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ISBN 978-93-5338-045-8

DISASTER MANAGEMENT

DISASTER MANAGEMENT

M.Com 3rd Semester-Free Elective

Author: Uday Singh

ଦୂରନିରନ୍ତର ଶିକ୍ଷା ନିର୍ଦ୍ଦେଶାଳୟ, ଉତ୍କଳ ବିଶ୍ୱବିଦ୍ୟାଳୟ
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Name of the Study Material: Disaster Management

Author: Uday Singh, Industrial Safety and Certified Safety Professional (CSP)

ISBN : 978-93-5338-045-8

Year of Print: 2021

No. of Copies: 501

Printed and Published by:

VIKAS PUBLISHING HOUSE PVT LTD
E-28, Sector-8, Noida - 201301 (UP)
Phone: 0120-4078900 • Fax: 0120-4078999
Regd. Office: A-27, 2nd Floor, Mohan Co-operative Industrial Estate, New Delhi 1100 44
Website: www.vikaspublishing.com • Email: helpline@vikaspublishing.com

For:

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SYLLABI-BOOK MAPPING TABLE

Disaster Management

Syllabi	Mapping in Book
UNIT I Disaster and its type, Flood Draught, Cyclone, Geographical Disaster, Earthquake, Landslide, Avalanches, Volcanic Eruptions, Climatic Disaster-Heat and Cold Wave, Climate Change, Global Warming, Sea level Rise, Ozone Depletion.	**Unit-1:** Understanding Natural Disasters **(Pages 3-32)**
UNIT II Manmade Disaster- Nuclear Disaster, Chemical Disaster, Biological Disaster, building Fire, Coal Fire, Oil Fire, Air Pollution, Water Pollution, Industrial Pollution, Deforestation, Rail & Road Accidents, Air & Sea Accidents.	**Unit-2:** Man-Made Disasters and Pollution **(Pages 33-60)**
UNIT III Disaster Preparedness, Disaster Prevention, Preparation and Mitigation, Disaster Information, System, Megha Satellite, Role of Various Agencies in Disaster Mitigation- National level and State levels.	**Unit-3:** Disaster Relief Operations **(Pages 61-104)**
UNIT IV Disaster Response: Disaster Medicine, Rehabilitation, Reconstruction and Recovery.	**Unit-4:** Disaster Response **(Pages 105-133)**

CONTENTS

INTRODUCTION

NOTES

Irrespective of whether the causes are natural or man-made, disasters can occur at any point of time. Often, the official response to a disaster is through relief and rescue operations that follow the catastrophe. Nevertheless, if the preparation is adequate, there might be a reduction in the impact of a disaster. This reduction can take place if sound knowledge of precautionary measures is applied accompanied by proper usage of specific life-saving apparatus and procedure. These, when utilized in the event of a disaster, are able to control the overall damage to life and property.

The major problem with disasters is the unexpectedness and quickness with which they occur. Therefore, for reducing the impact of a disaster the relief measures also have to be equally swift. Disaster is defined as a sudden incident that is marked by large-scale destruction of life and/or property. Earthquakes, industrial accidents, oil-spills, forest-fires, comprise a few of the more frequent disasters that we have come across. Disasters do not limit themselves to particular areas of the world, although, some places are likely to be more vulnerable to certain types of disasters, e.g., the belt around the Pacific Rim is more prone to earthquakes, a few of the coastal areas have more occurrences of cyclones, and some areas are more prone to floods.

However, the more developed a country is, characteristically, they are prepared in a better way. This superior level of preparedness gives them better control over the loss. There are certain types of calamities, where, the losses through the actual happening are not essentially as high, but, the losses gain momentum when the concerned authorities are unable to deal with the state of affairs in an appropriate manner. Usually, substantial amount of confusion and chaos result from excessive loss and disorganization in the employment of resources, which are already scarce. Another reason for suffering losses at the time of certain types of disasters is the incapability to appropriately deal with and secure the utilities, like electricity, gas, and water supply. On one hand, every utility is very important and on the other, owing to leakages/ruptures, some of these utilities are likely to come in contact with each other. This should not happen as it causes further damage. Therefore, the chief motive while managing a disaster is to reduce the losses and also to make sure that the resources, which are already limited, are utilized efficiently.

Disaster management is the discipline that pertains to the preparation for disaster before it occurs, response to disaster and support and reconstruction of society after the occurrence of natural and man-made disasters. It is a continuous process for the protection of all communities, regions and nations from serious hazards. In the absence of planning, a natural event may turn into a human and economic disaster. The aim of disaster management is to procure the most useful data for decision-making in the most cost-effective and practical manner in the face of any kind of disaster facing humanity.

The book, *Disaster Management*, has been written in the self-instructional mode or the SIM format wherein each unit begins with an *introduction* to the topic, followed by an outline of the *Unit Objectives*. The detailed content is then presented in a simple and organized manner, interspersed with '*Check Your Progress*' questions to test the student's understanding of the topics covered. A *Summary* along with a list of *Key Terms* and a set of *Questions and Exercises* is provided at the end of each unit for effective recapitulation.

UNIT 1 UNDERSTANDING NATURAL DISASTERS

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Structure

1.0 INTRODUCTION

Disasters can arise from both natural and human causes. They cannot be predicted, and once they occur, they need to be dealt with in a mature, tactful and responsible manner. A lot of on-the-spot decisions need to be taken and relief activities need to be organized and coordinated. In this unit, you will learn about various disasters and their impact on the living beings and the environment.

1.1 UNIT OBJECTIVES

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

- Discuss the meaning of disasters and its various types
- Describe the causes and consequences of floods, draughts, and cyclones
- Discuss the different types of geographical disasters
- Explain heat and cold wave
- Discuss the impact of climate change such as global warming, rise in sea level and ozone depletion

1.2 DISASTER AND ITS TYPES

A disaster is a mishap or hazard which causes huge loss of life and property and disrupts the balance of the economy. It is a tragic event with drastic consequences for living beings as well as social and individual development. A disaster can be caused by either natural or man-made factors. Both these factors need to be taken care of to prevent a disaster or lessen its impact. Disasters also arise due to inefficient management of risks. If a safety net is devised to address the potential risks, it would lead to reduction in damages triggered by disasters. Developing countries are more vulnerable to disasters.

An environmental disaster is a mishap or hazardous event which directly influences the environment, bringing serious alterations in the same. These alterations become the root cause of

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failures or damages that would occur following a disaster. Since the environmental disasters have direct impact on the environment, they could stunt economic growth, lead to socio-economic failures, deteriorate environmental conditions or threaten life.

Apart from heavy immediate effects or damages, the environment also suffers from the long-term consequences of a disaster, which can prove to be costly. As these long-term effects alter the ecosystem, they can lead to more deaths over the next few years by giving rise to certain diseases and ailments. They may also hinder tree growth or stop cultivation in a particular area, almost instantly.

When a disaster strikes, the economy needs to divert all its resources towards the affected areas to try and save its elements from damage to the maximum extent possible. However, it takes high costs to recover the elements which been lost in or damaged by the disaster.

Given below are some of the disasters which had taken place across different countries.

Agricultural

- Salinity in Australia
- Salinization of the Fertile Crescent
- The Dust Bowl in Canada and the United States (1934–1939)
- The Great sparrow campaign: sparrows were eliminated from Chinese farms, which caused locusts to swarm the farms and contributed to a famine which killed 38 million people
- Africanized bees, known colloquially as 'killer bees'
- Mismanagement of the Aral Sea
- 'Dirty dairying' in New Zealand

Biodiversity

- Introduction of the Nile perch into Lake Victoria in Africa, decimating indigenous fish species
- The Saemangeum Seawall
- Emerald Ash Borer
- Environmental threats to the Great Barrier Reef
- 2006 Zakouma elephant slaughter
- Invasive species in New Zealand
- The loss of biodiversity of New Zealand

Human health

- Introduction of the Bubonic Plague (the Plague of Justinian) in Europe from Africa in the 7th century resulting in death of about 60 per cent (100 million) of the population.
- Introduction of the Bubonic Plague (the Black Death) in Europe from Central Asia in the 14th century resulting in the death of up to 60 per cent (200 million) of the population and recurring until the 18th century.
- Introduction of infectious diseases by Europeans causing death of indigenous people during European colonization of the America.
- Health effects arising from the September 11 attacks

Industrial

- Minamata disease—mercury poisoning in Japan (1950s and 1960s)
- Ontario Minamata disease in Canada
- Itai-itai disease, due to cadmium poisoning in Japan
- Love Canal toxic waste site
- Seveso disaster (1976), chemical plant explosion, caused highest known exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in residential populations
- Bhopal disaster (3 December 1984, India)
- Sandoz chemical spill into the Rhine river (1986)

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Air

- The Donora Smog of 1948 in Donora, Pennsylvania in the United States
- The Great Smog of 1952, which killed 4,000 Londoners
- The 1983 Melbourne dust storm
- The 1997 Southeast Asian haze
- The 2005 Malaysian haze
- Yokkaichi asthma in Japan

Land

- The Dust Bowl of Canada and the United States
- Contaminated soils in Mapua, New Zealand due to the operation of an agricultural chemicals factory
- Basin F, a disposal site in the United States for contaminated liquid wastes from the chemical manufacturing operations of the Army and its lessee Shell Chemical Company
- 2006 Côte d'Ivoire toxic waste dump

Water

- Sandoz chemical spill, severely polluting the Rhine in 1986
- Selenium poisoning of wildlife due to farm runoff used to create Kesterson National Wildlife Refuge, and the artificial wetland
- The Jiyeh Power Station oil spill in the Mediterranean region
- Coral bleaching
- The artificial Osborne Reef off the coast of Fort Lauderdale, Florida in the United States
- Dumping of conventional and chemical munitions in Beaufort's Dyke, a sea trench between Northern Ireland and Scotland
- Marine debris

Causes of Environmental Disasters

The common causes of environmental disasters are as follows—haphazard population growth, poor planning and environmental deterioration.

- **Haphazard population growth:** Population explosion is a disaster in itself. To enable the growing population lead a healthy and satisfied life, it is necessary to fulfil its essential needs such as food, housing, employment, educational and health facilities. However, governments, particularly in developing countries, find it difficult to fulfil these needs of all their citizens. The non-fulfilment of essential human needs makes developing countries more vulnerable to natural disasters.
- **Poor planning:** Planners and developers have not been able to plan effectively to take care of the essential needs of the growing population. It is for this reason that more and more people have been left unprotected and vulnerable to disasters.
- **Environmental deterioration:** Gradual deterioration of the environment and the tools that nature has provided us as protection against disasters has also emerged as a major cause of disasters. If natural remedies for and protections against disasters are removed, then man-made protections need to be provided.

