurrence cannot be predicted, making it very deadly.

The place inside the earth where an earthquake originates is known as the focus or hypocenter of the earthquake. Generally, the focus of the earthquake is found 30 to 50 km inside the earth. However, sometimes the focus of the earthquake may be as deep as 700 kilometres inside the earth. A shallow-focus earthquake is generally more deadly than a deep-focus earthquake. The place right above the focus and on the surface of the earth is called the epicentre of the earthquake. The shaking from an earthquake is greatest over the epicentre, and it progressively decreases away from the epicentre.

Causes of earthquakes

Earthquakes are primarily caused by tectonic forces within the earth's crust, and powerful earthquakes occur whenever there is sudden movement along faults inside the earth. Such movements along faults release enormous amounts of energy, resulting in the shaking of the ground, which we call an earthquake. Volcanic eruptions often cause earthquakes, and the occurrence of frequent earthquakes in volcanic regions is often considered an early warning for eruptions. However, earthquakes can also occur due to extraterrestrial causes, i.e., impact by a comet, or due to anthropogenic activities like underground nuclear explosions.

Seismic waves:

Seismic waves are shockwaves of energy that occur whenever there

is an earthquake. Seismic waves originated at the focus of an earthquake and then rapidly spread everywhere. There are three types of seismic waves: P waves, or primary waves; S waves, or secondary waves; and L waves, or surface waves. Whereas P and S waves can penetrate the interior of the earth, L waves are mostly confined to the surface of the earth. P waves are the fastest waves, followed by S waves and L waves. Although L waves are slow, they are the most destructive, and all their energy is confined to the upper part of the earth.

Earthquakes in India:

India is one of the countries in the world that is frequently struck by earthquakes. During the last 100 years, India has been rocked by several powerful earthquakes, causing large-scale destruction and bringing untold misery and death. However, fortunately, not all parts of the country are equally vulnerable to earthquakes. Southern parts of India are generally regarded as stable, and earthquake activity is at its lowest over there. Similarly, central India is also less vulnerable to earthquakes. In India, the northern and north-eastern parts are most vulnerable to powerful earthquakes, along with the state of Gujarat.



CHECK YOUR PROGRESS

Q. 1: What is focus of an earthquake?

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Q. 2: Name the different seismic waves.

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3.4 TSUNAMIS

A tsunami is a series of waves in a sea, ocean, or large lake that are formed due to the displacement of a huge volume of water. This displacement of water is usually caused by an earthquake, but itcan also be caused by other factors. Most of the tsunamis are small and don't cause any destruction, but some are large and extremely powerful. A tsunami is one of the most

powerful and destructive natural forces, capable of killing a large number of people and destroying property worth billions of dollars. Tsunamis cause destruction in two ways: first, by the smashing force of huge volumes of water travelling at very high speed; and second, when huge volumes of water drain off the land, they carry a large amount of debris, including houses, cars, etc., to the sea. Fortunately, destruction by tsunami is mostly limited to coastal areas, and interior areas that are far away from the sea are generally safe from tsunami. Again, high-altitude areas like hills are safe from tsunamis, even if they are located along coastlines. Tsunami waves are different from normal sea waves due to their long wavelength. Whereas normal sea waves are generated by wind or tides, tsunamis are generated due to the displacement of huge volumes of water. A tsunami cannot be prevented, but its destructive effect can be reduced by proper planning and by adopting measures like planting trees or building strong walls along coastlines. Most of the tsunamis occur in the Pacific Ocean, and countries like Japan, Indonesia, and Chile are worst affected by them. Some of the most recent tsunamis are the 2004 Indian Ocean tsunami and the 2011 Japan tsunami. The 2004 tsunami, which originated in Indonesia, was the most destructive tsunami in recent history, killing around 230,000 people in 14 countries in Asia and Africa. This tsunami also affected India, and thousands of people died in coastal areas of Tamil Nadu, Andhra Pradesh, Kerala, and the Andaman and Nicobar Islands. The 2011 Japan tsunamis were also highly destructive and were responsible for large-scale death and destruction. It is estimated that this tsunami was responsible for killing around 20,000 people.

What causes tsunamis?

Primarily, tsunamis are caused by earthquakes. The Global Historical Tsunami Database indicates that over 80 percent of tsunamis since 1900 have been caused due to seismic activity. Besides earthquakes, tsunamis can also result from massive landslides, volcanic eruptions, meteorite impacts, and underground nuclear explosions.



CHECK YOUR PROGRESS

Q. 3: Which ocean experiences the majority of tsunamis?

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Q. 4: Name two countries that are often affected by tsunamis.

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Q. 5: What are some other causes of tsunamis besides earthquakes?

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3.5 LANDSLIDE

A landslide is the downward movement of a mass of rock, debris, or soil. It is a type of mass waste or mass movement. Although landslides are primarily caused by gravity, heavy rainfall and earthquakes can also trigger them. It occurs when the ground on a slope becomes unstable due to various reasons. As the slope steepened, the probability of a landslide increased, which is why landslide events are always found on hills, plateaus, and mountains. Beside slope, other natural factors affecting landslide events are local geology, vegetation cover, rainfall patterns, etc. Landslides also occur under water, and they are called submarine landslides. The occurrence of landslides is often influenced by various human actions like deforestation, mining, road and railway line construction, and urban development. In the recent decade, a marked increase in landslide events has been seen, and it is primarily due to human action, as various human activities like blasting for construction and deforestation often lead to instability of hill slopes and consequent landslides.

In India, landslides are common in the Great Himalayan Mountain, the tallest mountain in the world, the Western Ghats, the Nilgiris, the Eastern Ghats, the Vindhyas, and the hills and mountains of North-East India. As the Himalayan mountain chain is geologically young and still not fully

stabilised, it frequently suffers from landslides, resulting in the loss of life and property. According to the Geological Survey of India, 12.6 percent of the geographical area of the country is prone to landslide hazards. Therefore, proper evaluation and adaptation of mitigation strategies for landslide hazards are really important.

3.6 VOLCANIC ACTIVITY

A volcanic eruption is the expulsion of molten lava, rock fragments, dust, and hot gases through a vent onto the earth's surface. Most of the eruption occurs from the top of the volcano, but sometimes lava is also thrown out from the side branches. A volcanic eruption can be quite outflowing, or it may be a terrible explosion releasing huge amounts of energy, thereby causing immense destruction. Explosive volcanic eruptions cause powerful earthquakes, and if a volcano is located on an island or in coastal areas, a destructive tsunami may be generated, thereby causing immense destruction. Basically, volcanoes are of two types: stratovolcanoes and shield volcanoes. Stratovolcanoes have steep sides and conical shapes, and they used to form when volcanic material was sticky and did not flow easily. Eruptions of stratovolcanoes are often accompanied by huge explosions and powerful earthquakes. India's only active volcano, the Barren Island volcano, belongs to stratovolcano type. In shield volcanoes, volcanic material is less sticky, and lava used to flow easily, often far from the source of the volcano. Therefore, shield volcanoes always have gentle slopes, and their conical shape is less pronounced. Like earthquakes, the distribution of volcanoes is highly uneven, and most of the volcanoes are found along tectonic plate boundaries. In India, its only active volcano is located on Barren Island in the union territory of Andaman and Nicobar. The first recorded eruption of this volcano took place in 1787. Since then, it has erupted numerous times, and the last eruption took place in the year 2020.



CHECK YOUR PROGRESS

Q. 6: State true or false

i. The distribution of volcanoes is evenly spread across the Earth's surface.

ii. The Barren Island volcano in located in Indonesia.

iii. Explosive volcanic eruptions can cause powerful earthquakes.

iv. Stratovolcanoes and shield volcanoes are the two basic types of volcano.

3.7 AVALANCHE

An avalanche is the downward movement of loose snow from a hill or mountain. An avalanche has a rapid flow down a slope; it is always unpredictable, and escaping from an avalanche is always difficult. An avalanche can be triggered by multiple factors, like an earthquake, increased precipitation, or human or animal movement. On average, humans are responsible for more than 80 percent of avalanches. An avalanche is of two types: a slab avalanche and a loose snow avalanche. Whereas the first one is composed of tightly packed snow, the second one is composed of loose snow. A slab avalanche is generally more deadly as it is composed of a thick slab of snow that may act as broken glass as it moves downhill. A fast-moving avalanche, often mixed with air, forms a powder snow avalanche that rapidly engulfs a large area, endangering human and animal life. In India, avalanches are common at higher altitudes in the Himalayas and are responsible for numerous deaths and destruction. Mountain climbers, soldiers serving at higher altitudes, and adventure tourists who often visit high altitude regions are most vulnerable to avalanche events.

3.8 MUDFLOW

A mudflow involves the fast-moving flow of mud down a slope. It is also known as a mudslide. Heavy rainfall in a short period of time often triggers mudflow, especially in clayey, rich soil. Besides rainfall, snowmelt,

groundwater flowing through cracked bedrock, and volcanic eruptions can also trigger mudflows. Mudflows move at high speed and pose a significant hazard to life and property. Mudflows from different sources can combine in a channel, creating a huge volume of mudflow that can cause immense destruction. Areas that have limited or zero vegetation cover are always prone to mudflow as soil binding by the roots of the plant is absent. Mudflows occur with little warning, can exert great impulsive loads on objects in their paths, and can strip vegetation, block drainage ways, damage structures, and endanger human life (Iverson, 1997). In India, mudflow occurrences are sometimes seen in the Himalayan region, especially in areas with heavy rainfall and low vegetation cover.



3.9 LET US SUM UP

- The shaking from an earthquake is greatest over the epicentre, and it progressively decreases away from the epicentre.
- Seismic waves are shockwaves of energy that occur whenever there is an earthquake.
- A tsunami is a series of waves in a sea, ocean, or large lake that are formed due to the displacement of a huge volume of water.
- A tsunami cannot be prevented, but its destructive effect can be reduced by proper planning.
- Landslides occur under water are called submarine landslides.
- The two types of volcanos are stratovolcanoes and shield volcanoes.
- An avalanche is the downward movement of loose snow from a hill or mountain.
- In India, mudflow occurrences are sometimes seen in the Himalayan region, especially in areas with heavy rainfall and low vegetation cover.



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3.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The place inside the earth where an earthquake originates is known as the focus of the earthquake.

Ans. to Q. No. 2: Three types of seismic waves are P waves or primary waves, S waves or secondary waves and L waves or surface waves.

Ans. to Q. No. 3: The Pacific Ocean experiences the majority of tsunamis.

Ans. to Q. No. 4: Japan and Indonesia are often affected by tsunamis

Ans. to Q. No. 5: Tsunamis can also be caused by massive landslides, volcanic eruptions, meteorite impacts, and underground nuclear explosions.

Ans. to. Q. No. 6: i. False ii. False iii. Truei v. True



3.12 MODEL QUESTIONS

Q.1: Discuss briefly the major types of geological disasters.

Q.2: What is Avalanche?

Q.3: What are the two main types of volcano?

Q.4: What are the causes of an earthquake?

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UNIT 4 : HYDRO-METEOROLOGICAL DISASTERS

UNIT STRUCTURE

4.1 Learning Objectives

4.2 Introduction

4.3 Flood and River Bank Erosion

4.4 Cyclone

4.5 Drought

4.6 Desertification

4.7 Forest Fire

4.8 Let Us Sum Up

4.9 Further Reading

4.10 Answers to Check Your Progress

4.11 Model Questions

4.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe about hydro-meteorological disasters
- identify the causes and impacts of different hydrometeorological hazards like floods, bank erosion, cyclones, droughts, desertification, and forest fires
- formulate the mitigation and management measures for hydro-meteorological hazards.