The intensity of a disaster in an area is inversely proportional to the natural and man-made protection the area has, and thus it becomes necessary to ensure that such a protection remains intact.

1.2.1 Types of Disasters

Broadly, disasters have been categorized as natural and man-made disasters on the basis of their causes. The cause-based disaster classification facilitates altering or stopping altogether such activities that lead to a disaster. Taking such steps would help in reducing the impact of a disaster even if it strikes. The magnitude of a disaster also decides the kind of damage it would cause and the steps required to avoid or lessen the damage. Therefore, disasters are also classified on the basis of their magnitude. Disasters

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which cause large-scale loss are called major disasters while those which do not cause heavy devastation are called minor disasters.

Natural disasters

Natural disasters are those hazardous events which occur naturally. They are caused by sudden changes in the environment. Natural disasters include earthquakes, cyclones, volcanic eruptions, forest fires, tornadoes. They can cause heavy loss of life and damage to physical structures, leading to huge financial losses. The magnitude of these disasters may vary. Every area is susceptible to its own set of natural disasters and thus it is important to take preventive measures accordingly. For example, the areas where tectonic plates are too close would be susceptible to earthquakes, whereas areas near volcanic formations would be more likely to suffer from volcanic eruptions. Governments must make necessary arrangements to protect people from area-specific natural disasters. This would ensure minimum damage. One effective way to reduce the impact of disasters is to use latest technology. For example, infrastructure and buildings can be strengthened to withstand natural disasters by using new construction technology and materials. Natural disasters are also known as geographical disasters, which are discussed ahead in detail.

Natural disasters can be of various kinds, the most prominent of which, have been listed as follows:

- **Land-movement disasters:** These kinds of disasters can further be classified into the following:
  - o Avalanches
  - o Earthquakes
  - o Landslides and mudflows
  - o Volcanic eruptions
- **Water disasters:** The various water disasters are:
  - o Floods
  - o Limnic eruptions
  - o Tsunamis
- **Weather disasters:** The disasters caused by weather disturbances are:
  - o Blizzards
  - o Cyclonic storms
  - o Droughts
  - o Hailstorms
  - o Tornadoes
- **Natural fires (like forest fire)**
- **Health and diseases:** The hazards that can be caused due to health problems are as follows:
  - o Epidemic
  - o Famine

Man-made disasters

As is clear from their name, man-made disasters are caused by human intervention or activities. These may be dangerous to life, physical elements or economic components of the environment and the resultant damage could prove disastrous for the whole economy. Man-made disasters occur due to a variety of reasons. One reason is the hardened human attitudes and approaches to view things and situations in certain ways. These lead to man-made disasters such as big crimes, arson, civil disruption, war, and terrorism. Another type of man-made disasters includes those hazardous events which are caused by technological faults or breakdowns. These disasters include industrial fires, structural collapse, chemical or gaseous release and accidents involving transport means such as cars, planes, ships, trains or space shuttles. Better technology, sufficient precautions and careful working with technology are the only steps which can prevent or lessen the damage from technology-related disasters.

With the growing climatic changes and unstable landforms all over the world, human beings are

becoming more vulnerable to disasters and hazards. The drastic changes in the weather patterns have also led to a number of occurrences of the disasters. Technological advancements and the growing population density have also contributed to the world becoming increasingly unsafe.

Anthropogenic disasters

Anthropogenic disasters are threats that have an element of human intent, negligence or error or have witnessed failure of a man-made system. They are also known as man-made disasters since they are the result of a failing or error on the part of humans.

Anthropogenic disasters can be classified into the following categories:

- **Sociological hazards:** The disasters that are caused due to sociological factors are:
  - o Crime
  - o Arson
  - o Civil disorder
  - o Terrorism
  - o War
- **Technological hazards:** Technological advancements can lead to the following disasters:
  - o Industrial hazards
  - o Structural collapse
  - o Power outage
  - o Fire
- **Hazardous materials:** The chemical substances that can cause disasters are as follows:
  - o Radiation contamination
  - o CBRNs

Check Your Progress

1. Define disaster.
2. What is an environmental disaster?
3. Mention the two types of disasters.
4. What is meant by anthropogenic disasters?

1.3 FLOODS

Floods are caused by too much rain or water in a location, when the excess water surpasses the limits of its confines. Generally, occurrences of floods are more frequent in low-lying lands. Some plains may periodically flood; known as a flood plain. Ancient Egypt relied on these floods for agriculture. Floods present a significant danger with enough force to sweep away massive objects such as houses, cars and trees.

Many reasons could lead to a flood, including prolonged rainfall from a storm, thunderstorms, rapid melting of snow, overflowing rivers from excess rain, bursting of man-made dams or levees. Monsoon rainfalls can also cause floods, such as in Bangladesh due to extended periods of rainfall. There is a growing feeling that the incidence and intensity of floods has grown alarmingly over the years. A major cause is the increased encroachment of flood plains because of development and population pressure. The damage caused by floods can at best be minimized and not altogether eliminated or in other words, there can really be no such thing as 'fool proof protection' or 'absolute flood control' for all magnitudes of floods. The concept of flood management, therefore, aims for such planned measures which ensure profitable and economic utilization of the flood plains for the benefit of mankind and at the same time emphasizing that during high floods, there is no severe damage as far as possible. An essential part of a disaster preparedness plan is education for those who may be threatened by disaster.

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Types of Floods

1. **Flash floods:** If extremely heavy rainfall occurs for some time and the ground loses its absorbing capacity then this type of flood generally takes place. These types of floods last for a short duration with a relatively high peak discharge.
2. **River floods:** If due to heavy rain the water level of river flows much above the danger mark, this type of flood occurs.
3. **Storm surge:** Low-pressure storm associated with strong wind causes the sea level to rise suddenly. If strong winds are directed towards the shore, they drive the seawater onto the land. The storm that produces the surge can also give rise to heavy rainfall, resulting in coastal areas being subjected simultaneously to flooding due to incessant rains and seawater.

Factors that cause floods

Some of the factors responsible for causing floods are listed below:

- Rivers in spate due to heavy and continuous rain for a long period such as few days or weeks
- Flowing of water much above its danger level due to inadequate capacity within the banks of the river to contain high flows
- Breaching of embankments
- Breaching of water reservoir
- Storm surges
- Snowmelt
- River bank erosion and silting of riverbeds
- Landslides leading to obstruction of flow and change in the river course
- Poor natural drainage
- Flow retardation due to tidal and backwater effects
- Deforestation
- Cyclone
- The resistance to the flow of water due to various reasons

Among all the natural disasters affecting India, frequent river floods are the most devastating, which cause maximum damages of life and property. Total flood prone areas in India are 40 million hectares, out of which 9.4 per cent falls in Assam. Besides draught, about 90 per cent damages to crops are only due to flood.

Check Your Progress

5. What are the three types of floods?
6. List some of the factors that cause floods.

1.4 DRAUGHTS

A drought is an extended period of months or years when a region notes a deficiency in its water supply. Although droughts can persist for several years, even a short, intense drought can cause significant damage and harm the local economy.

Causes

Generally, droughts occur when a region receives consistently below-average precipitation. It can have a substantial impact on the ecosystem and agriculture of the affected region. This global phenomenon has a widespread impact on agriculture. Generally, rainfall is related to the amount of water vapour in the atmosphere, combined with the upward forcing of the air mass containing that water vapour. If either of these are reduced, the result is a drought. This can be triggered by an above average prevalence of high pressure systems, winds carrying continental, rather than oceanic air masses (ie. reduced water content), and ridges of high pressure areas form with behaviours which prevent or restrict the developing of

thunderstorm activity or rainfall over one certain region. Oceanic and atmospheric weather cycles such as the El Niño-Southern Oscillation (ENSO) make drought a regular recurring feature of the Americas along the Pacific Coast and Australia.

Human activity can directly trigger exacerbating factors of droughts such as over-farming, excessive irrigation, deforestation, and erosion adversely impacting the ability of the land to capture and hold water. While these tend to be relatively isolated in their scope, activities resulting in global climate change are expected to trigger droughts with substantial impact on agriculture throughout the world, especially in developing nations. Overall, global warming will result in increased world rainfall. Along with drought in some areas, flooding and erosion will increase in others. Paradoxically, some proposed solutions to global warming that focus on more active techniques, solar radiation management through the use of a space sunshade for one, may also carry with them increased chances of drought.

Dry Earth as a result of drought (Source: Wikipedia)

Consequences

Periods of drought can have significant environmental, agricultural, health-related economic and social consequences. The effect varies according to vulnerability. For example, subsistence farmers are more likely to migrate during drought because they do not have alternative food sources. Areas with population that depend on subsistence farming as a major food source are more vulnerable to drought-triggered famine. Drought is rarely, if ever, the sole cause of famine; socio-political factors such as extreme widespread poverty play a major role. Drought can also reduce water quality, because lower water flows reduce dilution of pollutants and increase contamination of remaining water sources. A few common consequences of drought include:

- Diminished crop growth or yield productions and carrying capacity for livestock
- Dust bowls, themselves a sign of erosion, further erode the landscape
- Dust storms occur when drought hits an area suffering from desertification and erosion
- Famine due to lack of water for irrigation
- Habitat damage, affecting both terrestrial and aquatic wildlife
- Malnutrition, dehydration and related diseases
- Mass migration, resulting in internal displacement and international refugees
- Reduced electricity production due to insufficient available coolant for power stations and reduced water flow through hydroelectric dams
- Shortages of water for industrial users
- Social unrest
- War over natural resources, including water and food
- Wildfires, such as Australian bushfires, are more common during times of drought

1.5 CYCLONES

A tropical cyclone is a storm system characterized by a large low-pressure centre and numerous thunderstorms that produce strong winds and heavy rain. Tropical cyclones feed on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air. The term 'tropical'

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refers to both the geographic origin of these systems, which form almost exclusively in tropical regions of the globe, and their formation in maritime tropical air masses. The term 'cyclone' refers to such storms' which are cyclonic in nature, with counterclockwise rotation in the Northern Hemisphere and clockwise rotation in the Southern Hemisphere. Depending on its location and strength, a tropical cyclone is referred to by names such as hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, and simply cyclone. In the Atlantic and northern Pacific, the storms are called 'hurricanes,' after the Caribbean god of evil, named Hurrican. In the northwestern Pacific, the same powerful storms are called 'typhoons.' In the southeastern Indian Ocean and southwestern Pacific, they are called 'severe tropical cyclones'. In the northern Indian Ocean, they're called 'severe cyclonic storms.' In the southwestern Indian Ocean, they're just 'tropical cyclones.'

Hurricane Isabel (2003) seen from the International Space Station (Source: Wikipedia)

Why do cyclones occur?

- When warm air rises from the earth and condenses to form clouds, a great amount of heat is released. The combination of this heat and moisture often leads to thunderstorms, from which a tropical storm can develop.
- The trigger for most Atlantic hurricanes is an easterly wave, a band of low pressure moving westwards, which may have begun as an African thunderstorm.
- Typhoons in the Far East and Cyclones in the Indian Ocean often develop from a thunderstorm in the equatorial trough. During the hurricane season, the Coriolis Effect of the Earth's rotation leads to the winds in the thunderstorm spinning in a circular motion.

Effects

While tropical cyclones can produce extremely powerful winds and torrential rain, they are also able to produce high waves and damaging storm surge as well as spawning tornadoes. They develop over large bodies of warm water, and lose their strength if they move over land. This is why coastal regions can receive significant damage from a tropical cyclone, while inland regions are relatively safe. Heavy rains, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 40 kilometres from the coastline. Although their effects on human population can be devastating, tropical cyclones can also relieve drought conditions. They also carry heat and energy away from the tropics and transport it toward temperate latitudes, which make them an important part of the global atmospheric circulation mechanism. As a result, tropical cyclones help to maintain equilibrium in the Earth's troposphere, and a relatively stable and warm temperature worldwide.

Tropical cyclones out at sea cause large waves, heavy rain, and high winds, disrupting international shipping and, at times, causing shipwrecks. Tropical cyclones stir up water, leaving the air cooler behind them, which causes the region to be less favourable for subsequent tropical cyclones. On land, strong winds can damage or destroy vehicles, buildings, bridges, and other outside objects, turning loose debris into deadly flying objects. The storm surge, or the increase in sea level due to the cyclone, is

typically the worst effect from tropical cyclones, historically resulting in 90 per cent of tropical cyclone deaths. The broad rotation of a tropical cyclone, and vertical wind shear at its periphery, spawns tornadoes.

Over the past two centuries, tropical cyclones have been responsible for the deaths of about 1.9 million people worldwide. Large areas of standing water caused by flooding lead to infection, as well as contributing to mosquito-borne illnesses. Crowded evacuees in shelters increase the risk of disease. Tropical cyclones significantly interrupt infrastructure, leading to power outages, bridge destruction, and the hampering of reconstruction efforts.

Check Your Progress

7. Define drought.
8. What is a cyclone?

1.6 NATURAL/GEOGRAPHICAL DISASTERS

Natural/geographical disasters have already been discussed in the earlier section. In this section, we will discuss the different types of geographical disasters.

1.6.1 Earthquakes

Earthquakes are caused by a sudden shift or movement deep underground in the Earth's tectonic plates, causing the Earth's crust to shake violently, with vibrations varying in magnitude. On the surface, we see this as the shaking of the ground, causing damage to poorly built structures. Earthquakes occur unpredictably along fault lines and are capable of killing thousands of people. The most powerful earthquakes can destroy even the best built structures. Earthquakes can also cause other disasters including tsunamis and volcanic eruptions. Seismometers can detect the strength of an earthquake. In the past, seismologists used to estimate earthquake intensity using the Richter scale devised by Charles Richter. However, today, the moment magnitude scale, which is an improved version of the Richter scale, is used by seismologists to measure the size of earthquakes in terms of the energy released.

Picture taken in the aftermath of the 1964 Alaska Earthquake, the second most powerful earthquake in recorded history (Source: Wikipedia)

An earthquake has point of origin underground called 'focus'. The point directly above the focus on the surface is called the 'epicentre'. Earthquakes by themselves rarely kill people or wildlife. It is usually the secondary events that they trigger, such as building collapse, fires, tsunami (seismic sea waves) and volcano. Many of the disasters related to an earthquake are actually human disasters and

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could be avoided by better construction, safety systems, early warning and evacuation planning, the term unnatural disaster is not unwarranted.

Some of the most recent and disastrous earthquakes in recent times are:

- The 2011 Japanese Earthquake, registering a magnitude of 9.0, triggered a massive tsunami. Over 15,000 people were killed in the disaster.
- The 2010 Haiti Earthquake, registering a magnitude of 7.0, killed an estimated 100,000-150,000 people.
- The 2004 Indian Ocean earthquake, the third largest earthquake in recorded history, registered a moment magnitude of 9.3. The huge tsunami triggered by the earthquake cost the lives of at least 229,000 people in 14 countries.
- The 2001 Gujarat Earthquake, measuring 7.7 on the moment magnitude scale, killed at least 20,000 people.

1.6.2 Landslides

Landslides are an extremely frequent geological event. They occur when masses of rock, earth, or debris move down a slope, caused by disturbances in the natural stability of a slope. They are defined as downslide of soil and rock, which happen due to natural phenomena or man-made actions. There are various kinds of movements like falls, slides, topples, lateral spreads, and flows. Landslides generally occur in hilly terrains. In India, they usually occur in the Himalayan region as the Himalayas are geologically young and susceptible to earthquakes and intensive soil erosion. Landslides also occur in the Western Ghats, Eastern Ghats and the Nilgiri hills with lesser frequency and intensity. Over the years, due to increasing human activity, the incidences of landslides have shown a disturbing upward trend of occurrence with higher damage to life and property.

Landslides take place when there are disturbances in the natural stability of a slope. They can accompany heavy rains or follow droughts, earthquakes, or volcanic eruptions. Mudslides develop when water rapidly accumulates in the ground and results in a surge of water-saturated rock, earth, and debris. Mudslides usually start on steep slopes and can be activated by natural disasters. Areas where wildfires or human modification of the land have destroyed vegetation on slopes are particularly vulnerable to landslides during and after heavy rains.

Landslides are often secondary effects of heavy storms, volcanic eruptions and earthquakes. They cause high mortality, killing many thousands by burying villages and hillside houses, by sweeping vehicles off the road into ravines. Death mostly results from trauma and suffocation by entrapment under debris. Significant damage to property is also caused like a breakdown in the water systems, constructions, and lines of communication, and damaged crops.

Factors that cause landslides are often man-made, like intense deforestation, soil erosion, construction of human settlement in landslide prone areas, roads or communication lines in mountain areas, buried pipelines, among others.

Apart from landslides there are also:

- **Mudslides:** Debris flows, also known as mudslides, are a common type of fast-moving landslide that tends to flow in channels.
- **Lahars:** A lahar is a volcanic mudflow or landslide. The 1953 Tangiwai disaster was caused by a lahar, as was the 1985 Armero tragedy, in which the town of Armero was buried and an estimated 23,000 people were killed.

1.6.3 Avalanches

Avalanche can be defined as a swift flow of snow down a slope, which may have been triggered naturally or due to human activity. An avalanche typically happens in mountainous regions, and also brings down air and water along with snow. A strong enough avalanche can drag down with itself ice, and large objects like rocks, trees, and other material down the slope. While rock slides, mudslides, serac collapses and rock avalanches are all caused by icefalls, an avalanche is different from them because it is primarily composed of flowing snow. In the mountains, avalanches are one of the commonest threats faced by life and property, mainly because they are rapid and have enough power to carry down other objects with them.

Usually, avalanches are categorized according to their size and other shape-related characteristics and rated according to the destruction they are capable of causing. Some traits of an avalanche used to categorize it include nature of the failure, sliding surface, type of snow involved, propagation mechanism of the failure, reason for trigger of avalanche, direction, slope elevation and slope angle. Avalanche size, mass, and destructive potential are rated on logarithmic magnitude scales, which usually consist of 4 to 7 categories, which vary with the system of observation being used and/or the region in which forecast is being done.

Classification and Terminology

There are some elements that are common to all avalanches, such as a trigger, a starting point of origin, the path along which the avalanche goes, a point where the avalanche stops and the debris that an avalanche collects along its way down, along with the mass of snow. Other things common to all avalanches are the failure layer along which the avalanche moves and the bed surface which lies at the original starting point of the avalanche. In most avalanches, the two things — failure layer and bed surface— are the same. Besides these, a slab avalanche also has a crown fracture at the top of the starting point, flank fractures on the sides of the start zones, and a shallow staunch fracture at the bottom of the start zone. Crown and flank fractures can be defined as vertical walls in the snow which distinguish the snow falling down the slope from snow remaining on the slope.

The avalanche is morphologically classified by studying the nature of the failure of the snowpack. For instance, a slab avalanche is triggered when some kind of surplus load leads to a failure of a slab lying over a weak layer of snow; the failure occurs when a fracture is formed in the slab. Similarly, loose snow, point release, and isothermal avalanches get triggered when some type of stress generates a shear failure in a weak interface, which may be at the base or within the snow pack. In case of failure at the base, it is known as a full depth avalanche. When snow is lifted by the wind and funnels into a steep drainage from the top zone of the drainage, a spin drift avalanche is triggered.

On steep terrains, loose snow avalanches are the most common because freshly fallen snow has low density and disintegrates easily. In this kind of avalanche, the avalanche starts small, from a point and then gains in size as it progresses down the slope, eventually taking on a teardrop shape, which is a complete contrast to the slab avalanche.

Slab avalanches are the most powerful and therefore most destructive—they cause nearly 90 per cent of deaths caused by avalanches. These avalanches take place when a slab of snow forms as falling snow is deposited on a lee slope by the wind or when a large amount of loose snow moves. The moment a failure occurs in a weak layer, the fracture extends very rapidly over a very large area, such that a snow slab, hundreds of meters in length and equally thick, begins to move almost immediately.

The wet snow avalanche or isothermal avalanche is triggered when a snowpack is saturated by water. Such avalanches also spread forward after they originate from a single point. If the water content is high, the avalanche is categorized as a slush flow and can move down largely shallow slopes. As far as the power and speed of an avalanche is concerned, a powder snow avalanche is known to travel with a speed upwards of 300 km/h, and be of 10,000,000 tonnes of volume. They are so powerful that they can travel over largely flat surfaces or even uphill. This kind of avalanche is formed of a powder cloud that is a result of an avalanche accelerating over a sudden change in slope, for example, a cliff band, leading the snow to mix with air. This chaotic suspension of snow powder turns into a gravity current.

Terrain

Terrain plays an important role in the formation and trigger of an avalanche in three ways—first, the evolution of the snowpack is determined by the meteorological surroundings of the snow pack, which are affected by the terrain. Second, the stability of the snowpack is determined by the ground composition and geometry of the slope, again functions of the terrain. Third, the down slope angle and direction of the terrain determine the route and impact of an avalanche.

An avalanche can happen on a slope only if the slope is capable both of retaining snow and also at an angle which allows snow to accelerate once it is triggered. Besides this, it also depends on the quality of the snow—whether it is ductile and has optimum shear strength, which in turn depends on the moisture content and temperature of the snow. If the snow is dry and very cold, with low shear strength and ductility, it will remain bonded only to slopes only with a lower angle slopes; and on the other hand, wet and warm snow, that has high shear strength and ductility will bound to very steep slopes. It is seen

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in coastal mountains, for instance, the Cordillera del Paine region of Patagonia, that deep snowpacks remain collected on vertical, and overhanging, rock faces.