4.2 INTRODUCTION

In the preceding unit, you gained knowledge about geological disasters. This unit will focus on hydro-meteorological disasters. Hydro-meteorological disasters encompass events of atmospheric, hydrological, or oceanographic origin. These include floods, bank erosion, cyclones, severe thunderstorms, droughts, desertification and forest fires, which impact both the atmosphere and hydrology. As a result, they are categorized as hydro-meteorological disasters. Globally, these disasters are responsible

for more than 75% of damages, including casualties, economic losses, infrastructure damage, and disruptions to daily life.

4.3 FLOOD AND RIVER BANK EROSION

Flood is defined as a body of water that rises to overflow land not normally submerged. This situation usually arises when a river carries a flow in excess of its transport capacity. Floods can cause widespread devastation, resulting in loss of life and damage to personal property and infrastructure. People who live in floodplains or non-resistant buildings, or lack warning systems and awareness of flooding hazards are most vulnerable to floods.

Types of Floods

There are three common types of floods: flash floods, river floods, and coastal floods.

Flash floods are caused by rapid and excessive rainfall that raises water levels quickly, and rivers, streams, channels, or roads may be overtaken.

River floods are caused when consistent rain or snow melt forces a river to exceed its capacity.

Coastal floods are caused by storm surges associated with tropical cyclones and tsunamis.

Floods have been a recurrent phenomenon in many parts of India, causing the loss of lives and public property and bringing untold misery to the people.

Causes of Floods in India

The major factors that causes flood in India are meteorological factors, physical factors and human factors.

1. Meteorological factors: The meteorological factors includes heavy rainfall in a smaller time window, tropical cyclones and cloud bursts, acts as the most important causes of flood.
2. Physical factors: large catchment area; inadequate drainage arrangement

3. Human factors: Human causes of flooding basically refers to the deforestation, siltation, faulty agricultural practises, burst dams, and accelerated urbanization. Trees and vegetation absorb significant amounts of rainfall which reduces the volume of water that flows into rivers and streams. When forests are cleared, this natural absorption is lost and increases the risk of flooding.

Impacts of floods

Floods have a wide range of impacts that can significantly affect the economy, society, environment, and public health. Some of the serious consequences of floods are as follows:

1. Frequent inundation of agricultural land and human settlements has serious consequences for the national economy and society.
2. Floods not only destroy valuable crops each year but also damage physical infrastructure, including roads, railways, bridges, and human settlements.
3. Millions of people are rendered homeless and are also washed away along with their cattle in the floods.
4. Spread of diseases like cholera, gastroenteritis, hepatitis, and other waterborne diseases in the flood-affected areas.
5. Floods also make a few positive contributions. Every year, floods deposit fertile silt over agricultural fields, this is good for the crops.

Riverbank Erosion

Riverbank erosion is another major riverine hazard worldwide associated with floods, which occurs both naturally and through human impact. Erosion involves the wearing away of soil from banks. Compared to floods, river bank erosion is a bigger problem, as the land loss due to bank erosion is irreversible.

Devastation from bank erosion is notable in many major rivers like the Mississippi-Missouri of North America; Danube of Europe; Amazon of South America; Nile of Africa; Mekong, Yellow, Irrawaddi, Ganges, and Brahmaputra of Asia.

The Brahmaputra valley in Assam has been facing heavy landmass instability due to river bank erosion, believed to have been accelerated

after the 1950 earthquake. Assam has lost more than 4.27 lakh hectares of land (7.4% of the area of the state) due to bank erosion and channel migration of the Brahmaputra and its tributaries since 1950. Recurrent erosion has caused permanent damage to important places and landmarks along the river bank, besides capsizing cultivable and homestead land.

Flood management in Assam

Flood management measures started in Assam after the declaration of the National Policy in 1954. Accordingly, a huge network of flood embankments along the Brahmaputra and its tributaries was erected across the state. Extensive riverbank protection or anti-erosion measures were initiated only when the existing embankments became more and more vulnerable to breaches from erosion. Different protection works and technologies taken up in different erosion affected reaches of Brahmaputra since 1970 include the construction of:

- Boulder revetment with launching apron
- Deflector/bull head along with up-stream and downstream protection work.
- Spurs/land spurs.

RCC porcupines have been used as pro-siltation devices. The Water Resources Department has started using geo-textile technology in the form of geo-bags and geo-tubular mattresses in selected areas.

It has been observed that flood management measures implemented so far could provide reasonable protection to the area from low and medium floods, but during high floods there have been large-scale breaches. Due to financial and geographic constraints, no structural measure can be adopted for total or absolute protection against all conceivable magnitudes of floods. No method can be termed the best, and any method can be adopted according to the circumstances. A combination of various measures is possibly the best way to manage floods.



CHECK YOUR PROGRESS

Q.1: What are hydro-meteorological disasters?

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Q.2: What are the different types of floods?

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.....

Q.3: What are the causes of floods in India?

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.....

4.4 CYCLONE

The word "cyclone" is derived from the Greek word "cyclos," meaning the coils of a snake. It was coined because the tropical storms in the Bay of Bengal and the Arabian Sea appear like coiled serpents of the sea.

Cyclones and anticyclones are regions of relatively low and high pressure, respectively. Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are usually accompanied by violent storms and bad weather. The air circulates inward in an anticlockwise direction in the northern hemisphere and clockwise in the southern hemisphere. Cyclones are classified as: (i) extratropical cyclones (also called temperate cyclones); and (ii) tropical cyclones.

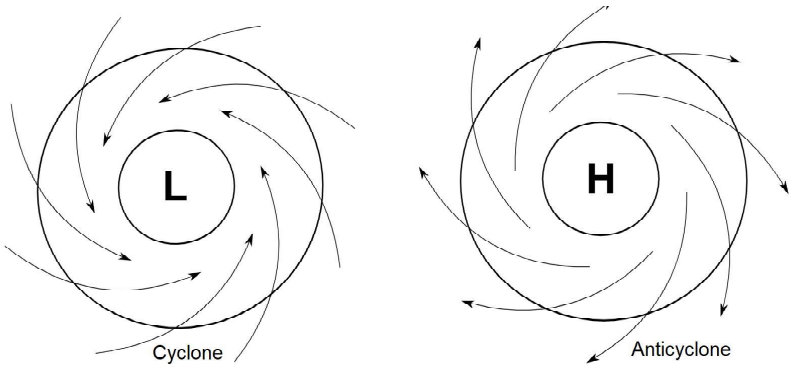


Fig. 4.1: Occurance of Cyclones and anticyclones

Cyclones are called by various names in different parts of the world like Typhoons in the Northwest Pacific Ocean west of the dateline, Hurricanes in the North Atlantic Ocean, the Northeast Pacific Ocean east of the dateline, or the South Pacific Ocean, Tropical cyclones in the Southwest Pacific Ocean and Southeast Indian Ocean, Severe cyclonic storm in the North Indian Ocean, Tropical cyclones in the Southwest Indian Ocean, Willie-Willie in Australia and Tornado in South America.

In India, cyclones are classified by

Strength of associated winds,

Storm surges

Exceptional rainfall occurrences.

The 7516.6 kilometre long Indian coastline is the world's most cyclone battered stretch. Around 8 percent of the total land area in India is prone to cyclones. About two-thirds of the cyclones that occur along the Indian coastline occur in the Bay of Bengal. The states that are generally affected on the east coast are West-Bengal, Orissa, Andhra Pradesh; Tamil Nadu and on the west coast, Gujarat, Maharashtra, Goa, Karnataka, and Kerala.

Cyclone Risk Reduction Measures

Coastal belt plantation: green belt plantation along the coastal line in a scientific interweaving pattern can reduce the effect of the hazard. Forests act as a wide buffer zone against strong winds and flash floods.

Hazard mapping: Meteorological records of the wind speed and the directions give the probability of the winds in the region. Past records and paths can give **a** pattern of occurrence for particular wind speeds. A hazard map will illustrate the areas vulnerable to cyclones in any given year. It will be useful to estimate the severity of the cyclone and various damage intensities in the region.

Engineered structures: structures need to be built to withstand wind forces. Good site selection is also important. The majority of the buildings in coastal areas are built with locally available materials and have no engineering input. Good construction practises should be adopted, such as:

- Cyclonic wind storms inundate the coastal areas. It is advised to

construct on stilts or on an earth mound.

- Houses can be strengthened to resist wind and flood damage. All elements holding the structures need to be properly anchored to resist the uplift or flying off of the objects.
- A row of planted trees will act as a shield. It reduces energy.
- Buildings should be wind and water resistant.
- Buildings storing food supplies must be protected against the winds and water.
- Protect river embankments. Communication lines should be installed underground.
- Provide strong halls for community shelter in vulnerable locations.

Flood management: Torrential rains, strong wind, and storm range lead to flooding in the cyclone affected areas. There are possibilities for landslides too. Flood mitigation measures could be incorporated.



CHECK YOUR PROGRESS

Q.4: What is a cyclone?

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.....

Q.5: What are the different types of cyclone in India?

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.....

Improving vegetation cover: The roots of the plants and trees keep the soil intact and prevent erosion and slow runoff to prevent or lessen flooding. The use of tree planted in rows will act as a windbreak. Coastal shelterbelt plantations can be developed to break severe wind speeds. Species chosen for this purpose should not only be able to withstand the impact of strong cyclonic winds, but also check soil erosion.

4.5 DROUGHT

Drought is either the absence or deficiency of rainfall from its normal pattern in a region for an extended period of time, leading to general suffering in society. Thus, drought is a prolonged dry period in the natural climate

cycle that can occur anywhere in the world. It is a slow- onset disaster characterised by the lack of precipitation, resulting in a water shortage. Drought can have a serious impact on health, agriculture, economies, energy, and the environment. Drought can occur due to improper distribution of rain in time and space, not just by its amount.

Based on the principles of drought mathematics, three occurance of drought are onset of drought, moderate drought and severe drought.

- Onset of drought: Deficiency of a particular year's rainfall exceeding 25 % of normal.
- Moderate drought: Deficit of rainfall between 26-50 % of normal.
- Severe drought: Deficit of rainfall more than 50 % of normal.

An estimated 55 million people globally are affected by droughts every year. Drought threatens people's livelihoods, increases the risk of disease and death, and fuels mass migration. Water scarcity impacts 40% of the world's population, and as many as 700 million people are at risk of being displaced as a result of drought by 2030. Around 70% of the total cultivable area of India is vulnerable to drought. It is the major hazard in terms of economic loss in India.



CHECK YOUR PROGRESS

Q.6: State true or false:

1) Flood is the major hazard in terms of economic loss in India.
2) Drought is a slow-onset disaster.
3) Drought occurs in specific places only.
4) 70 % of the total cultivable area of India is vulnerable to drought.

4.6 DESERTIFICATION

Desertification is the process by which fertile land changes itself into a desert by losing its flora and fauna. Desertification can be caused by drought, deforestation, climate change, human activities, or improper agriculture. It occurs because of man-made activities and climate change.

Desertification Impacts

Farming becomes difficult or even impossible in the area.

Flooding chances are higher.

Hunger, because of no farming

Poor quality of water

Poverty as a result of the above

Steps to reduce desertification

- Water management
- Rainwater harvesting
- Reforestation and tree regeneration
- Buttressing the soil
- Better fertilisation and hyper-fertilisation of soil through planting

Desertification in India

Population growth, removal of wood, overgrazing, soil erosion, etc. are important factors that have caused desertification in India. According to the government's data, India lost 31%, or 5.65 million hectares, of its grassland area in a decade. Over 105 million hectares, or about 32% of India's area, have degraded. Between 2003–2005 and 2011–2013, 26 states witnessed an increase in the level of desertification in India.

Measures taken to curb desertification in India

Multiple steps and measures have been taken by the concerned authorities regarding curbing desertification in India. A Command Area Development Programme was launched in 1974. It aims at improving the irrigational potential through water management. In 1989–90, the Integrated Watershed Management Programme was launched, which was later renamed the Haryali Guidelines in 2013 and then subsumed under the Pradhan Mantri Krishi Sinchai Yojana.

India became a signatory to the United Nations Convention to Combat Desertification (UNCCD) in 1994. The Desert Development Programme was launched in 1995 to minimise the effects of drought in areas across the country.

The Ministry of Environment, Forestry, and Climate Change implemented the National Afforestation Programme and the National Action Programme to Combat Desertification in 2000 and 2001, respectively.



CHECK YOUR PROGRESS

Q.7: What do you mean by desertification?

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Q.8: What are the causes of desertification?

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.....

4.7 FOREST FIRE

A forest fire is also known as a bushfire or vegetation fire. Forest fire is any uncontrolled and unprescribed burning of plants in a natural context such as a forest, grassland, brushland, or tundra that spreads due to environmental conditions (e.g., wind and topography). Humans are responsible for around 75% of all wildfires.

From the Amazon to the Arctic, wildfires around the world are increasing in frequency and intensity every year, causing severe long-term problems for the health of the planet and people. Climate change and wildfires mutually reinforce each other, and the fires burning today in many parts of the world are bigger, more intense, and last longer than they used to. The ferocious fires destroy vital ecosystems, impact economies and people, threaten property and livelihoods, and release millions of extra tonnes of carbon.

Forest fires are a regular phenomenon in our country, often observed during the summer. Severe fires occur in many forest types, particularly dry deciduous forests, while evergreen, semi-evergreen, and montane temperate forests are comparatively less prone. More than 36% of the country's forest cover has been estimated to be prone to frequent forest fires. Precious forest resources, including carbon locked in the biomass, are lost due to forest fires every year, which adversely impact the flow of goods and services from forests.

Satellite based remote sensing technology and GIS tools have been effective in improving the prevention and management of fires through the

creation of early warning systems for fire-prone areas, monitoring fires on a real-time basis, and the estimation of burnt scars.



CHECK YOUR PROGRESS

Q.9: State true or false

i) Forest fire is uncontrolled fire

ii) Humans are responsible for maximum forest fires.



4.8 LET US SUM UP

- Hydro-meteorological disasters are of an atmospheric, hydrological, or oceanographic nature.
- Floods, cyclones, drought, desertification, forest fires, etc. are examples of hydro-meteorological disasters.
- Floods may be flash floods, river floods, or coastal floods.
- Forty million hectares of land, roughly one-eighth of the country's geographical area, are prone to flooding.
- Cyclones and anticyclones are regions of relatively low and high pressure, respectively.
- The Indian coastline is cyclone prone.
- Drought is the absence or deficiency of rainfall from its normal pattern in a region for an extended period of time.
- Around 70 % of the total cultivable area of India is vulnerable to drought.
- Desertification is the process by which fertile land changes itself into a desert by losing its flora and fauna.
- There are policies and programmes for the management of different disasters.



4.9 FURTHER READINGS

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2) Carter, W. Nick, 1991: Disaster Management, Asian Development Bank, Manila.
3) Central Water Commission, 1987, *Flood Atlas of India*, CWC, New Delhi.
4) Government of India, 1997, *Vulnerability Atlas of India,* New Delhi.
5) Sahni, Pardeep et.al. (eds.) 2002, *Disaster Mitigation Experiences and Reflections*, Prentice Hall of India, New Delhi.



4.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q.No.1: Disasters of atmospheric, hydrological, or oceanographic nature are hydro-meteorological disasters.

Ans. to Q. No. 2: Floods may be flash floods, river floods, or coastal floods.

Ans. to Q. No. 3: Causes of floods in India are heavy rainfall in a smaller time window, tropical cyclones, cloud bursts, large catchment areas, inadequate drainage arrangements, deforestation, river bed siltation; faulty agricultural practises, bursting of dams, and unplanned urbanisation.

Ans. to Q. No. 4: A cyclone is a large air mass that rotates around a strong centre of low atmospheric pressure, anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Ans. to Q. No. 5: In India, cyclones are classified by strength of associated winds, storm surges, exceptional rainfall occurrences.

Ans. to Q. No. 6: 1) False 2) True 3) False 4) True

Ans. to Q. No. 7: Desertification is the degradation process by which a fertile land changes itself into a desert by losing its flora and fauna.

Ans. to Q. No. 8: Causes of desertification are drought, deforestation, climate change, human activities, or improper agriculture.

Ans. to Q. No. 9: i) True ii) True



4.11 MODEL QUESTIONS

Q.1: Give examples of hydro-meteorological disasters.

Q.2: Write about flood mitigation measures in Assam.

Q.3: What do you mean by drought?

Q.4: Differentiate between a cyclone and an anticyclone.

Q.5: Write about cyclone vulnerability in India.

Q.6: Write about cyclone risk reduction measures in India.

Q.7: What are the impacts of desertification?

Q.8: Write about steps to reduce desertification.

Q.9: Mention a few programmes to manage desertification in India.

Q.10: What are the causes and consequences of forest fires?

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UNIT 5 : BIOLOGICAL DISASTER

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Understanding Biological Disaster

5.4 Outbreak of Avian Flu Epidemic

5.5 Outbreak of Swine Flu

5.6 Outbreak of Plague

5.7 Pandemic and COVID-19

5.8 Let Us Sum Up

5.9 Further Reading

5.10 Answers to Check Your Progress

5.11 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to-

- interpret the meaning of biological disaster
- summarize about epidemics like Avian Flu, Swine Flu and Plague
- discuss the COVID-19 Pandemic.

5.2 INTRODUCTION

In the previous units, you learned about geological and hydro-meteorological disasters. In this unit, we will focus on biological disasters. This unit will also provide fundamental knowledge about several major epidemics and pandemics, including Avian Flu, Swine Flu, Plague, and COVID-19.

5.3 UNDERSTANDING BIOLOGICAL DISASTER

Biological disaster is defined as, ‘the devastating effects caused by an enormous spread of a certain kind of living organism that may spread a

disease, viruses or infestation of plant, animal or insect life on an epidemic or pandemic level'. Biological disasters may be in the form of epidemics or pandemics which are caused by microorganisms.

Epidemic affecting a disproportionately large number of individuals within a population, community, or region at the same time. Examples of epidemics include Cholera, Plague, and Japanese Encephalitis (JE) / Acute Encephalitis Syndrome (AES). Some of the microorganisms responsible for these diseases include bacteria, viruses, fungi, and toxins.

A **pandemic** is an epidemic that spreads across a large region, such as a continent or even worldwide, affecting existing, emerging, or reemerging diseases and pestilences. An example of a pandemic is Influenza H1N1 (Swine Flu).

Causes for epidemics and pandemics may be generalized as under:

- Congested living areas with inadequate hygiene and sanitation arrangements.
- Movement of infected personnel to non-epidemic areas carrying the micro-organisms during their incubation period.
- Movement of non-immune persons to endemic areas.
- Malnutrition, particularly among children.
- Ecological changes conducive to breeding of vectors.
- Poor or insufficient water supply system, leading to consumption of contaminated water, leading to water borne diseases.
- Poor health services and lack of programmes for immunization and vector control.



CHECK YOUR PROGRESS

Q.1: What is a biological disaster?

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Q.2: What is the difference between epidemic and pandemic?

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5.4 OUTBREAK OF AVIAN FLU EPIDEMIC

Avian influenza, commonly known as 'bird flu', is a viral disease primarily affecting birds. Depending on the subtype of the virus, it can be classified as either high or low pathogenicity, each presenting different symptoms in infected birds. The Low Pathogenic Avian Influenza Virus (LPAIV) can cause mild illness in birds, often unnoticed or without symptoms. In contrast, the Highly Pathogenic Avian Influenza Virus (HPAIV) results in severe illness in birds, spreading rapidly and leading to high death rates across various bird species. Some strains of HPAIV have the capacity to infect humans, posing a significant threat to public health.

Transmission

The most common way for the virus to enter a territory is through migratory wild birds. Humans who have close contact with sick birds are at risk of infection with bird flu. For example, a person may handle a sick bird, contaminate their hands with chicken faeces, and forget to wash their hands before eating. They will then ingest the infected bird faeces. This is the most common way for a human to catch the bird flu. The virus can also survive in raw poultry meat but is destroyed during normal cooking.

There is no evidence that the current circulating H5N1 strain of bird flu can be spread easily from human to human.

Symptoms

When avian influenza is transmitted to humans, symptoms in people can range from mild upper respiratory tract infection (fever and cough) to severe pneumonia, acute respiratory distress syndrome (difficulty breathing), shock, and even death.

Complications of bird flu

Bird flu in humans can cause a range of serious and potentially fatal complications, including:

- eye infections
- pneumonia, including viral pneumonia
- acute respiratory distress
- inflammation of the brain and heart.

Treatment and vaccines for bird flu

Several antiviral medications used to treat human influenza are also effective for bird flu. These could be used if a person developed symptoms after possible exposure to avian influenza, or to prevent illness in a person who was in close contact with avian influenza.

Vaccine is a specially prepared antigen administered to a person for the purpose of providing immunity. Vaccines stimulate the immune system of the body to protect against the infection. Vaccines are usually administered through needle injections, but some can also be administered by mouth or sprayed into the nose.



CHECK YOUR PROGRESS

Q.3: What is avian influenza?

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Q.4: How is avian flu transmitted to humans?

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5.5 OUTBREAK OF SWINE FLU

Swine flu is a viral infection that causes respiratory disease in pigs by influenza A virus. This influenza virus is commonly called swine influenza viruses or swine flu viruses. H1N1 swine influenza virus is a subtype of influenza A virus that causes infections in pigs worldwide, that is why it is also called swine flu. Swine flu is a communicable viral disease, that causes respiratory tract infections in pigs, resulting in symptoms such as nasal secretions, chills, fever, decreased appetite.

Swine flu viruses do not normally infect humans and have not been transmissible to people through eating properly handled and prepared pork (pig meat) or other products derived from pigs. However, sporadic human infections with influenza viruses have occurred.

In 2009, an H1N1 pandemic infected millions of people worldwide. Swine flu was first recognized in the 1919 pandemic and still circulates as a

seasonal flu virus. Swine flu is caused by the H1N1 virus strain, which started in pigs. Today, H1N1can be prevented with an annual flu shot.

Causes of swine flu (H1N1)

Influenza A virus causes swine flu (H1N1) in humans. Influenza viruses can be directly transmitted from pigs to people who are closely associated with infected pigs or located in proximity to infected pigs. Influenza virus can enter the human respiratory system through inhalation of droplets with influenza virus that spread in the air from infected pig cough or sneezing. It can also cause infection in humans through touching a surface with virus on it and then touching mouth or nose. A third way to possibly get infected is inhalation dust containing influenza virus.

What are the symptoms of swine flu (H1N1)?

Swine influenza viruses can potentially cause respiratory infections in humans. People with swine flu (H1N1 flu) have symptoms like regular human seasonal influenza. The symptoms may start three to five days after exposure to the virus. Symptoms may include.

- Fever.
- Chills.
- Cough.
- Sore throat.
- Body or muscle aches.
- Headache.
- Fatigue.
- Lethargy

Diagnosis of swine flu (H1N1)

Healthcare providers can diagnose swine flu (H1N1) by physical examination and ask about symptoms. The health care provider may advise a rapid flu test. A rapid flu test checks for several different flu viruses. It may take a few days to get the H1N1 test results back.

Treatment of swine flu (H1N1)

Most people with swine flu (H1N1) who are otherwise healthy don't need special drugs or treatments. If swine flu symptoms appear, the following precautionary measures should be taken.

- Sufficient rest
- Drink fluids
- Eat a light diet
- Stay home

Depending on the health conditions, the healthcare provider may prescribe an antiviral medicine that can kill the virus.