Snow which is saturated with moisture so much that it becomes slush will flow better on shallow angled terrain; and a dense snow pack will not flow down really steep slopes, for instance, the snowpack in the Chugach Mountains of Alaska.

Snow packs that exist on slopes that are regularly exposed to the sun are also affected by the sunshine. During the day, the snow melts to a certain extent and then refreezes during nighttime. This daily cycle stabilizes the snow pack. Very strong sunshine and very cold nights lead to formation of surface crusts during the night and unstable isothermal snow during daytime. Slopes that are protected from the wind collect more snow, wind slabs and cornices which are likely triggers of avalanches when disturbed. On the other hand, a slope exposed to strong winds will not have collected snow.

The point where the avalanche originates needs to be steep enough to allow it to gain speed. Moreover, concave slopes are comparatively more stable than convex slopes, due to the difference between the tensile and compressive strength of snow layers. The nature of ground surface (composition and structure) that lies underneath the snow pack affects the stability of the snow pack, and may either provide it strength or make it weak. Big trees that have strong roots can stabilize a snow pack; and big, heavy rocks and sparse vegetation leads to weak areas deep inside the snow pack, owing to strong temperature gradients. Full depth avalanches are those which clean out a slope of snow almost entirely. They are mostly seen on slopes that have a smooth surface, like rock slabs or grass.

An avalanche usually follows the drainage path that already exists on a slope, which is very similar to a summertime watershed. The drainage routes are usually demarcated by natural vegetation boundaries in places where previous avalanches have led to low vegetation growth. Deliberately created drainage routes, such as the avalanche dam on Mount Stephen in Kicking Horse Pass, are meant to protect people and property, by naturally redirecting avalanches, which are common in the area. Large debris deposits that result from avalanches tend to rest in depressions in the ground, such as river beds and gullies.

There is less likely to be an avalanche if the slope is less than 25 degrees or steeper than 60 degrees, or if the slope is regularly exposed to sunlight or strong winds. Avalanches caused by human activity are most likely when the snow lies at an angle between 35 and 45 degrees. It has been observed that the critical angle, where human-triggered avalanches are most common, is 38 degrees. When human activity is only restricted to recreational ones, the danger is higher on steeper slopes. Usually it has been observed that if a slope is steep enough to ski and flat enough to hold snow, can potentially cause an avalanche, irrespective of its angle.

Weather

Avalanches take place only in a standing snow pack. It is normal in winters at high altitudes or snow to accumulate into a snow pack. The formation of a snow pack is an occurrence that is orchestrated by many meteorological conditions coming together with very narrow margin of error. The critical conditions include heating by the sun, radiational cooling, vertical temperature gradients in standing snow, snowfall amounts and snow types. Surprisingly, mild winters lead to formation of snow packs and very cold, extremely windy conditions lead to weakening of snowpacks.

When the temperature is close to 0 degrees, the freezing point for water, or even when the sun is mild, the free-thaw cycle is gentler than it is in harsher weather. During the free-thaw cycle, the snow pack is strengthened during the freezing stage and weakens when the thaw stage comes on. In such conditions, when there is a sudden elevation in temperature where it goes much higher than 0 degrees, an avalanche may be triggered due to a thaw. This happens in the spring season when temperatures rise.

If temperatures are consistently very low for a sustained period, it may lead to either stabilizing or destabilizing of a snow pack. When the base temperature of a snow pack is close to freezing, cold winds hitting the snow surface lead to a temperature gradient. However, if the snow pack is lying on top of a glacier, the temperature at its base will be much less than freezing point.

If the temperature gradient inside the snow pack is more than 10°C change per vertical meter for more than a day, a depth hoar would be generated in the snow pack, because moisture will move from the bottom to the top of the temperature gradient. The depth hoar causes a fundamental weakness in the

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snow pack and leads to grains being formed. If a slab lying on this weak portion is destabilized, an avalanche will be triggered.

Any reasonably strong wind will lead to quickly accumulation of snow on slopes that are downwind and sheltered. At the same time, a favorable angle of wind pressure leads to stabilization of slopes. A brittle and unstable structure which is not strongly bound to the surface it rests on is known as a wind slab. A strong wind can move this structure and lead to an avalanche in two ways—top-loading or cross-loading. Top-loading is said to happen when snow is deposited on a slope perpendicular to the fall-line and cross-loading is said to happen when snow is deposited parallel to the fall line.

The occurrence of avalanches is most likely during or just after snowstorms and rainstorms. Fresh snowfall destabilizes existing snow pack, due to the weight as well as because new snow has not had any time to bond itself to existing snow layers. Similarly, rain also causes instability in the snow pack by weighing down on the snow and reducing the friction that holds the various layers of snow together, thus triggering an avalanche.

Triggers

Avalanches are never random events. They always occur due to an external stress trigger on the snowpack. A few common natural triggers are heavy rain or snow, sudden rise in temperatures, and sudden impacts due to rock falls or ice falls. A more slow-moving cause is the cracks and fractures that develop over time despite constant temperatures and pressures. These cracks develop due to the gradual downward creep of the snow pack. Some human triggers are skiing, engineered explosions and snowmobiles. The stress trigger of an avalanche may be localized or remote. Common localized trigger are rocks that become warm due to sunlight. A remote trigger is when there is some transfer of stress from the slab to the origin and this initiates a fracture which propagates rapidly and triggers an avalanche. The triggering of an avalanche is always critical phenomena.

Prevention

Avalanches may be prevented to a certain extent. Over time, humans have come up with ways to mitigate the destructive power and incidence of avalanches. There are largely two kinds of techniques used:

1. Active techniques: Under this method, small artificial avalanches are triggered which are obviously less harmful than big avalanches. This is done by disturbing the snow deliberately using explosives like bombs or shelling or even howitzer rifles.
2. Passive techniques: Under this method, basically, snow is either slowed down, stopped or diverted or prevented from moving in large masses that could cause damage. One of the ways to block snow is to build a cemented structure blocking it.

   Some classifications of avalanche control structures are:

   - Snow retention structures like snow racks, avalanche snow bridges and snow nets. These are all used in the upper path of likely avalanche routes.
   - Avalanche barriers: The key to an avalanche barrier is a strong steel wire mesh, which is extended across the slope. The support provided by the mesh helps prevent creeping within the snowpack. The avalanche is thus stopped at the starting point itself and minor snow shifts remain harmless. The stress caused by the snow pressure is absorbed into the snow nets and taken away over the swivel posts and anchor ropes into anchor points.
   - Snow redistribution structures (wind baffles, snow fences)
   - Snow deflection structures: These are used to restrict and redirect the moving snow within the avalanche path. The redirecting should be gradual and not sharp because if it is sharp they might be overpowered by the avalanche.
   - Snow retardation structures like snow breakers are usually used in small slope portions of the avalanche path, to promote its slowdown naturally
   - Snow catchment structures
   - Direct protection of important objects and structures, such as using snow sheds (avalanche sheds)

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- Avalanche dams, ditches, earth mounds, terraces, etc. may also help in redirecting, slowing down, and engineered collection of snow. Other passive methods are:
  - o Reforestation on the natural tree line because forests are the best means of retaining, redistributing, retarding and storing snow
  - o Snow compaction is done mostly in ski resorts using mechanical equipment like snow groomers

Search and rescue equipment

People who have to go to avalanche-prone areas use certain equipment that would help rescue them in case of an avalanche. This equipment includes:

- **Avalanche cords:** These are the oldest and simplest equipment used in areas with heavy snow. They were used before beacons came into normal use. A 10-meter long red avalanche cord is attached to the belt of the skier and drags along behind the person. If the person gets caught in an avalanche, they can be traced using the red, easily visible cord. The cord is marked at every meter so that the rescue personnel know the distance to the victim. However, this is not an adequate or foolproof safety technique and no record is there of any live recoveries made using this equipment.
- **Beacons:** These emit beeps that can be traced using radio signals. They are held by every member of a party and can be used to trace a buried victim up to 80 meters away. Individuals using beacons need to be trained in their use before using them in real-life situations. The newer models also help to track a victim by indicating direction and distance from victim.
- **Probes:** These can be used to penetrate the snow up to several meters to locate buried victims. They are portable and collapsible. In case multiple individuals are buried, probes are used to decide who would be rescued first because victims in shallow snow have a better chance of survival. Probes alone may not be a very quick technique of reaching the buried victims, but if used in conjunction with beacons, they can prove to be very effective.
- **Shovels:** After an avalanche comes to rest, it becomes a hard mass of compressed snow and shovels need to be used to dig victims out. Shovels can also be used to detect hidden dangers packed in dense snow and for digging snow pits.
- **Witnesses as rescuers:** Witnesses of an avalanche should remain aware and alert and inform authorities in case they know of someone who has been buried, especially witnesses from the same party as the victim/s. A quick rescue in case of an avalanche is essential because the human body cannot stay warm enough for survival for very long when buried in snow. Sometimes just a couple of minutes can be the deciding factor between life and death for a buried victim. This is why, people who are travelling to a snow-bound mountainous area should be trained in basic life skills as preparation.

Victims who are buried in shallow snow or partially buried can be located through just visual scanning and should be provided with immediate first aid as soon as they are pulled out. Some common first aid required by avalanche victims is related to breathing, circulation/pulse, arterial bleeding, spinal injuries, fractures, shock, hypothermia, internal injuries, etc.

Safety in avalanche terrain

- **Terrain management:** This entails minimizing the risk factor faced by an individual while traveling in avalanche terrain by travelling only on selected slopes. Some key things to be kept in mind are—slopes should not be undercut because this removes the support of the snowpack, staying away from convex rolls because here the snowpack is under considerable stress, steering clear of sharp, exposed rocks and terrain traps like gulleys, cliff edges and heavy timber forests.
- **Group management:** This technique aims to mitigate risks related to a whole party getting buried in an avalanche. Basically, the members of a group/party are spread out over the slope rather than moving in close bunches. For instance, if there is a precarious stretch to be traversed, members do it only one by one—only after has one member reached safety does the next member start moving.
- **Route selection**: This involves mapping out the route with least risk factor of an avalanche. The camping sites are also marked out after careful consideration. There should be contingency

plans and escape routes planned in case of an emergency. Party members should never travel singly and always take someone along even for short explorations. And finally, there should be clear communication among all party members and there should be transparency among the leaders and the rest of the members.