Prevention of swine flu (H1N1)

The best way to prevent swine flu (H1N1) is to get annual flu vaccine. The flu vaccine helps to protect against swine flu since 2010. Other ways to prevent getting and spreading swine flu (H1N1) include:

- Cover your nose and mouth with a tissue when sneezing or coughing.
- In absence of a tissue, sneeze or cough into elbow.
- Wash hands with soap and water.
- Don't touch your eyes, nose or mouth.
- Avoid people who are sick.
- Stay home when sick.
- Don't share personal items such as cups, straws and utensils.



CHECK YOUR PROGRESS

Q.5: State which of the following are true:

i. Swine flu is caused by Influenza virus.

ii. Swine flu is caused by bacteria.

iii. Swine flu cause respiratory infections in pigs.

iv. Swine flu is a communicable disease.

v. Swine flu was first detected in 2009.

5.6 OUTBREAK OF PLAGUE

Plague is an infectious disease caused by the bacteria *Yersinia pestis*, a zoonotic bacterium, usually found in small mammals and their fleas. It is transmitted between animals through fleas. Plague caused deadly pandemics in the past and still exists in many countries today. The three most common plague endemic countries are the Democratic Republic of the Congo, Madagascar, and Peru.

Types of Plague

There are three types of plague. These are bubonic, septicemic and pneumonic —each named for the part of human body that gets infected.

Transmission of Plague

Plague is a zoonotic disease, which means an infectious disease that is transmitted from animals to humans (or from humans to animals). Animals can also get plague from other animals. This disease usually spreads through bites from fleas that previously bit an infected animal. Plague is caused by *Yersinia pestis* bacterium. Humans can be infected through:

- the bite of infected vector fleas
- unprotected contact with infectious bodily fluids or contaminated materials
- the inhalation of respiratory droplets/small particles from a patient with pneumonic plague.

Symptoms of plague

Plague symptoms depend on how the patient was exposed to the plague bacteria. Plague can take different clinical forms, but the most common are bubonic, pneumonic, and septicemic.

In bubonic plague, patients develop fever, headache, chills, and weakness and one or more swollen, painful lymph nodes (called buboes).

In septicemic plague, patients usually develop fever, chills, extreme weakness, abdominal pain, shock, and possibly bleeding into the skin and other organs. Skin and other tissues may turn black and die, especially on fingers, toes, and the nose.

In pneumonic plague, patients develop fever, headache, weakness, and a rapidly developing pneumonia with shortness of breath, chest pain, cough, and sometimes bloody or watery mucous.

Treatment of plague

Plague is a serious illness, hence a person with symptoms above should Seek immediate medical attention. Prompt treatment with the correct medications is necessary to prevent complications or death.



CHECK YOUR PROGRESS

Q.6: State True or False:

I. Plague is caused by *Yersinia pestis* bacterium.

II. Pneumatic plague is the only plague that can be spread from person to person (by infectious droplets).

III. There are two forms or types of plague.

IV. Pneumatic plague cause pneumonia.

V. Plague still exists in several countries.

VI. There is no treatment for plague.

5.7 PANDEMIC AND COVID-19

Coronavirus disease (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome (SARS-CoV-2) virus. The term Covid 19 is coined by the World Health Organization. It is very contagious and spreads quickly that cause pandemic in 2020. The incubation period ranges between 2-14 days. Covid-19 most often causes respiratory symptoms including cold, flu, or pneumonia. It can cause mild to moderate respiratory illness and recover without requiring special treatment.

Research evidence suggests that SARS-CoV originated in bats. SARS-CoV then spread from infected civets to people. However, to date, the origin of SARS-CoV-2 that caused the Covid-19 pandemic has not been identified. The emergence of Covid-19 was first observed at Wuhan city of China when cases of unexplained pneumonia were noted in early December 2019. The virus then rapidly widespread with confirmed cases in almost every country across the world.

As of May 31, 2023, globally, there have been 767,364,883 confirmed cases of COVID-19 reported to the WHO, resulting in 6,938,353 deaths. In India, there have been 44,990,278 confirmed cases of COVID-19 and 531,867 deaths reported to the WHO by the same date.

Transmission of COVID 19

Covid -19 virus can spread from one infected person to another person through droplets that comes out during cough, sneeze, speak, sing

or breathe. In some circumstances, they may contaminate the surfaces they touch. These particles may range from larger respiratory droplets to smaller aerosols.

Symptoms of COVID 19

Covid-19 affects different people in different ways. A wide range of symptoms are reported in covid patients ranging from mild to severe illness. Most infected people develop mild to moderate illness and recover without hospitalization. Symptoms may appear 2-14 days after exposure to the virus. The symptoms of Covid 19 are as follow:

Most Common symptoms:

- Fever
- Cough
- Tiredness
- Loss of taste or smell.

Less common symptoms:

- Sore throat
- Headache
- Aches and pains
- Diarrhoea
- Rash on skin, or discolouration of fingers or toes
- Red or irritated eyes.

Serious symptoms:

- Difficulty breathing or shortness of breath.
- Loss of speech or mobility, or confusion.
- Chest pain.

It is advisable to seek immediate medical attention in case of serious symptoms. People with mild symptoms who are otherwise healthy should manage their symptoms at home.

Detection of Covid 19 virus

When symptoms appear, it is suggested to take a test for confirmation. There are two main types of viral tests:

- Polymerase Chain Reaction (PCR) tests
- Antigen tests

Prevention

There are many ways to prevent infection and to slow transmission of Covid-19. These include:

- Stay at least 1 metre apart from others, even if they don't appear to be sick.
- Wear a properly fitted mask when physical distancing is not possible or when in poorly ventilated settings.
- Choose open, well-ventilated spaces over closed ones. Open a window if indoors.
- Wash hands regularly with soap and water or clean them with alcohol-based hand rub.
- Cover mouth and nose when coughing or sneezing.
- Stay home and self-isolate until you recover.



CHECK YOUR PROGRESS

Q. 7: How is Covid-19 transmitted from one person to another?

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Q. 8: What are the most common symptoms of covid 19 infection?

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.....



5.8 LET US SUM UP

- Biological disasters are natural scenarios involving disease, disability or death on a large scale among humans, animals and plants due to micro-organisms like bacteria, or virus or toxins. Biological disasters may be in the form of epidemic and pandemic.
- Vaccination is a simple, safe, and effective way of protecting people against harmful diseases before they come into contact with them.
- Swine flu, plague and covid 19 are communicable diseases.

- Bird flu, swine flu, covid 19 are viral diseases while plague is a bacterial disease.
- Covid 19 can be tested by antigen test or PCR test.



5.9 FURTHER READINGS

1) *Biological Disasters* by G. Bhatia and N. Sandhu, 2020, Satyam Law International
2) *Biological Disaster Management: Major Events and Existing Framework* by Ranjeet Kumar Singh and Kumari Swarnim, 2010, Rajat Publications
3) Centers for Disease Control and Prevention (CDC), USA: https://www.cdc.gov/
4) World Health Organization (WHO): https://www.who.int/



5.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q.No.1: Biological disasters are natural scenarios involving disease, disability or death on a large scale among humans, animals and plants due to micro-organisms like bacteria, or virus or toxins. Biological disasters may be in the form of epidemic and pandemic.

Ans. to Q. No. 2: Epidemic: Biological disaster affects large numbers of people within a given community or area.

Pandemic: Biological disaster that affect a much large region, sometimes crossing countries or spanning continents or the globe

Ans. to Q. No. 3: Avian influenza, also known as 'bird flu', is a disease primarily affecting birds and is caused by a virus.

Ans. to Q. No. 4: Bird flu transmission happens from birds to humans through direct or indirect contact with infected birds or with environments and surfaces contaminated by faeces.

Ans. to Q. No. 5:

i. True ii. False iii True

iv. True v. False

Ans. to Q. No. 6:

i. True ii. True iii. False

iv. True v. True vi. False

Ans. to Q. No. 7: Covid -19 virus can spread from one infected person to another person through droplets that comes out during cough, sneeze, speak, sing or breathe. In some circumstances, they may contaminate the surfaces they touch.

Ans. to Q. No. 8: Most Common symptoms of Covid 19 are fever, cough, tiredness and loss of taste and/or smell.



5.11 MODEL QUESTIONS

Q.1: What are the causes of biological disasters?

Q.2: What are the symptoms of avian fu?

Q.3: What are the causes of swine flu?

Q.4: What are the symptoms of swine flu?

Q.5: What is plague? What are the different types of plague?

Q.6: How is plague treated?

Q.7: What are the detection measures of covid virus?

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UNIT 6 : MAN MADE DISASTER

UNIT STRUCTURE

6.1 Learning Objectives

6.2 Introduction

6.3 Overview of Man-made Disaster

6.4 War and Conflicts

6.5 Secondary Disaster

6.6 Let Us Sum Up

6.7 Further Reading

6.8 Answers to Check Your Progress

6.9 Model Questions

6.1 LEARNING OBJECTIVES

After going through this unit, you will able to-

- describe the causes and consequences of man-madedisaster
- compare the difference between war and conflicts
- summarize the various secondary disasters.

6.2 INTRODUCTION

In the previous unit, we have discussed the biological disasters. In this unit we are going to study about the man-made disaster. Here we will focus on the meaning and nature of man-made disasters. The adverse effects of man-made disasters like war and conflicts and post disasters needs will also be presented in this unit. This unit will also deal with various types of secondary man-made disasters like road accidents, building fire, forest fire, air and water pollution etc.

6.3 OVERVIEW OF MAN MADE DISASTER

Man-made disasters are also referred as anthropogenic disasters or human induced disasters. These disasters originate from human activities,

whether intentional or unintentional, resulting in significant negative impacts on human life, property and the environment. Man- made disasters are different from natural disasters, which are caused by natural phenomena like earthquakes, floods, or cyclones.

Man-made disasters occur due to variety of causes. Unintentional actions, such as inadequate maintenance, substandard workmanship, human error, technological failure, industrial accidents, or environmental degradation, contributeto their occurrence. Conversely, intentional actions, including acts of revenge, riots, mob violence, human conflicts or cybersecurity breaches, also play a significant role in precipitating these man-made disasters.

Like natural disasters, man-made disasters are indeed emergency situations that disrupt normal life, affect people, alter social structures and damage economies. They can lead to loss of life, injuries, displacement of populations, destruction of infrastructure, disruption of essential services and economic hardships. The social impacts can include psychological trauma, displacement, breakdown of social networks and strained community relations. Additionally, the economic impacts can involve direct costs associated with rescue and recovery efforts, as well as indirect costs stemming from property damage, loss of productivity and long-term economic downturns. Overall, man-made disasters have wide-ranging and severe consequences that necessitate effective response, recovery and resilience-building efforts.

Comprehensive risk management strategies are essential for addressing and mitigating the impacts of man-made disasters.

Nature of Man-made Disasters

The basic characteristics of man-made disasters are as follows:

- Predicting man-made disasters is not feasible. While with ecological disasters, we can anticipate that we are headed towards disaster but the exact timing and location remain unpredictable.
- Man-made disasters originate from human activities, decisions or negligence. Many man-made disasters can be prevented or mitigated through proper planning.

- The frequency and severity of man-made disasters are expected to increase due to population growth, industrial expansion and increasing technological complexity.
- There is minimal awareness among the general public about the intensity of man-made disasters, which increases vulnerability.
- Man-made disasters can have long-lasting effects on communities, economies, the environment and public health. It requires extensive efforts for recovery and rebuilding.

Type of Man-made Disasters

Man-made disasters can be classified into three categories. They are- sudden, insidious and wars.

Sudden Disasters: Sudden disasters are those that occur abruptly without much warningin which human factors are responsible, rather than natural factors. It causes immediate and significant damage.The release of methyl isocyanate at the pesticide plant in Bhopal, India in 1984, and the leakage of radioactive substances following an explosion at the Chernobyl nuclear power reactor in the Soviet Union in 1986 are theexamples of sudden disasters. Sudden disasters that areconsidered 'natural' may often be caused by preceding human activities. Mining catastrophes, earthquakes, sudden floods and landslides may be the result of indiscriminate deforestation or of construction of dams or by seemingly unrelated human activity.

Some types of sudden disaster include:

i. Fire in residential areas, industrial complexes, or forests due to negligence or accidents.
ii. Explosions in factories, mines, or public places due to industrial accidents, or other causes.
iii. Mining accidents due tosudden collapses or explosions in mines.
iv. Nuclear accidents in nuclear power plants due to catastrophic failures leading to radiation leaks.

Insidious Disasters: Insidiousand continuing disasters develop gradually over time and may not be immediately noticeable until they reach a critical point.The long-term alteration of temperature and weather patterns due to human activities like deforestation and burning fossil fuels leading to

loss of biodiversity and changes in climate patterns. Amazon rainforest deforestation anddisasters like global warming or the greenhouse effect and its associated impactsare the examples of insidious disaster.Industrial Pollution due to continuous discharge of pollutants from factories affecting the environment and human health.Some natural phenomenon like prolonged drought may be examples of insidious disasters.



Fig. 6.1: Forest fires

Wars and Civil Conflicts: Wars and civil conflicts involve organized and large-scale violence between nations, groups, or factions, often leading to widespread destruction and loss of life. Wars involvesarmed conflicts between countries whereas civil conflict is the internal conflicts within a country, such as civil wars or insurgencies.

World War II (1939-1945), the Syrian Civil War (2011-present), and the Russia-Ukraine war (2022-present) have resulted in millions of deaths and injuries, extensive infrastructure damage, environmental degradation, and long-term ecological impacts.

Terrorist attacks, which involve deliberate acts of violence by non-state actors targeting civilians or infrastructure, fall into this category of man-made disasters. The event of 9/11 attacks on September 11, 2001 in the United States was the deadliest terrorist attack in history.

Thus, man-made disasters encompass a wide range of events, including industrial accidents, transportation accidents, chemical spills, nuclear incidents, terrorism and cyber-attacks**.**



Fig. 6.2: Russia- Ukraine war in 2022



Fig. 6.3: The 9/11 attacks in the United States (2001)

Environmental Degradation

Environmental degradation is the process of deterioration of the natural environment through various human activities. Environmental degradation contributes to climate change through processes such as deforestation, habitat destruction, loss of biodiversity, soil erosion, greenhouse gas emissions and the destruction of natural carbon sinks like forests and wetlands. These activities release carbon dioxide and other greenhouse gases into the atmosphere that leads to global warming and climate instability. Therefore, addressing environmental degradation is important not only for mitigating climate change impacts but also for promoting sustainable environmental practices that ensure the health and stability of ecosystems for future generations.

Consequences of Man-Made Disasters

Man-made disasters can cause short-term morbidity and mortality, resulting in injuries, emotional stress, epidemics, and an increase in indigenous diseases.One glaring example is forest fires. Each year, millions of tons of forests around the world are destroyed.The disappearance of many animal and plant species due to deforestation and fires caused by human activity. The drastic reduction in forests significantly impacts the delicate global ecosystem.The public health response to man-made disastersis the primary prevention.Implementing tighter safety regulations for chemical production facilities, ensuring safe handling of hazardous substances, locatinghigh-risk facilities away from populated areas and human habitats, andensuring safety regulations with quality inputs in engineering and technological safety measures as well as early warning system would result in reducing the occurrence of man-made disasters.



CHECK YOUR PROGRESS

Q 1: What are the different types of man-made disasters?

.....

.....

Q 2: What do you mean by environment degradation?

.....

.....

Q 3: Write two consequences of man-made disasters.

.....

.....

6.4 WAR AND CONFLICTS

War and conflict represent as one the most severe forms of man-made disasters. They occur due to human interventions andlead to widespread destruction, loss of life and property, and long-lasting societal impacts. The intentional human actions in wars and conflicts create catastrophic conditions that disrupt the social, political, economic and

surrounding environment of affected regions.When war is declared, there is no way to avoid the consequences. During war, there have been more civilian deaths than military deaths and thousands of people are displaced as refugees. Children are the most affected in these conflicts.Armed conflicts, warfare, and civil unrest result in the displacement of populations, destruction of infrastructure and loss of lives.

In case of war, greater emphasis should be placed on the pre-disaster stage rather than the post-disaster stage. This means prioritizing efforts to reduce the likelihood of war and focusing on prevention. Prevention involves measures such as mitigation, negotiation, and reconciliation, all of which should occur before a conflict arises. Post-event efforts in the context of war tend to exacerbate the situation, bringing the disaster to its serious stage and accelerating surrounding conditions, ultimately resulting in even more severe consequences.

Conflict as man-made disaster is a concept realizing the severe and destructive impacts on society.Conflicts are struggles that can arise during active disagreements over opinions or interests between two parties. It begins when one party perceives that another party has negatively affected, something the first party values or considers a legitimate possession or belonging. The current Russian-Ukrainian war is an example of it. Conflicts should be addressed and normalized before they intensify into more destructive behaviors. The sooner the conflict is resolved the less likely it will escalate.

In recent times, the geography of warfare has changed drastically. Civil wars representing power conflicts within nations have increased abruptly, with most wars now fought in developing countries. These conflicts often involve indirect and covert involvement from major powers. The use of powerful weaponry, supported tacitly by global industrial nations, leads to high casualties and significant public health risks.The Israeli-Palestinian dispute is an example of conflicts.

Scarcity is a fundamental concept on which conflicts are formed. Conflicts can arise over natural resources, where people fight over ownership and access, especially concerning water resources. Additionally, poverty is

a primaryfactor for social conflict in society.A conflict area tends to have a high level of poverty, stemming from the inability to meet basic life needs. The government is responsible for addressing this man-made disasterrelated issues in conflict areas. If the government acts slowly or implements incorrect policies, the conflict's conditions will worsen. Trust is another essential characteristic in determining conflict resolution that must be developed among the negotiating parties. High levels of trust make it easier to achieve peace, whereas low levels of trust make it challenging to reach an understanding.

Thus, war and civil conflict not only result in loss of lifeand immediate physical devastation but also create long-term economic, political, social, and environmental challenges.



Fig. 6.4: Destruction of public infrastructure in Ukraine



CHECK YOUR PROGRESS

Q 4: Fill in the blanks

a) ..... are the most affected in these conflicts.

b) In case of war, greater emphasis should be placed on the ..... stage rather than the ..... stage.

c) A conflict area tends to have a high level of .....

d) ..... is a characteristic in determining conflict resolution that must be developed among the negotiating parties.

6.5 SECONDARY DISASTERS

Man-made secondary disasters are catastrophic events that occur as indirect consequences of human activities or following natural disasters. Various types of man-made secondary disasters are industrial accidents, chemical spills, infrastructure failure, technological failure, environment pollution etc.

Natural disasters such as earthquakes, floods, or hurricanes can lead to many accidents by damaging industrial facilities. Release of toxic chemicals, explosions and fires that cause widespread environmental pollution and health hazards.Chemical spills are caused by the damage of chemical storage facilities or transportation systems due to human error or natural disasters. These spills result in the contamination of water sources, soil and air.It leads to long-term health issues and ecological damage. Infrastructure failurecan lead to the collapse of buildings, bridges, dams and other critical structures. The collapse of the Morandi Bridge in Genoa, Italy, in 2018, which caused numerous fatalities. These secondary man-made disasters have immense impacts on livelihoods. The COVID-19 pandemicin 2020 is also a secondary man-made disaster affecting on health, economic, education, environment and social vulnerability.

Technological Disasters:

Technological man-made disasters or technological hazards result from human error, technological failures, or hazardous materials. Industrialization and technological advancements have resulted in accidents and the unexpected, uncontrolled release of hazardous and explosive materials. These incidents are referred to as technological disasters. They can have severe consequences on public health, the environment and the economy.The occurrence of technological disasters is due to many reasons. Some of the main reasons of technological disasters includes human error, inadequate maintenance, design defect, regulatory failures, natural disasters, cybersecurity breaches and economic pressures.

Some examples of technological disasters that have shown devastating effects are highlighted below.

- Bhopal Gas Tragedy (1984): A leak of methyl isocyanate gas from a pesticide plant in Bhopal resulted in an immediate death toll of over 2,000, with long-term health effects including respiratory problems and birth defects. It was the first major industrial disaster in India.
- Chernobyl Nuclear Disaster (1986):The Chernobyl disaster began on April 26, 1986, with the explosion of a reactor at the Chernobyl Nuclear Power Plant near the city of Pripyat in the northern Ukrainian Soviet Socialist Republic. The environment around the site remains contaminated and many cases of cancer and other radiation-induced illnesses caused.
- Fukushima Daiichi Nuclear Disaster (2011): It was a major nuclear accident at the Fukushima Daiichi nuclear power plant in Japan triggered by a tsunamion 11 March 2011. Large amounts of radioactive material were released into the environment, resulting in long-term health risks and the evacuation of thousands of residents.



Fig. 6.5: Bhopal pesticide plant

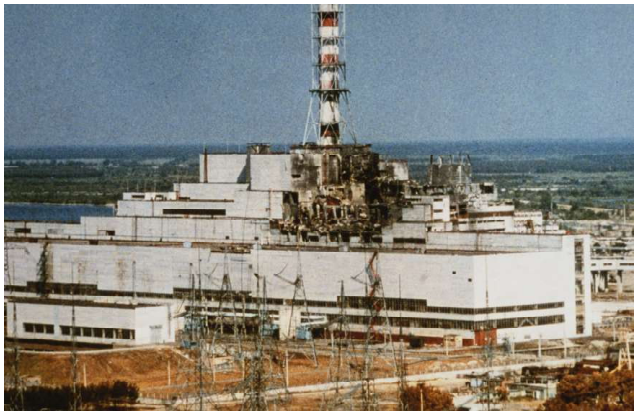


Fig. 6.6: Chernobyl nuclear power plant



Fig. 6.7: Fukushima Daiichi Nuclear Disaster

Preventing technological disasters requires a comprehensive strategy. Essential measures include thorough training, stringent safety regulations, advanced technologies, routine maintenance, enhanced design methodologies, robust cybersecurity, and emergency readiness. Cultivating a safety-first mindset, learning from past incidents, and fostering collaboration are also plays a vital role in reducing these disasters. By adopting these practices, we can establish a safer technological environment, safeguarding our communities and the environment from the severe consequences of man-made disasters.



CHECK YOUR PROGRESS

Q 5: What is technological disaster?

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Q 6: Give some examples of secondary disasters.

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6.6 LET US SUM UP

- Man-made disasters can have long-lasting effects on communities, economies, the environment and public health.
- The three types of man-made disasters are sudden, insidious and wars.
- Sudden disasters are those that occur abruptly without much warning

in which human factors are responsible rather than natural factors.

- Insidious and continuing disasters develop gradually over time and may not be immediately noticeable until they reach a critical point.
- Wars involves armed conflicts between countries whereas civil conflict is the internal conflicts within a country
- In case of war, greater emphasis should be placed on the pre-disaster stage rather than the post-disaster stage.
- Conflicts are struggles that can arise during active disagreements over opinions or interests between two parties.
- Various types of man-made secondary disasters are industrial accidents, chemical spills, infrastructure failure, technological failure, environment pollution etc.
- Technological man-made disasters or technological hazards result from human error, technological failures, or hazardous materials.
- The main reasons of technological disasters includes human error, inadequate maintenance, design defect, regulatory failures, natural disasters, cybersecurity breaches and economic pressures.



6.7 FURTHER READINGS

1) Barry A. Turner, ýNick F. Pidgeon, Man-Made Disasters, Butterworth Heinemann, Oxford, 1997,
2) Disaster by Choice: How Our Actions Turn Natural Hazards into Catastrophes" by Ilan Kelman
3) Frederick Cuny, Displaced Persons in Civil Conflict, Disaster Management Training Programme, UNDP, Geneva, 1997.



6.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The three types of man-made disasters are sudden, insidious, and wars.