- **Risk factor awareness:** Before traveling to a particular area, gather basic knowledge about the area including its meteorological history, existing weather and snow conditions and the social and physical indicators of the group.
- **Leadership:** The leader of the party should be a certified trainer, well-experienced in the safety measures, risk assessment, first aid techniques specific to snow victims, and decision making protocols. Such training is offered by resource centers in Nort America and Europe. The leader should also have a calm temperament and a quick thinking ability. These are the qualities of a person and cannot be taught. A calm leader inspires confidence and can keep his wits about him in a crisis situation rather than breaking down under pressure and taking inappropriate decisions.

Avalanches in the Indian context

In India, Snow and Avalanche Study Establishment (SASE) has the responsibility of handling various aspects of avalanches and their hazards. The Border Roads Organization (BRO) also plays a major role enabled by its large network of roads in the high altitude snow-bound areas of Leh in Jammu and Kashmir, Sikkim, Arunachal Pradesh, Himachal Pradesh, and Uttarakhand, in the task of snow-avalanche clearance. One of the main tasks of BRO is keep communication lines open in snow-bound regions using measures like sophisticated snow cutting equipment/snow cutters/snow sweepers, conventional dozers, experienced workforce and total station survey instruments.

Every year, snow is cleared out across a 50 km stretch on the Zojilla-Pass on the Srinagar-Leh road. In fact this is the part of the road that is not open to traffic in the winter months and upto May every year. Snow is also cleared from a 100 km stretch on the Manali-Leh road across the Rohtang Pass and Baralachla Pass. There are many avalanche-prone zones in this area and need to be treated with extreme caution. Besides clearing the roads, the BRO marks and monitors the avalanche zones and updates the SASE whenever a fresh avalanche takes place. The SASE in turn keeps record of the avalanche zones and accordingly forecasts avalanches. The government of the area and the Central governments collaborate with the BRO to implement clearance and control strategies for handling the avalanches that take place.

1.6.4 Volcanic Eruptions

An opening in the surface of the earth that allows lava, volcanic ash and gases to escape from its magma chamber below the surface is called a volcano. The sudden occurrence of a violent discharge of steam and volcanic material from a volcano is a volcanic eruption. There are essentially three meta types of volcanic eruptions. The most common are magmatic eruptions, which involve the decompression of gas within magma that propels it forward. Another type of volcanic eruptions are known as phreatomagmatic eruptions. These are driven by the compression of gas within magma, direct opposite of the process powering magmatic activity. The third type of volcanic eruption is known as phreatic eruption. It occurs as a result of the superheating of steam via contact with magma. Phreatic eruptions often exhibit no magmatic release, instead causing the granulation of existing rocks.

There are two types of volcanic eruptions in terms of activity—explosive eruptions and effusive eruptions. Explosive eruptions are characterized by gas-driven explosions that propel magma and tephra. Effusive eruptions, meanwhile, are characterized by outpouring of lava without significant explosive eruption. The most dangerous eruptions are explosive eruptions; in the history of the earth some explosive eruptions are thought to have caused climate changing events such as the Lake Toba eruption in Indonesia that occurred 69,000 years ago.

Hazards

Volcanic eruptions are extremely dangerous. Hazards during volcanic eruptions include emission of volcanic gases like carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. When sulfur dioxide gases react with water droplets in the atmosphere, it creates acid rain that corrodes vegetation. Carbon dioxide concentrations are poisonous to people and animals alike. Fluorine is a toxic gas that is absorbed onto volcanic ash which falls to the ground during eruptions. These ashes can poison livestock as well as water supplies. Along with volcanic gases, lava flows are another hazard of

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volcanic eruptions. Lava flows are molten rocks that ooze onto the earth's surface. They are hot enough to burn everything in its path.

Pyroclastic flows, or high-speed avalanches of hot ash, rock fragments, and gas, are other hazards of volcanic eruptions. Pyroclastic flows are extremely fast moving and have temperatures that exceed 1000°C. They can cause apocalyptic devastation during explosive eruptions. For example, the eruption of Mount St. Helens on May 18, 1980, caused a huge pyroclastic surge which completely devastated an area of 230 square miles. Other dangers during volcanic eruptions are earthquakes, landslides and mudslides. When Pyroclastic flows mix with water, they can cause mudflows, also known as lahars.

Some of the most significant volcanic eruptions of recent times include:

- On May 18th, 1980, Mount St. Helens erupted in the United States causing 57 deaths and over a billion dollars in damage.
- On November 13th, 1985, an eruption on Nevado del Ruiz produced an enormous lahar that buried and destroyed the town of Armero in Tolima, killing around 25,000 people.
- On 10th April 1815, Mount Tambora on the island of Sumbawa in Indonesia erupted. The eruption was the largest in the recorded history of man. An estimated 90,000 people were killed as a direct result of the explosion or due to the aftermath. The eruption caused global anomalies in the climate. As a result of the eruption, the year 1816 came to be known as the 'Year Without a Summer'.

Check Your Progress

9. What is an epicenter?
10. What is a lahar?
11. Define an avalanche.
12. What is meant by effusive eruptions?

1.7 CLIMATIC DISASTER: HEAT AND COLD WAVE

A heat wave is a prolonged period of excessively hot weather, which may be accompanied by high humidity. There is no universal definition of a heat wave; the term is relative to the usual weather in the area. Temperatures that people from a hotter climate consider normal can be termed as heat wave in a cooler area if they are outside the normal climate pattern for that area. The term is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century. Severe heat waves have caused catastrophic crop failures, thousands of deaths from hyperthermia and widespread power outages due to increased use of air conditioning.

The definition recommended by the World Meteorological Organization is when the daily maximum temperature of more than 5 consecutive days exceeds the average maximum temperature by 5°C. A formal, peer-reviewed definition from the *Glossary of Meteorology* is a period of abnormally and uncomfortably hot and usually humid weather. To be a heat wave, such a period should last at least 1 day, but conventionally it lasts from several days to several weeks. In 1900, A.T. Burrows more rigidly defined a 'hot wave' as a spell of 3 or more days on each of which the maximum shade temperature reaches or exceeds 90°F (32°C). More realistically, the comfort criteria for any one region are dependent upon the normal conditions of that region.

In addition to physical stress, excessive heat causes psychological stress, to a degree that affects performance and is also associated with an increase in violent crime.

Incidence

Some regions of the globe are more susceptible to heat waves than others, typically inland deserts, semi-deserts and Mediterranean-type climates. According to climatologist David Jones, the likelihood of heat waves occurring is expected to increase with global warming. Heat waves are spans of extreme heat.

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How they occur

In the summer in warm climates, due to an area of high pressure with little or no rain or clouds, the air and ground easily heats to excess. A static high pressure area can impose a very persistent heat wave.

The position of the jet stream allows air on one side to be considerably warmer than the other side. Heat waves are far more common and more severe on the warm side and at times an unusual position of the jet stream places unusual warmth in an unusual place for hot weather, and imposes a heat wave. El Niño and La Niña (opposite reaction to El Niño) can severely disrupt the positions of the jet streams.

Large desert zones and dry areas are more likely to get extreme heat because there is rarely any high cloud cover with very low humidity.

Winds from hot deserts typically push hot, dry air towards areas normally cooler than during a heat wave. During the summer an area that has no geographic features that might cool winds that originate in the hot deserts get little mitigation, especially near the summer solstice when long days and a high sun would create warm conditions even without the transport of hot air from other locations. Should such a hot air mass travel above a large body of water, as a sirocco of Saharan origin crossing the Mediterranean sea, it is likely to pick up much water vapour with a reduction in temperature but far greater humidity that makes the original desert air little less moderate as demonstrated in a high heat index. Heat waves can also come from air originating over tropical seas penetrating far into the middle latitudes, as often occurs in the eastern United States and southeastern Canada. The heat island effects of large cities only exacerbate heat in large cities that endure heat waves because of the weakness of night-time cooling.

Mortality

Intense perspiration can be a sign of excess heat exposure. Heat waves are the most lethal type of weather phenomenon, overall. The 1995 Chicago Heat Wave, one of the worst in American history, led to approximately 600 heat-related deaths over a period of 5 days. Despite the dangers, Scott Sheridan, professor of geography at Kent State University, found that less than half of people age 65 and older abide by heat-emergency recommendations like drinking lots of water.

Underreporting and 'harvesting' effect

The number of heat fatalities is highly underreported due to lack of reports and misreports. Part of the mortality observed during a heat wave, however, can be attributed to a so-called harvesting effect, a term for a short-term forward mortality displacement. It has been observed that for some heat waves, there is a compensatory decrease in overall mortality during the subsequent weeks after a heat wave.

Impact of heat waves

- **Power outage:** Heat waves often lead to electricity spikes due to increased air conditioning use, which can create power outages, exacerbating the problem. During the 2006 North American heat wave, thousands of homes and businesses went without power, especially in California. In Los Angeles, electrical transformers failed, leaving thousands without power for as long as 5 days. The heat wave in Melbourne, Australia, also caused major power disruptions leaving over half a million people without power as the heat wave blew transformers and overloaded the power grid.
- **Wildfires:** If a heat wave occurs during a drought, which dries out vegetation, it can contribute to bushfires and wildfires. During the disastrous heat wave that struck Europe in 2003, fires raged through Portugal, destroying over 3,010 square kilometres (7,40,000 acres) of forest and 440 square kilometres (1,10,000 acres) of agricultural land and causing an estimated €1 billion worth of damage. High-end farmlands have irrigation systems to back up crops with.
- **Physical damage:** Heat waves can and do cause roads, highways to buckle, water lines to burst and power transformers to detonate, causing fires.

History

- The European heat wave of 2003 killed around 35,000 people. Much of the heat was concentrated in France, where nearly 15,000 people died. In Portugal, the temperatures reached as high as 48°C (118°F) in the south.
- The European heat wave of 2006 was the second massive heat wave to hit the continent in 4 years, with temperatures rising to 40°C (104°F) in Paris; in Ireland, which has a moderate maritime

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climate, temperatures of over 32°C (90°F) were reported. Temperatures of 35°C (95°F) were reached in Benelux and Germany (in some areas 38°C (100°F), while Great Britain recorded 37°C (99°F). Many heat records were broken (including the hottest ever July temperature in Great Britain) and many people who experienced the heat waves of 1976 and 2003 drew comparisons with them.