Ans. to Q. No. 2: Environmental degradation is the process of deterioration of the natural environment through various human activities.

Ans. to Q. No. 3: Two major consequences of man-made disasters are the loss of human lives and properties and environmental destruction.

Ans to Q. No. 4: a) Children b) pre-disaster, post-disaster c) poverty d) Trust.

Ans to Q. No.5: Industrialization and technological advancements have resulted in accidents and the unexpected, uncontrolled release of hazardous and explosive materials. These incidents are referred to as technological disasters.

Ans. to q. No. 6: Some examples of secondary disasters are industrial accidents, chemical spills, infrastructure failure and technological disasters.



6.9 MODEL QUESTIONS

Q 1: Discus the types of man-made disasters.

Q 2: What are the causes and impacts of technological disasters?

Q 3: Explain the causes and impacts of forest fire.

Q 4: Write a short note on the impacts of industrial accidents.

Q 5: Explain any three significant causes of man-made disasters with the help of examples.

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UNIT 7 : ENVIRONMENTAL DEGRADATION

UNIT STRUCTURE

7.1 Learning Objectives

7.2 Introduction

7.3 Deforestation

7.4 Land Pollution

7.5 Water Pollution

7.6 Air Pollution

7.7 Climate Change

7.8 Let Us Sum Up

7.9 Further Reading

7.10 Answers to Check Your Progress

7.11 Model Questions

7.1 LEARNING OBJECTIVES

After going through this unit, you will be able to-

- discuss the issues related to environmental degradation
- identify the causes and consequences of deforestation
- explain causes, consequences and preventive measures of land pollution, water pollution and air pollution
- summarize the concept of climate change and its implications.

7.2 INTRODUCTION

In the previous unit, you learned about man-made disasters. In this unit, we will discuss environmental degradation. Environmental degradation refers to the deterioration of the environment due to the increasing human population and various developmental activities. This includes the depletion of natural resources, destruction of ecosystems, habitat loss, wildlife extinction, and pollution of air, water, and soil. Additionally, we will explore topics such as deforestation, environmental pollution, and climate change. Desertification and forest fires were covered in Unit 4.

7.3 DEFORESTATION

Deforestation is large-scale removal of trees for the facilitation of human activities. Deforestation rate is alarming in tropical countries. It is a serious environmental concern since it can result in the loss of biodiversity, damage to natural habitats, disturbances in the water cycle and soil erosion. Deforestation is also a contributor to climate change and global warming. About 30% of the world's land area has forest cover. According to the World Bank, 1.3 million km^2 forests has been lost from 1990 to 2016.

Causes of Deforestation

Activities that contribute to deforestation include:

- Agriculture – small-scale and large-scale farming including shifting cultivation for growing food needs of increasing population by clearing forests
- Logging – cutting of trees for use as raw material
- Mining, urban expansion and development projects – clearing of forest area for the construction of infrastructure.
- Overgrazing – Dependence for forest wood for source of fuel and overgrazing by the cattle
- Forest fires – natural and man-made

Agriculture is the root cause of 80% of deforestation. Logging accounts for another 14% and the cutting of trees for wood fuel account for 5%.

Consequences of Deforestation

Deforestation has several consequences that affect the environment, economy and society. Some of the significant consequences of deforestation are discussed below:

Loss of Habitat

70% of land animals and plant species live in forests. Deforestation results in a more drastic temperature variation from day to night, much like a desert, which could prove fatal for many inhabitants. Deforestation threatens the existence of many wildlife species due to destruction of their natural habitat.

Increased Greenhouse Gases

The lack of trees allows a greater amount of greenhouse gases to be released into the atmosphere.

Impact on Hydrological Cycle

Trees help to control the level of water in the atmosphere by helping to regulate the water cycle. Deforestation influences rainfall also.

Soil Erosion and Flooding

Trees help the land to retain water and topsoil, which provides the rich nutrients to sustain additional forest life. Without forests, the soil erodes and washes away, causing farmers to move on and perpetuate the cycle.

Effects on Indigenous People

The loss of forests has an immediate and direct effect on indigenous communities. Loss of forest resources poses many challenges to their health and wellbeing. These communities face the most immediate and threatening impacts of environmental degradation and climate change.

Control of Deforestation

- Implementation of security measures and strict laws to prevent illegal logging.
- Increasing the count and range of forests under government protection.
- Carefully planning the construction of infrastructure (roads, dams, etc.) in order to minimize the loss of forest area.
- Investing in new technologies in the agricultural industry (such as hydroponics) and helping farmers implement eco-friendly agricultural practices (such as cyclic agriculture)
- Optimizing the management of forests by banning inefficient agricultural practices (such as slash-and-burn agriculture).
- Facilitating the production and use of wood alternatives to reduce the demand for timber.
- Launching new reforestation campaigns to restore deforested lands.
- Individuals can also combat deforestation by spreading awareness about its negative consequences and participating in tree-planting campaigns.



CHECK YOUR PROGRESS

Q. 1: What is deforestation?

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Q. 2: What are the impacts of deforestation?

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7.4 LAND POLLUTION

Land pollution means degradation or destruction of the Earth's surface and soil, directly or indirectly, as a result of human activities.

Sources of Land Pollution

Agriculture –Widespread use of synthetic herbicides, insecticides, bactericides, and fertilizers contribute to soil pollution. Residues of those chemicals in the soils have long term negative effects.

Mining – Mining has the potential to pollute air and water, damage biodiversity and ecosystems, and permanently alter natural landscapes. Mining damages the ecosystem by destroying habitats, causing soil erosion, and polluting surface water, groundwater, and soil.

Urbanization and Industrialization – Improper disposal of municipal solid wastes and industrial wastes pollute air, water and soil.

Effects of Land Pollution on

i) Environment

- Reduces vegetation
- Ecological imbalance
- Air pollution and water pollution
- Climate change.

ii) Agriculture

- Reduces soil fertility
- Reduces nitrogen fixation
- Increased erosion
- Reduces crop yield.

iii) Health

- Harmful chemicals enter air, water and soil
- Biomagnification
- Health problems due to contamination of air, water and soil.

iv) Urban areas

- Clogging of drains
- Inundation of areas by flash floods
- Foul smell
- Waste management problem.

Control of Land Pollution

- Reducing chemical fertilizers and pesticide use
- Use of bio-fertilizers and bio-pesticides
- Organic farming
- Reforestation and afforestation
- Waste management
- Refuse, Reduce, Reuse, and Recycle.



CHECK YOUR PROGRESS

Q. 3: State whether true or false:

i. Fertilizers increases land pollution

ii. Land pollution does not have impact on ground water.

iii. Soil erosion is decreased from land pollution.

iv. Deforestation has implications on land pollution.

v. Mining supports habitats.

7.5 WATER POLLUTION

There is abundance of water on our planet. But only a small amount (0.3 percent) can be used by human. Water pollution is any chemical, biological, or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for designated use in its natural state. Water pollution is caused when water bodies such as rivers, lakes, oceans, groundwater and aquifers get contaminated with industrial and agricultural effluents. The distribution of world water is shown in the table 7.1.

Table 7.1: World Water Distribution

Sl. No.	Place	Percentage
1	Ocean	97.3%
2	Land	2.8%
3	Ice caps and glaciers	2.14%
4	Fresh water lakes	0.009%
5	Saline lake and inland lakes	0.008%
6	Rivers	0.0001%
7	Soil moisture	0.005%
8	Ground water	0.61%
9	Atmospheric water	0.001%
Total		**100%**

Sources of Water Pollution

Pollution of water can be caused by point sources or non-point sources. Point sources are specific sites near water bodies which directly discharge effluents into them. Industries, power plants, underground coal mines, offshore oil wells are examples of point sources of pollution. The discharge from non-point sources is not at particular site, rather, these sources are scattered which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are examples of non-point sources.

Water-borne diseases

i) Bacterial diseases: Typhoid, Cholera
ii) Viral disease: Infective Hepatitis
iii) Protozoan diseases: Amoebic dysentery, Diarrhoea,
iv) Vector borne diseases: Malaria, Filaria, Dengue

Effects of Water Pollution:

Water pollution has profound effects on both the environment and human health. Some of the key effects are discussed below:

Effects on aquatic ecosystem

i) Polluted water reduces Dissolved Oxygen (DO) content, thereby, eliminates sensitive organisms like plankton, molluscs and fish etc.
ii) Biocides, polychlorinated biphenyls (PCBs) and heavy metals directly eliminate sensitive aquatic organisms
iii) Hot waters discharged from industries, when added to water bodies, lowers its DO content.

Effects on human health

i) Polluted water usually contains pathogens like virus, bacteria, parasitic protozoa and worms, therefore. It is a source of water borne diseases.

ii) Mercury compounds in waste water are converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongue, deafness, blurring of vision etc.

iii) Water contaminated with cadmium can cause itai itai disease, a painful disease of bones and joints and cancer of lungs and fever.

iv) Lead compounds cause anemia, headache, loss of muscle power.

v) Presence of excess nitrate in drinking water may be fatal for infants for disease called Blue baby syndrome.

vi) Consumption of fluoride contaminated drinking water causes fluorosis.

vii) Chronic exposure to arsenic contaminated water causes arsenicosis.

Biomagnification

Biomagnification or biological magnification is a result of water pollution due to toxic chemicals. It is the increase in concentration of a substance, e.g., a pesticide, in the tissues of organisms at successively higher levels in a food chain.

Eutrophication

It is nutrient enrichment of lakes mostly from runoff of plant nutrients (nitrates and phosphates). Impacts of eutrophication are algae blooming, decrease of photosynthesis, decrease of DO level, dying algae, bad odour and killing of aquatic organisms including fish.

Control Measures of Water Pollution

i) Treatment of sewage water and industrial effluents before releasing into water bodies.

ii) Hot water from power plants should be cooled before release to water bodies.

iii) Excessive use of fertilizers and pesticides should be avoided.

iv) Organic farming and efficient use of animal residues as fertilizers.

v) Water quality monitoring of water bodies.



CHECK YOUR PROGRESS

Q. 4: State True or False:

I. Point source of pollution is easy to identify

II. Dissolved oxygen level is increased in eutrophication.

III. Agricultural field is an example of non-point source of pollution.

7.6 AIR POLLUTION

Human activities release a number of toxic chemicals, particulate matter and gaseous emissions into the ambient atmosphere. Air pollution means presence of one or more contaminants, in excessive concentrations (than maximum accepted and permissible limits), for sufficient duration, causing harm to human beings, plants and animal life, damage to the materials and interference to the normal activities.

India hosts 39 out of the world's 50 most polluted cities, with New Delhi ranking among the top 10 polluted cities globally.

Sources of Air Pollution

Natural Sources

Volcanic eruption, forest fires, storms, soil erosion, electrical discharges, decay of vegetation, salt sprays from ocean, spores and pollen from plants and weeds, anaerobic decomposition of wastes, photochemical and other natural reactions in the atmosphere.

Anthropogenic sources

Burning of fossil fuel, mining, transportation, industrial processes, agricultural activities.

Classification of air pollutants

Air pollutants can be classified into two main categories based on their sources and chemical composition. They are primary pollutant and secondary pollutant.

Primary Pollutants

The pollutants which are emitted directly from the source. Carbon monoxide (CO), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Hydrocarbons (HC), Hydrogen Sulfide (H_2S), particulate matter are examples

of primary pollutants. Transportation is a major source of pollution and Carbon monoxide is the main pollutant released into the atmosphere.

Secondary Pollutants

Secondary pollutants are formed in the atmosphere when some primary air pollutants react with one another or with other chemicals in the air. Sulphur trioxide (SO_3), Nitric Acid (HNO_3), Sulphuric Acid (H_2SO_4), Ozone (O_3), Peroxy acyl nitrate (PAN) are examples of secondary pollutants.

Effects of Air Pollution

- Health effect

  Table 7.2

Name of Pollutant	Source	Health effects
Carbon monoxide	Incomplete burning of fossil fuel	Reduces oxygen carrying capacity of blood, headache, unconsciousness, anemia
Sulphur dioxide	Coal burning	Respiratory irritant, effects lung function
Nitrogen oxides	Petroleum burning	Inflammation of lungs
Carbon dioxide	Burning of fossil fuel	Suffocation
Dust	Burning of fossil fuels	Cough, cold, asthma, bronchitis, allergy, T.B.
Hydrocarbons	Petroleum burning	Carcinogenic effect on lungs, effect on kidneys, respiratory distress

- Effects on plants

  Air pollutants affect plants by entering through stomata, destroy chlorophyll and affect photosynthesis. Necrosis (dead areas of leaf), chlorosis (loss of chlorophyll content causing yellowing of leaf), or epinasty (downward curling of leaf) and abscission (dropping of leaves) result from air pollution.

- Acid Rain

  The burning of fossil fuels releases harmful gases such as nitrogen oxides and sulphur oxides in the air. The water droplets combine with these pollutants, form droplets of nitric acid and sulphuric acids, become acidic and fall as acid rain which damages human, animal and plant life.

- Ozone Layer Depletion

  Ozone layer present in the Stratosphere of the atmosphere prevent the harmful ultraviolet rays coming from the sun. But, release of chlorofluorocarbons, halons, and hydrochlorofluorocarbons to the atmosphere is the major cause of depletion of the ozone layer.

- Effect on Animals

  The air pollutants suspend in the water bodies and affect aquatic life. Pollution also compels the animals to leave their habitat and shift to a new place. This renders them stray and has also led to the extinction of a large number of animal species.

Air Pollution Control

Some key methods and approaches used for air pollution control are discussed below:

- Avoid using vehicles for shorter distances

  People should avoid using vehicles for shorter distances. Rather, they should prefer public modes of transport to travel from one place to another. This not only prevents pollution, but also conserves energy.

- Energy Conservation

  A large number of fossil fuels are burnt to generate electricity. Therefore, do not forget to switch off the electrical appliances when not in use. Thus, you can save the environment at the individual level. Use of energy-efficient devices such as CFLs also controls pollution to a greater level.

- Use of Clean Energy Resources

  The use of solar, wind and geothermal energies reduce air pollution at a larger level. Various countries, including India, have implemented the use of these resources as a step towards a cleaner environment.

Other air pollution control measures include:

- By minimizing and reducing the use of fire and fire products.
- Selection of suitable fuel (e.g., fuel with low sulphur content) and its efficient utilization
- Modifications in industrial processes and/or equipment to reduce emission
- Destroying the pollutants by thermal or catalytic combustion
- Conversion of pollutants to less toxic form
- Collection of the pollutant
- Tree plantation.



CHECK YOUR PROGRESS

Q. 5: What is air pollution?

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Q. 6: What is acid rain?

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7.7 CLIMATE CHANGE

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

The Difference between weather and climate is that Weather refers to short term atmospheric conditions of a particular place while climate is the average weather of a specific region over a long period of time.

Global warming

Some gases of the atmosphere act like a blanket of the earth, trapping heat. These gases are called greenhouse gases. The phenomenon is known as the 'Natural Greenhouse Effect'. Without it, the earth would be much colder. The main greenhouse gases are Carbon dioxide, Methane,

Nitrous oxide, Ozone, Water vapour and Halocarbons.

Due to human activities like deforestation and fossil fuel burning, there is increase of the greenhouse gases in the atmosphere. Burning fossil fuels releases the carbon dioxide stored millions of years ago. Most of the increased carbon dioxide comes from fossil fuels. Deforestation releases the carbon stored in trees. Less trees also means less carbon dioxide can be removed from the atmosphere. Methane is produced when bacteria rot organic matter. Methane is also released when fossil fuels are extracted.

The average temperature of the Earth's surface is now about 1.1°C warmer than it was in the late 1800s (before the industrial revolution) and warmer than at any time in the last 100,000 years. The last decade (2011-2020) was the warmest on record, and each of the last four decades has been warmer than any previous decade since 1850.

The consequences of climate change now include, among others, change in rainfall pattern; increased likelihood of extreme events such as heat wave, flooding, drought, storms; water scarcity; severe fires; rising sea levels; melting polar ice; declining biodiversity and spread of diseases.

Switching energy systems from fossil fuels to renewables like solar or wind will reduce the emissions driving climate change.

Adapting to climate consequences protects people, homes, businesses, livelihoods, infrastructure and natural ecosystems.



CHECK YOUR PROGRESS

Q. 7: What is greenhouse effect?

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Q .8: What do you mean by climate change?

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7.8 LET US SUM UP

- Deforestation is large-scale removal of trees from forests (or other lands) for the facilitation of human activities.
- Causes of deforestation are agriculture activities, logging, overgrazing, mining, urban expansion and development projects
- Land pollution is degradation of the Earth's surface and soil, directly or indirectly, as a result of human activities.
- Agriculture, mining, urbanization and industrialization are the causes of land pollution.
- Land pollution effects environment and health.
- Water pollution is chemical, biological, or physical change in water quality that makes water unsuitable for designated use.
- Water pollution has negative impacts on aquatic ecosystem and human health.
- Air pollution is presence of one or more contaminants, in excessive concentrations for sufficient duration, causing harm to human beings, plants and animal life, damage to the materials and interference to the normal activities.
- Air pollution effects human health, plants and animals and materials.
- Climate change refers to long-term shifts in temperatures and weather patterns due to enhanced greenhouse effect.
- Climate change have serious implications on rainfall pattern, extreme events, water scarcity, rising sea levels, melting polar ice, declining biodiversity and spread of diseases.



7.9 FURTHER READINGS

1) Principles of Environmental Science and Engineering, P. Venugopala Rao, Prentice Hall of India Private Limited

2) Perspectives in Environmental Studies, Anubha Kaushik and C. P. Kaushik, New Age International Publishers



7.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q.No.1: Deforestation is large-scale removal of trees from forests (or other lands) for the facilitation of human activities. Deforestation rate is alarming in tropical countries.

Ans. to Q. No. 2: Impacts of deforestation are loss of habitat, increased greenhouse gases, rainfall alteration, soil erosion, flood, risk of indigenous people.

Ans. to Q.No.3: i) True ii) False iii) False
iv) True v) False

Ans. to Q.No.4: i) True ii) False iii) True

Ans. to Q.No.5: Air pollution means presence of one or more contaminants, in excessive concentrations, for sufficient duration, causing harm to human beings, plants and animal life, damage to the materials and interference to the normal activities.

Ans. to Q.No.6: Gases like nitrogen oxides and sulphur oxides released from fossil fuel burning combine with water droplets to form droplets of nitric acid and sulphuric acids in the atmosphere. These acid droplets make rain water acidic. This is called acid rain.

Ans. to Q.No.7: Gases like carbon dioxide, methane, water vapour act like a blanket of the earth, trapping heat. This phenomenon is called greenhouse effect.

Ans. to Q.No. 8: Climate change refers to long-term shifts in temperatures and weather patterns.



7.11 MODEL QUESTIONS

Q.1: What are the causes of deforestation?

Q.2: Write about preventive measures of deforestation.

Q.3: Mention five control measures of land pollution.

Q.4: What do you mean by water pollution?

Q.5: What are the impacts of water pollution?

Q.6: What are man-made sources of air pollution?

Q.7: What are impacts of air pollution on human health?

Q.8: What are the differences between weather and climate?

Q.9: What is enhanced greenhouse effect?

Q.10: What are the impacts of climate change?

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UNIT 8 : TECHNOLOGICAL DISASTER

UNIT STRUCTURE

8.1 Learning Objectives

8.2 Introduction

8.3 Nuclear Accidents

8.4 Toxic Wastes

8.5 Transport Accidents

8.6 Industrial Accidents

8.7 Fire Accidents

8.8 Oil Spills

8.9 Let Us Sum Up

8.10 Further Reading

8.11 Answers to Check Your Progress

8.12 Model Questions

8.1 LEARNING OBJECTIVES

After going through this unit, you will be able to-

- discuss the concept of nuclear accidents
- highlight the importance of toxic wastes
- elaborate the causes and consequences of transport accident
- explain the consequences of industrial accidents
- develop the concept of causes and impacts of the fire accidents
- investigate the risk factors associated with the oil spills.

8.2 INTRODUCTION

In the previous unit you were exposed to the environmental degradation. This unit will cover the different technological disasters caused by human. A technological disaster is a sudden or intense event caused by a malfunction of a technological structure and/or some human error in controlling or handling the technology. Examples include dam failures, fire, industrial accidents and transportation accidents. An important difference

between natural and technological disasters is that natural disasters often have a 'low point' at which it seems that the worst is over. In contrast to this situation, many technological disasters do not have a low point, a situation that can contribute to prolonged distress. Technological disasters pose greater challenges because their threats are often unforeseen, and they are typically triggered by human actions or errors.

8.3 NUCLEAR ACCIDENTS

Nuclear energy is produced by a nuclear reaction, in particular by ***nuclear fusion*** or **nuclear fission**. Wide application of nuclear energy in power generation, medicine, industry, agriculture, research and defense has led to an increase in the risk of occurrence of nuclear accidents.

Nuclear accidents scenarios:

- An accident in any nuclear facility of the nuclear fuel cycle including the nuclear reactor, or in a facility using radioactive sources
- An accident from uncontrolled nuclear chain reaction
- An accident during the transportation of radioactive material
- The malevolent use of radioactive material as Radiological Dispersal Device (RDD) by terrorists
- A large-scale nuclear disaster resulting from a nuclear weapon attack

Major nuclear accidents

Chernobyl, Ukraine (former Soviet Union), April 26, 1986

Chernobyl disaster is considered the world's worst nuclear disaster to date. It occurred on April 26, 1986, when a sudden surge in power during a reactor systems test resulted in an explosion and fire that destroyed Unit 4. Massive amounts of radiation escaped and spread across the western Soviet Union and Europe. Two workers died due to the explosion on the night of the accident, and a further 28 people died within a few weeks as a result of acute radiation syndrome. As a result of the disaster, approximately 220,000 people had to be relocated from their homes.

Fukushima Daiichi, Japan, March 11, 2011

Fukushima Daiichi nuclear accident was caused by a large tsunami along the Pacific coast triggered by the Tōhoku earthquake, one of the



Nuclear Fusion: In nuclear fusion, atoms combine to form a larger atom.

The Sun produces energy from nuclear fusion.

Nuclear Fission: In nuclear fission, the division of atoms takes place to form smaller atoms. Energy is released in both the cases. Nuclear power plants produce energy using nuclear fission.

largest earthquakes ever recorded. The earthquake and the ensuing tsunami resulted in the death of 19,729 people (with 2559 still missing) and devastated communities up and down the country. The Fukushima Daiichi Nuclear Power Plant suffered three core meltdowns due to failure of the emergency cooling system for lack of electricity supply. This resulted in the most serious nuclear accident since the Chernobyl disaster. The accident prompted a re-examination of nuclear safety and nuclear energy policy in many countries.



CHECK YOUR PROGRESS

Q. 1: What is nuclear energy?

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Q. 2: Write name of two major nuclear disasters.

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8.4 TOXIC WASTES

Toxic wastes are unwanted materials in all forms that can cause harm by being inhaled, swallowed, or absorbed through the skin. Toxic waste may be poisonous, radioactive, explosive, carcinogenic (causing cancer), mutagenic (causing damage to chromosomes), teratogenic (causing birth defects), or bioaccumulative that is, increasing in concentration at the higher ends of food chains. Waste containing dangerous pathogens, such as used syringes, is sometimes considered to be toxic waste. Poisoning occurs when toxic waste is ingested, inhaled, or absorbed by the skin.