- The 2007 Bulgarian heat wave triggered wildfires leading to a state of emergency being declared in three southern towns.
- In July 2006, the United States experienced a massive heat wave, and almost all parts of the country had recorded temperatures above the average temperature for that time of year. Temperatures in some parts of South Dakota exceeded 115°F (46°C), causing many problems for the residents. Also, California experienced temperatures that were extraordinarily high, with records ranging from 100°F to 130°F (38°C to 54°C). The county of Los Angeles recorded its highest temperature ever at 119°F (48°C).
- The European heat wave of 2007 affected primarily south-eastern Europe during late June through August. Bulgaria experienced its hottest year on record, with previously unrecorded temperatures above 45°C (113°F). The 2007 Greek forest fires were associated with the heat wave.
- During the 2007 Asian heat wave, the Indian city of Datia experienced temperatures of 48°C (118°F).
- In January 2008, Alice Springs in Australia's Northern Territory recorded 10 consecutive days of temperatures above 40°C (104°F) with the average temperature for that month being 39.8°C (103.6°F). In March 2008, Adelaide, South Australia, experienced maximum temperatures of above 35°C (95°F) for 15 consecutive days, 7 days more than the previous longest stretch of 35°C (95°F) days. The March 2008 heat wave also included 11 consecutive days above 38°C (100°F). The heat wave was especially notable because it occurred in March, an autumn month, in which Adelaide averages only 2.3 days above 35°C (95°F).
- The eastern United States experienced an early summer heat wave during June 6—10, 2008, with record temperatures. There was a heat wave in Southern California beginning late June, which contributed to widespread fires. On 6 July, a renewed heat wave was forecast, which was expected to affect the entire state.
- In early 2009, Adelaide, South Australia, was hit by a heat wave with temperatures reaching 40°C for 6 days in a row, while many rural areas experienced temperatures hovering around about mid-40s°C (mid-110s°F). Kyancutta, on the Eyre Peninsula, endured at least 1 day at 48°C, with 46°C and 47°C being common in the hottest parts of the state. Melbourne, in neighbouring Victoria, recorded 3 consecutive days over 43°C (109°F), and also recorded its highest ever temperature 8 days later in a secondary heatwave, with the mercury peaking at 46.4°C (115.5°F). During this heat wave, Victoria suffered from large bushfires which claimed the lives of more than 210 people and destroyed more than 2,500 homes. There were also over half a million people without power as the heatwave blew transformers and the power grid was overloaded.
- In August 2009, Argentina experienced a period of unusual and exceptionally hot weather during 24–30 August 2009 during the southern hemisphere winter, just a month before spring when a unusual and unrecorded winter heat wave hit the the country. A shot of tropical heat drawn unusually far southward hiked temperatures 22 degrees above normal in the city of Buenos Aires and across the northern-centre regions of the country.
- Even though normal high temperatures for late August are in the lower 15°C (59°F), readings topped 30°C (86°F) degrees at midweek, then topped out above 32°C (90°F) degrees during the weekend.
- Temperatures hit 33.8°C (92.8°F) on 29 August and finally 34.6°C (94.3°F) on 30 August in Buenos Aires, making it the hottest day ever recorded in winter breaking the 1996 winter record of 33.7°C (92.7°F). In the city of Santa Fe, a remarkable 38.3°C (100.9°F) degrees on 30 August was registered, notwithstanding the normal high in the upper 15°C/60°F. As per the Meteorological Office of Argentina, August 2009 has been the warmest month during winter since official measurements began.
- Heat-related deaths were reported from the capital New Delhi, northern Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh. After 3 days of intense heat with temperatures hovering about

40°C (104°F), New Delhi was relieved as the temperature slid down to 37.2°C (99°F). Meanwhile, the temperature soared to more than 46°C (115°F) at several places in northern Madhya Pradesh, with Datia turning out to be the hottest at 48°C (118°F).

- More than 120 peacocks died in Tughlakabad Fort and Surajkund due to the heat; additionally, reports of severe water shortages were common. A total of 400 peacocks died in Madhya Pradesh, about 200 of those being in Haryana and Punjab alone.
- The cotton crop in Punjab was severely affected by the heat wave. Meanwhile, the persisting heat wave in various parts of Chandigarh rendered milk cattle dry. When the day temperature hovered around 48°C (118°F), milk supply to various milk plants of cooperative unions went down by 40,000 litres per day. In addition, milk collection by private sector plants was reduced by 1,60,000 litres during the same period.

Is heat wave a result of global warming?

Some facts related to heat waves and global warming are as follows:

- The Earth is heating up by 1.4°F since 1920.
- The ice caps are melting and the level of sea is rising.
- The first 6 months of 2006 were the hottest since records were maintained in 1890.

The heat wave and the resultant extreme occurrences being witnessed in these recent years are consistent with what is seen as caused by global warming, even though there is no definite correlation. Until now, approximately several high-temperature records have been broken. However, scientists are researching to ensure if the global heat wave constitutes part of a longer and more intense pattern of heat waves before considering it as a part of the larger global warming picture. The movement to bring down greenhouse gas emissions is gaining international attention.

In the recent conference on climate change in Copenhagen, the deadline was determined for adopting 'green' policies and saving the planet from global warming. It was decided that if drastic cuts are not made in the pollution levels by 2020, it would cost the planet up to £150 per year, and we would not have virtually any chance of reducing the temperature. It was decided that geo-engineering and radical solutions would be adopted such as covering the planet with artificial trees or by reflecting sunlight back into space with mirrors. Global leaders meeting in Copenhagen are using rise in temperature issue as their target for the climate deal, which will see billions of pounds being handed down to developing countries to slow down climate change.

It is being said that a cut of 5 per cent in global emissions is the utmost even the most ambitious campaigner is possible. This means drastic changes in power generation, use of renewable energy like wind farms and solar energy, nuclear power, use of biofuels and driving electric cars. Deforestation would have to be brought down and use of fossil fuel reduced drastically.

Cold Wave

An unusual drop in the weather over a short period of time can be called a cold wave. Like heat waves, the term cold wave is relative to the usual weather in the area. A prolonged cold wave may be accompanied by heavy snowing. A cold wave is extremely hazardous to livestock, and also to humans. Since the exposure to cold mandates a greater intake of calories for animals, if there is snow, grazing animals may be unable to reach needed food and die of hypothermia or starvation. The 2012 European cold wave caused temperatures to fall below –35 °C and led to the deaths of 590 people.

Exhibit 1

Cold wave claims lives in north India

Jan 10, 2013

NEW DELHI: More than twenty people lost their lives due to cold wave in Uttar Pradesh and Uttarakhand as temperature in parts of north India plummeted.

Delhi has been witnessing cold wave conditions for the past one week with both minimum and maximum remaining five degrees below normal. In the plains of Uttar Pradesh, the biting

cold wave conditions snuffed out more than fifteen more lives in the last 24 hours as death toll due to the harsh weather touched almost 250.

Five persons died in Gorakhpur district which was the coldest place in the state yesterday, followed by four each in Farrukhabad and Barabanki, two in Sant Kabirnagar and one in Bijnore.

Met office said that Lucknow along with Najibabad in Bijnore were coldest in the state recording 0.5 (–6) degrees Celsius followed by Kheri with 1 deg C, Sultanpur 1.2 (–7) deg C and Gorakhpur 1.8 (–7) deg C.

Loss of seven lives was reported from Uttarakhand. Most of the casualties were reported from Roorkee and Haridwar districts where icy northwesterly winds continued to blow amid dense fog.

Mercury rose marginally in most places with Dehradun recording a minimum of 3.5 deg C, Pantnagar 0.2 deg C, Mukteshwar 0.2 deg C, Tehri 1.0 Pithoragarh 2.3 and Nainital 4.0 degree C, the MeT office said.

Chilly conditions prevailed in Jharkhand with Kanke on the outskirts of Ranchi recording a minimum of 3.4 degree Celsius and Ranchi's low temperature being 8 degree Celsius today.

The minimum temperatures recorded in Jamshedpur and Palamau were 5.1 degree and 6.4 degree Celsius respectively, the sources said adding chill also prevailed in other parts of the state.

(***Source:*** Adapted from http://articles.timesofindia.indiatimes.com/2013-01-10/india/36257505_1_degree-celsius-today-cold-wave-minimum-temperature, accessed on 29.11.13)

Check Your Progress

13. What is a heat wave?
14. Define a cold wave.

1.8 CLIMATE CHANGE

Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region. Such conditions which average over a long period of at least 30 years is called climate.

The Intergovernmental Panel On Climate Change (IPCC) in 1990 and 1992 published best available evidence about past climate change, green house effect and recent changes in global temperature. It is observed that earth's temperature has changed considerably over the years. It has experienced several glacial and interglacial periods. However, during the past 10000 years of the current interglacial period, the mean average temperature has fluctuated by 0.51° C over 100 to 200 year period. Even small changes in climatic conditions may disturb agriculture that would lead to migration of animals and even humans beings.

Anthropogenic activities are upsetting the delicate balance that has been established between various components of the environment. Green house gases are increasing in atmosphere resulting in increase in the average global temperature. This may upset the hydrological cycle; result in floods and droughts in different regions of the world, cause sea level rise, changes in agricultural productivity, famines and death of humans as well as livestock.

1.8.1 Global Warming

The average temperature of the planet has increased more than 1 degree Fahrenheit since 1900 and the speed of warming has been almost threefold since 1970. This increase in the planet's average temperature is called *global warming*.

According to the scientists of the National Oceanic and Atmospheric Administration, period between 1998 to 2007 rank among the topmost 25 hottest years for the United States. We are considering the example of United States, because the US and China are the two biggest polluters in the world and

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have gained negative attention for their dumping policies. The planet could heat by an additional 7.2 degrees Fahrenheit during this century if we do not reduce emissions from fossil fuels such as coal and oil. This rise in the average temperature will have wide-reaching effects on the earth's climate patterns and on all living things, and many of these changes have already begun.

1. Consequences of global warming on weather patterns

Increase in temperatures could lead to increased droughts and wildfires, heavier rainfall and a greater number of intense hurricanes. Warmer water in the oceans pumps more energy into tropical storms, making them stronger and potentially more destructive. The warning signs prevalent today are as follows:

The number of intense storms has greatly increased over the past years, in addition to ocean temperature.

- The Atlantic hurricane season in 2005 was the most active in recorded history, with 27 named storms, of which 15 became hurricanes. Seven of the hurricanes strengthened into major storms, five became intense hurricanes and four became very intense hurricanes.
- In August 2005, Hurricane Katrina was the costliest and deadliest hurricanes in American history.
- Warmer temperatures have increased the possibility of droughts. Increased evaporation could increase drought conditions and increase the risk of wildfires.
- Expenditures incurred in firefighting have consistently gone up by $1 billion per year.
- Warmer temperatures have increased the energy of the climatic system and have increased the possibility of heavier rainfall in some areas.
- The national annual precipitation has surged between 5 and 10 per cent since the early 20th century, largely due to heavy downpours.
- According to the Intergovernmental Panel on Climate Change, intense rain events have increased in frequency during the last 50 years and human-induced global warming most likely contributed to the trend.
- According to the National Oceanic and Atmospheric Administration, the northeast region of the US has had its wettest summer on record in 2006, exceeding the previous record by more than 1 inch.