CHECK YOUR PROGRESS

Q. 3: What are toxic wastes?

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Q. 4: What are the impacts of toxic wastes?

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8.5 TRANSPORT ACCIDENTS

A transport accident occurs during any type of transportation, including those occurring during road transport, rail transport, marine transport and air transport. It can refer to:

- a road traffic incident (including vehicle collision, pedestrian–bicycle collisions, pedestrian–pedestrian collisions etc.
- a marine accident (sailing ship accident, including man overboard)
- railroad accidents (including train wreck)
- an aviation accident and incident

Road traffic injuries are the leading cause of death globally and the principal cause of death in the age group of 15 to 49 years. Approximately 1.3 million people die in a year globally as a result of a road accident. Road accident is the 8th leading cause of death globally. up to 50 million people suffer serious, life-altering injuries from road accidents. Unfortunately, more than 90 percent of road traffic deaths occur in low- and middle-income countries, even within high-income countries, people from lower socioeconomic backgrounds are more likely to be involved in road traffic crashes. India, ranks at the top with highest number of fatalities with about 11% share in the world. Every year, approximately 1.5 lakh people dies on India roads, which translate, on an average, into 1130 accidents and 422 deaths every day or 47 accidents and 18 deaths every hour.

Risk factors of road accidents include:

1. Over Speeding
2. Drunken Driving
3. Distractions to Driver
4. Red Light Jumping
5. Avoiding Safety Gears like Seat belts and Helmets
6. Non-adherence to lane driving and overtaking in a wrong manner.

Strengthening the capability of the road traffic police to enforce traffic laws is fundamental to deterring road users from violating the laws, to reduce harm and to reduce inappropriate and unsafe behaviour on the roads.

Rail accident is another major transport accident. In India, more than half of major train accidents have been caused due to the negligence of railway staff. Other causes of rail accidents in India are failure of persons other than railway staff, failure of equipment and incidental (boulder fall, landslide and tree fall etc.).

A few deadliest rail accidents in India are mentioned below:

Bihar train disaster: On June 6, 1981, a passenger train carrying more than 800 passengers between Mansi and Saharsa, India derailed and plunged into the river Bagmati in Bihar while it was crossing a bridge. Estimates of total deaths range from 500 to 800 or more

Firozabad rail disaster: On 20 August 1995 near Firozabad, Uttar Pradesh on the Delhi-Kanpur section of India's Northern Railway, major rail disaster occurred when a passenger train collided with a train which had stopped after hitting a nilgai at 2.55 hrs killing 358 people.

Gaisal train disaster: Two trains carrying about 2,500 people collided at the remote station of Gaisal in West Bengal on August 2, 1999 at 1.30 AM. Owing to a signalling error, both trains were using the same track on a day when three of the four tracks on the line were closed for maintenance. Their combined speeds were so great that the trains exploded on impact, killing at least 290 people.

In 2004, Railway Minister Nitish Kumar launched a project for Anti-Collision Device (ACD), which was developed by the Konkan Railway and given the name "Raksha Kavach".

Anti Collision Device is a fully integrated Electronic Control System designed to minimize collisions and increase safety on Railway system.

Mr Rajaram Bojji, former MD of the Konkan Railway is regarded as the inventor of ACD Technology.

Air travel is one of the most popular methods of transportation in the world, particularly for passengers traveling long distances. While many people have a fear of flying, air travel is actually a safer means of

transportation than traveling by car. Unfortunately, while the odds of being involved in an aviation accident are extremely low, the injuries and number of fatalities resulting from such accidents tend to be far greater than other means of transportation.

Some of the common causes of aviation accidents are Pilot Error, Mechanical Error, Inclement Weather and Air Traffic Controller Error



CHECK YOUR PROGRESS

Q. 5: State whether true or false:

i. Road accident is the main transport accident

ii. Air travel is safe mode of transportation in case of accidents

iii. Anti Collision Device aims at reducing aviation accidents

8.6 INDUSTRIAL ACCIDENTS

When an industrial worker is injured or killed on the job, or an industrial company causes an accident that harms one or more people, the incident is typically referred to as an industrial accident. When one of these accidents harms a large group of people, it may be referred to as an industrial disaster.

Most industrial accidents are based on negligence, which means most of them are also largely preventable. By ensuring a safe work environment, adequate training and supervision, and proper maintenance of equipment, the risk of serious injury and death in an industrial accident drops dramatically.

Bhopal Gas Tragedy, December 3, 1984

The single worst industrial accident in history occurred on December 3, 1984, when some 45 tons of the dangerous gas methyl isocyanate escaped from the Union Carbide plant in Bhopal, Madhya Pradesh. The gas drifted over the densely populated neighborhoods around the plant, killing thousands of people immediately and creating a panic as tens of thousands of others attempted to flee Bhopal. The final death toll was

estimated to be between 15,000 and 20,000, while a half million survivors suffered respiratory problems, eye irritation or blindness.

Windscale Accident, October 8, 1957

On October 8, 1957, the Windscale reactor in United Kingdom experienced an uncontrolled burn of its graphite control blocks, causing adjacent uranium canisters to rupture. The ensuing fire burned for 16 hours and released significant amounts of radioactive iodine and polonium into the atmosphere.



CHECK YOUR PROGRESS

Q. 6: Name the gas responsible for Bhopal Gas Tragedy in 1984.

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Q. 7: Windscale accident is an example of chemical/ nuclear accident (Choose the correct option)

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8.7 FIRE ACCIDENTS

Fires are events in which something burns. Generally, they are destructive, killing people. More people die in fires than in cyclones, earthquakes, floods, and other natural catastrophes combined. Throughout cities, there are fires breaking out in homes, factories, warehouses, and other buildings. Fires are a significant threat to forests and wildlife because they spread rapidly and cause tremendous damage. Fire can transmit to a large area. Many people could succumb to burns and asphyxiation. This contamination may also harm plants, animals, and soil, affecting crops, water, and soil fertility.

Causes: Fires generally occur during the summer months. Fires can be caused by many factors, such as:

- Firecrackers or cigarettes are being thrown.
- Fires can occur due to unattended cooking, which is one of the major

causes of home fires.

- Fire can also be caused by LPG gas cylinder malfunction, electric short circuits, electric appliances that overheat, and appliances of lower quality.
- If people throw burning matchsticks or cigarette ends on the waste lying along roadsides or near homes, the waste may catch fire.
- Store and transport of explosive chemicals or inflammable substances without proper precautions.
- Human negligence or carelessness

Effects:

Death of humans and livestock may occur due to burning or severe injuries from the fire. A rural area often experiences fires that burn to ashes the entire harvest crop stored securely.

More than 11,000 fire incidents were reported nationwide in 2019, according to the Accidental Deaths and Suicides in India (ADSI) -2019 report. The much greater proportion of deaths relative to injuries is worrying. This greater mortality may be a sign that medical and emergency services have trouble handling such accidents, which could have helped to lower the death toll. Other factors, such as the severity and form of fire accidents, may also contribute to higher mortality.

Two major fire accidents in history

- Camp Fire in California began on 8th November, 2018 and caused 85 deaths and destroyed more than 18,000 structures.
- Gospers Mountain bushfire in 2019 became the largest single-ignition fire from lightning strike Australia has ever seen, reaching over 512,000 hectares with a perimeter of 1,503 kilometres.



CHECK YOUR PROGRESS

Q. 8: What are the causes of fire accidents at home?

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Q. 9: Proportion of deaths from fire relative to injuries is worrying. Why?

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8.7 OIL SPILLS

When oil accidentally spills into the ocean, it can cause big problems. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil.

Oil spills can be caused by:

- people making mistakes or being careless
- equipment breaking down
- natural disasters such as hurricanes, storm surge or high winds
- deliberate acts by terrorists, acts of war, vandals or illegal dumping.

Large oil spills are major, dangerous disasters. These tend to happen when pipelines break, big oil tanker ships sink, or drilling operations go wrong. Consequences to ecosystems and economies can be felt for decades following a large oil spill.

Oil on ocean surfaces is harmful to many forms of aquatic life because it prevents sufficient amounts of sunlight from penetrating the surface, and it also reduces the level of dissolved oxygen. Crude oil ruins the insulating and waterproofing properties of feathers and fur, and thus oil-coated birds and marine mammals may die from hypothermia. Moreover, ingested oil can be toxic to affected animals. Saltwater marshes and mangroves ecosystems frequently suffer from oil spills. Tourism and fishing are also affected by oil spills.

Two enormous oil-tanker spills were the Torrey Canyon disaster of Cornwall, England in 1967 (119,000 metric tons of crude oil were spilled) and the Amoco Cadiz disaster of Brittany, France in 1978 (223,000 metric tons of crude oil and ship fuel were spilled).





CHECK YOUR PROGRESS

Q.10: What are the causes of oil spills?

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8.9 LET US SUM UP

- A technological disaster is a sudden or intense event caused by a malfunction of a technological structure and/or some human error.
- Nuclear accident may result from nuclear reactor, transport of radioactive material and nuclear weapon attack.
- Oil spills have serious short term and long term negative impacts on economy and ecosystems.
- Toxic wastes may be poisonous, radioactive, explosive, carcinogenic, mutagenic, teratogenic, or bioaccumulative.
- Transport accidents include road traffic accident, marine accident, rail accident and aviation accidents.
- Industrial accidents, caused by human negligence and/or technical problem, may have serious negative impacts on human, society and environment.



- Fires break out in homes, factories, warehouses, other buildings, and in forests also.
- Oil spills have serious short term and long term negative impacts on economy and ecosystems, particularly marine ecosystems.

8.10 FURTHER READINGS

1) Goel, S.L., 2006, Encyclopedia of Disaster Management (3)

Management of Man-made Disasters, Deep & Deep Publications, New Delhi

2) Parasuraman, S. and P. V. Unnikrishnan (Ed.), 2000, India Disaster Reports, Oxford University Press, New Delhi

3) Majumdar, S. K., Natural and Technological Disasters: Causes, Effects and Preventive Measures, Pennsylvania Academy of Science.

8.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No.1: Nuclear energy is energy released from the nucleus of an atom by nuclear reaction.

Ans. to Q. No. 2: Two nuclear disasters in history are Chernobyl nuclear accident in Ukraine on April 26, 1986 and Fukushima Daiichi in Japan on 11th March, 2011.

Ans. to. Q. No. 3: Toxic wastes are unwanted materials in all forms that can cause harm by being inhaled, swallowed, or absorbed through the skin.

Ans. to. Q. No. 4: Toxic waste may be poisonous, radioactive, explosive, carcinogenic (causing cancer), mutagenic (causing damage to chromosomes), teratogenic (causing birth defects), or bioaccumulative (that is, increasing in concentration at the higher ends of food chains).

Ans. to Q. No. 5: i) True ii) True iii) False

Ans. to Q. No. 6: Methyl Isocyanate

Ans. to Q. No. 7: Nuclear accident

Ans. to Q. No. 8: Fires can occur due to unattended cooking, which is one of the major causes of home fires. Fire can also be caused by LPG gas cylinder malfunction, electric short circuits, electric appliances that overheat, and appliances of lower quality.



Ans. to Q. No. 9: Because medical and emergency services have trouble handling such accidents.

Ans. to Q. No. 10: Causes of oil spills are human mistakes or carelessness, equipment breaking down, natural disasters such as hurricanes, deliberate acts by terrorists, acts of war, vandals or illegal dumping.

8.12 MODEL QUESTIONS

Q.1: When nuclear accidents can happen?

Q.2: When did Chernobyl accident occur?

Q.3: How can toxic substances enter human body?

Q.4: What are the causes of road accidents?

Q.5: What are the common causes of aviation accidents?

Q.6: Write a short note on Bhopal gas tragedy.

Q.7: What are the characteristics of fire disasters?

Q.8: What are the impacts of oil spills?

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2) FEMA. 1997. *Multi Hazard Identification and Assessment*. Washington, D.C.: FEMA.
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