2. Consequences of global warming on health

Carbon dioxide in the air aggravates asthma and allergies. More frequent and severe heat waves will result in a greater number of heat-related deaths. The warning signs prevalent today are as follows:

- In 2003, very intense heat waves killed approximately 70,000 people in Europe. In France alone, about 15,000 people died during 2 weeks of increasing temperatures that reached as high as 104 degrees Fahrenheit.
- Most areas of North America underwent a severe heat wave in July 2006, which led to the deaths of over 140 people.
- In the 1995 heat wave in Chicago, 739 heat-related deaths had occurred within a week.
- Global warming could lead to an increase in smog pollution in some areas and intensify pollen allergies and asthma. It could also increase local air quality problems.
- Research shows that a higher level of carbon dioxide spurts the increase in the growth of ragweed, whose pollen leads to allergies and worsens asthma.
- Diesel exhaust particles can also mix with pollen and deliver it deeper into the lungs.
- The rise in temperatures can increase ground-level ozone smog production, which is a grave threat to asthmatics.
- The number of mosquitoes and disease outbreaks, such as dengue and malaria increase as the climate allows them to survive in formerly inhospitable areas.
- Higher outdoor temperatures can also lead to more outbreaks of foodborne illnesses such as salmonella, which reproduces rapidly in warm temperatures.

3. Consequences of global warming on wildlife

Rising temperatures have destroyed coral reefs and melted the habitats of polar bears and penguins. Increasing global temperatures have disrupted ecosystems and pushed to extinction species that have not been able to adapt. A comprehensive assessment of the extinction risk from global warming found that more than 1 million species could be extinct by 2050 if the current trend continues. The warning signs prevalent today are as follows:

- A recent analysis of about 2000 plant and animal species discovered movement towards the poles at an average rate of 3.8 miles per decade.
- The latest Intergovernmental Panel on Climate Change report found that approximately 20 to 30 per cent of plant and animal species assessed are likely to be extinct if global average temperature increases by more than 2.7 to 4.5°F
- The US Geological Survey has predicted that two-thirds of the world's polar bear sub-populations will be extinct by mid-century because of melting of the Arctic ice cap.
- In Washington's Olympic Mountains, the sub-alpine forest has invaded higher elevation alpine meadows.
- The mangrove forests in Bermuda are disappearing.
- Over the past years, some Antarctic penguin populations have reduced by 33 per cent due to decline in winter sea-ice habitat.
- The ocean has become more acidic due to carbon dioxide emissions, because of which species with hard calcium carbonate shells are vulnerable.
- Scientists predict that an increase by 3.6°F in temperature would wipe out 97 per cent of the world's coral reefs.

4. Consequences of global warming on glaciers and sea levels

It is being predicted that the polar regions could be devoid of ice by 2040 and the sea levels could rise by 23 inches by 2100 if the current warming patterns continue. The rising global temperatures will speed the melting of glaciers and ice caps and cause ice to thaw early. The warning signs prevalent today are as follows:

- The northern section of the Larsen B ice shelf in Antarctica, a section larger than the state of Rhode Island in the US, collapsed between January and March 2002 and disintegrated at a rate that astonished scientists.
- According to NASA, the polar ice cap is melting at a rate of 9 per cent per decade. Arctic ice thickness has decreased by 40 per cent since the 1960s.
- Over the past three decades, more than a million square miles of perennial sea ice, an area the size of Norway, Denmark and Sweden combined, has disappeared.

Warning signs

According to scientists at the University of Oxford, England, and the Hadley Centre for Climate Research and Prediction in Exeter, England, global warming caused by human activity has increased the possibility that Europe will witness extreme summer heat waves. It is also estimated that by the middle of this century, every second European summer will get warmer.

According to Kevin Trenberth, head of the climate analysis section at the National Center for Atmospheric Research in Boulder, Colorado, 'the link between the current heat waves and global warming is a little complex'. According to him, 'the immediate cause of heat waves is a weather pattern known as an anticyclone, or a high-pressure ridge. Anticyclones lead to dry conditions'. This means all the heat is getting to raise temperatures rather than evaporate moisture. For instance, if the ground is wet that usually acts somewhat as an air conditioner. However, the art lies in differentiating between climate change signals from natural variability.

According to climate experts, other signs of global warming are as follows:

- Spring is arriving by February in New England.
- Glacier ice is reducing throughout the world, from the European Alps to Kenya's Mount Kilimanjaro to Glacier National Park in Montana, United States.

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- The warm climate zone has shifted higher in the mountains of Central America. Several species of animals have nowhere left to move and are rapidly going extinct.
- The National Oceanic and Atmospheric Administration recently said the first half of 2006 was the warmest ever for the US.

Almost all specialists examining the climate patterns of the earth opine that human actions, mainly releasing greenhouse gases from vehicles, industries and burning forests, are the leading causes of global warming. The gases released permit sunlight in, but stop some of the ensuing heat from radiating back to space, leading to a greenhouse effect.

Global warming causes

- The major cause of global warming is the emission of greenhouse gases like carbon dioxide, methane and nitrous oxide into the atmosphere. Power plants are one of the major sources of carbon dioxide. These power plants produce carbon dioxide by burning fossil fuels for the purpose of electricity generation. Burning gasoline in vehicles contributes about 20 per cent of carbon dioxide emitted in the atmosphere.
- Both commercial and residential buildings represent a larger source of global warming pollution. Constructing these requires a lot of fuel to be burnt which emits a large amount of carbon dioxide in the atmosphere.
- Methane is 20 times more effectual than carbon dioxide at trapping heat in the atmosphere. It is obtained from rice paddies, bovine flatulence, bacteria in bogs and fossil fuel manufacture. When fields are flooded, anaerobic bacteria build up and the organic matter in the soil decays, releasing methane to the atmosphere.
- Cars with catalytic converters, using fertilizers in agriculture and burning organic matter releases nitrous oxide that includes nylon and nitric acid production.
- Deforestation caused by cutting and burning of forests for the purpose of residence and industrialization is also a cause of global warming.

Fight global warming

Many steps are being taken by various nations to decrease the rate of global warming. One such effort is the Kyoto agreement made between various nations to reduce the emissions of various greenhouse gases. Also, many not-for-profit organizations are working on the same cause. Al Gore has been one of the foremost American politicians to raise the alarm about the hazards of global warming. He has produced a significantly acclaimed documentary movie called *An Inconvenient Truth*, and written a book that archives his advice that the planet is rushing towards an immensely warm future. He has also given speeches to raise awareness about global warming and warned people about the ill effects of global warming and its remedies.

Economics of global warming

The economics of global warming refers to the economic costs and benefits of global warming, and to the economic impacts of actions aimed at the mitigation of and adaptation to global warming. Estimates come from a variety of sources, including integrated assessment models, which seek to combine socio-economic and biophysical assessments of climate change. At an Intergovernmental Panel on Climate Change (IPCC) conference in April 2007, delegates from 120 nations discussed the specific economic and societal costs of mitigating global warming, and eventually approved the IPCC Fourth Assessment Report. The IPCC Fourth Assessment Report, published in 2007, looked at the aggregate economic impacts of climate change.

Impacts of climate change are very likely (greater than 90 per cent probability) to impose net annual costs, which will increase over time as global temperatures increase. Peer-reviewed estimates of the social cost of carbon (net economic costs of damages from climate change aggregated across the globe and discounted to the specified year) in 2005 average US$ 12 per tonne of carbon dioxide, but the range from 100 estimates is large (-$3 to $95/t carbon dioxide). This is due in large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses and discount rates. Aggregate estimates of costs mask significant differences in impacts across sectors, regions and populations and very likely underestimate damage costs because they cannot include many non-quantifiable impacts.

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Aggregate impacts have also been quantified in other metrics, for example, climate change over the next century is likely to adversely affect hundreds of millions of people through increased coastal flooding, reductions in water supplies, increased malnutrition and increased health impacts.

According to the IPCC Report, 'aggregate market sector impacts of 2°C global mean temperature increase, above the 1990 level, will be plus or minus a few percent of global GDP, with most people in the world negatively affected. Studies of aggregate economic impacts found net damages beyond temperature increases of 2 to 3°C above 1990 levels, with increasing damages at higher magnitudes of climate change.' The report adds that 'On balance, the current generation of aggregate estimates in the literature is more likely than not to understate the actual costs of climate change.'

In 2005, the UK House of Lords Economic Affairs Select Committee produced a report on the economics of climate change. The Report notes the complexities in making forecasts of climate change mitigation costs. The Report refers to the 2001 IPCC report for an estimate of the costs of stabilizing atmospheric CO_2-equivalent at 550 ppm. The annual mitigation cost for this stabilization target is given as being between $78 billion and $1141 billion. This amounts to 0.2 per cent to 3.2 per cent of world GDP in 2005. Costs are estimated to be between 0.3 per cent and 4.5 per cent of GDP if borne by the richest nations alone. In this estimate, world income is assumed to be growing. With 2 per cent per annum growth, the worst case level of costs (with the assumption that all costs are spread over 20 years, from 2005—2025) is estimated to fall to 2.3 per cent of world income in 2035. If the costs are spread out over 50 years (2005—2055), the fraction falls to 1.3 per cent of world income. In terms of world costs per tonne of carbon, the range is estimated to be between $18 and $80 for a 550 ppm CO_2-equivalent target. This figure is based on calculations using the MERGE and FUND integrated assessment models.

The Copenhagen Consensus

The 2004 Copenhagen Consensus assessed the problem of climate change compared to other issues such as control of diseases and malnutrition. Projects were proposed to address these problems, with each project judged by a panel of eight economists. The panel looked at three proposals, including the Kyoto Protocol, for dealing with climate change by reducing emissions of carbon. The expert panel regarded all three proposals as having costs that were likely to exceed the benefits. The panel recognized that global warming must be addressed, but agreed that approaches based on too abrupt a shift toward lower emissions of carbon are needlessly expensive. The experts expressed an interest in an alternative, proposed in one of the opponent papers, that envisaged a carbon tax much lower in the first years of implementation than the figures called for in the challenge paper, rising gradually in later years. Such a proposal however was not examined in detail in the presentations put to the panel, and so was not ranked. The panel urged increased funding for research into more affordable carbon-abatement technologies. The three climate change proposals were rated 'bad' and finished bottom in a ranking of all projects. In the 2008 Copenhagen Consensus, out of the 30 projects evaluated, climate change projects were ranked at number 14 (R&D in low-carbon energy technologies), 29, (R&D and mitigation) and 30 (mitigation only).

Stern Review

One of the most widely noted projections on this issue is the *Stern Review*, a 2006 report by the former Chief Economist and Senior Vice-President of the World Bank, Nicholas Stern, predicts that climate change will have a serious impact on economic growth without mitigation. The report suggests that an investment of 1 per cent of global GDP is required to mitigate the effects of climate change, with failure to do so risking a recession worth up to 20 per cent of global GDP. In the *Stern Review*, net monetized cost estimates of climate change were negative (i.e., net damages) for all global mean temperature increases. The Review has been criticized by some economists, saying that Stern did not consider costs past 2200, that he used an incorrect discount rate in his calculations and that stopping or significantly slowing climate change will require deep emission cuts everywhere. Some economists have supported Stern's approach, or argued that Stern's estimates are reasonable, even if the method by which he reached them is open to criticism. Research by Weitzman has suggested that structural uncertainty and low-probability high-impact risks are very important.

Kyoto Protocol

Primarily industrialized countries who ratified the Kyoto Protocol committed themselves to targets that require lowering their national greenhouse gas emissions to a specified level relative to their actual 1990 emissions. According to the IPCC report, notable achievements of the Kyoto Protocol include:

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- Establishment of a global response to the climate problem
- Stimulation of an array of national policies
- Creation of an international carbon market
- Establishment of new institutional mechanisms that may provide the foundation for future mitigation efforts

Significant differences exist between countries in meeting their Kyoto commitments. Collectively, industrial countries who ratified the treaty will probably meet their 2010 emission limitation targets. The Kyoto Protocol was the first international agreement to set mandatory limits on greenhouse gas emissions. Kyoto's emission reduction targets have been criticized, with some saying they are too weak and others saying they are too strong. The IPCC report describes Kyoto's emission reduction targets as being modest. It was calculated that the present value cost of the Kyoto Protocol would be $800 billion to $1,500 billion if implemented as efficiently as possible. Some economists view Kyoto as a useful first step in responding to climate change. Climate scientists O'Neill and Oppenheimer support Kyoto's targets, arguing that they are consistent with atmospheric carbon dioxide stabilization at 450 ppm. A 450 ppm target could forestall the disintegration of the West Antarctic Ice Sheet, but this is by no means certain, because additional warming would occur beyond 2100.

Cost distribution

The costs and benefits of global warming are distributed quite unequally.

- Low-lying countries' risk of floods
- Many countries subject to increased drought are poor African countries
- Ability of poor countries to mitigate/adapt (margin)
- GW increases variability of weather, which implies greater capital requirements for water storage systems, flood defenses as well as individual requirements to cope with wider variation in weather patterns

The costs of mitigation may also be distributed unequally, both within and between countries.

1.8.2 Sea Level Rise

Over the past century, the Global Mean Sea Level (GMSL) has risen by 4 to 8 inches (10 to 20 centimeters). However, the annual rate of rise over the past 20 years has been 0.13 inches (3.2 millimeters) a year, roughly twice the average speed of the preceding 80 years.

Human activities have released enormous amount of heat-trapping gases into the atmosphere. These emissions have caused the Earth's surface temperature to rise. The increase in temperature will result in melting of glaciers and polar ice caps. This will increase the sea level. The low-lying islands and coastal areas will be eventually submerged. The rise in sea levels is linked to three factors, all induced by this ongoing global climate change:

- **Thermal expansion:** When water heats up, it expands. About half of the past century's rise in sea level is attributed to warmer oceans simply occupying more space.
- **Melting of glaciers and polar ice caps:** Glaciers and polar ice caps melt back a bit each summer. But in winter, the snow formed is generally sufficient to balance out the melting. Recently, higher temperatures caused by global warming have increased the level of melting of snow as well as diminished snowfall due to later winters and earlier springs. This causes the sea levels to rise.
- **Ice loss from Greenland and West Antarctica:** Like glaciers and the ice caps, global warming is causing massive ice sheets that cover Greenland and Antarctica to melt at an accelerated pace. Higher sea temperatures are causing the massive ice shelves that extend out from Antarctica to melt from below, weaken, and break off.

Consequences

A small increase in sea level can have devastating effects on coastal habitats. It can cause flooding of wetlands, destructive erosion, contamination of aquifers and agricultural soils, and loss of habitat. People live in coastal areas will become vulnerable to flooding. Higher sea levels would force them to abandon their homes and relocate. Low-lying islands could be submerged completely.

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1.8.3 Ozone Depletion

The highest level of ozone in the atmosphere is in the stratosphere and this zone of about 10 to 50 km is known as ozone layer. The rest 10 per cent of ozone is in the troposphere. Ozone is beneficial when it is in the stratosphere as it protects us from the harmful UV rays and is harmful, in the troposphere as it helps in formation of photo-chemical smog. It needs to be mentioned here that the photo-chemical smog formation is mainly due to human activities. Thus, ozone is mainly beneficial for us.

Ozone absorbs all the solar ultraviolet radiations of wavelength less than 290 nm and negligibly absorbs those in between 290 to 350 nm. Ozone is continuously created in the stratosphere and at the same time continuously removed. Thus, there is an apparent equilibrium in the ozone region with the concentration of ozone remaining constant.

The formation of ozone has been described here. In the first step, photolytic decomposition of diatomic oxygen produces atomic oxygen; the atomic oxygen reacts rapidly with diatomic oxygen in presence of third body (M, most abundant N_2 or O_2) to form ozone (O_3).

$$O_2 + h\nu \rightarrow O + O \ (\lambda < 242 \text{ nm})$$

$$O + O_2 + M \rightarrow O_3 + M$$

$$O_3 + h\nu \rightarrow O_2 + O \ (\lambda < 350 \text{ nm})$$

$$O + O_3 \rightarrow 2O_2$$

Equilibrium reaction can be shown as

$$3O_2 \overset{h\nu}{\rightleftharpoons} 2O_3$$

The principal effect of the overall reaction is that most of the potentially damaging short wavelength ultraviolet radiation is absorbed as it tries to pass through stratosphere. Further, as the absorption of this radiation heats the stratosphere stable atmospheric conditions are achieved.

A satellite data, however, indicated damage to the stratospheric ozone layer over Antarctica, a hole of the size of a big continent. The main chemicals responsible for depletion of ozone layer were found to be chlorofluorocarbons (CFCs) and especially $CFCl_2$, CF_2Cl_2, $C_2F_3Cl_3$ and chloroflouro bromine (CF_3Br). These gases are very stable (residence time: 75–185 years). They are inert in lower atmosphere but are destroyed by the UV radiation (l< 220 nm) in the ozonosphere and release atomic Cl. This atomic Cl, subsequently, destroys the ozone layer through the following processes:

$$CF_2Cl_2 + h\nu(\lambda < 220 \text{ nm}) \rightarrow CF_2Cl + Cl$$

The freed chlorine then act as a catalyst,

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O \rightarrow Cl + O_2$$

$$O_3 + O \rightarrow 2O_2$$

Part of the atomic Cl, however, are removed through reaction with potent greenhouse gas CH_4 and harmful NO_2, producing HCl and ClO NO_2 which are then removed by rain. Under these two circumstances, these gases become part of the cure.

$$Cl + CH_4 \rightarrow HCl + CH_3$$

$$Cl + NO_2 \rightarrow ClO\,NO_2$$

Another potent ozone depleting gas is methyl bromide (CH_3Br), which is used in agriculture to sterilize soil and fumigate crops after harvesting. The released atomic bromine acts in the same way as chlorine and in the same way can be removed through reaction with CH_4 and NO_2.

Greater concentration of NO_2 if present in the upper atmosphere (main source, jet planes) may also destroy ozone.

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

Hydrogen chloride (HCl) and chlorine nitrate ($ClONO_2$) are inactive and do not destruct ozone layer. However, in the month of September (Antarctic winter) the atmosphere in the Antarctic becomes

very cool (temperature < – 90°C) and then the small ice crystals which make up polar clouds provide the surface to HCl and $ClONO_2$ to stay for a longer duration and subsequent reaction follows:

$$ClONO_2 + H_2O \rightarrow HOCl + HNO_3$$

$$HOCl + HCl \rightarrow Cl_2 + H_2O$$

$$ClONO_2 + HCl \rightarrow Cl_2 + HNO_3$$

Once the sun rises, (Antarctic spring) the chlorine thus formed in winter gets photolyzed and forms atomic chlorine.

$$Cl_2 + h\nu \rightarrow 2Cl$$

This atomic chlorine leads to the destruction of O_3.

$$O_3 + Cl \rightarrow ClO + O_2$$

In the Arctic, the combination of land and ocean maintains warmer temperature and atmospheric conditions are not as in Antarctica and, thus, there is lesser thinning of ozone layer over the Arctic in spring.

However, it is of great concern that due to troposphere warming by greenhouse gases, there is a possibility of stratospheric cooling which ultimately might lead to same atmospheric condition in Arctic like the Antarctic and cause dramatic ozone layer depletion.

Depletion of ozone layer will lead to increase in the flux of UV radiation over the biosphere of the earth. This ultimately will lead to:

- Skin cancer
- Eye and lung irritation
- Reduced photosynthesis
- Lower crop productivity
- Change in weather patterns through interference with oxygen

The depletion of ozone (O_3) molecule by CFC can be depicted as given here:

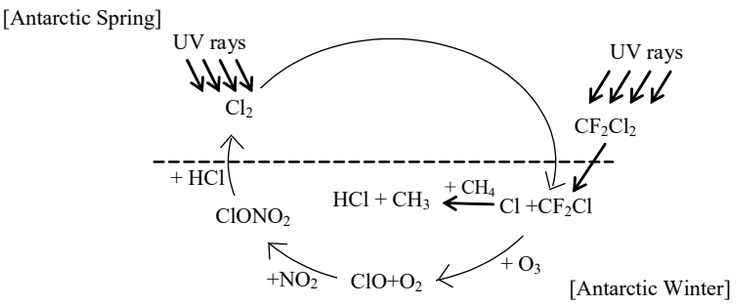

Fig. 1.1 *Ozone Depletion by CFC*

Check Your Progress

15. Define climate.
16. What is global warming?
17. Why is ozone beneficial in the stratosphere and harmful in the troposphere?
18. What are the effects of depletion of the ozone layer?

1.9 SUMMARY

- A disaster is a mishap or hazard which causes huge loss of life and property and disrupts the balance of the economy. It is a tragic event with drastic consequences for human life as well as social and individual development.

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- An environmental disaster is a mishap or hazardous event which directly influences the environment, bringing serious alterations in the same.
- Broadly, disasters have been categorized as natural and man-made disasters on the basis of their causes.
- Anthropogenic disasters are threats that have an element of human intent, negligence or error or have witnessed failure of a man-made system. They are also known as man-made disasters since they are the result of a failing or error on the part of humans.
- Floods are caused by too much rain or water in a location, caused by excess water surpassing the limits of its confines.
- The three types of floods are— flash floods, river floods and storm surge.
- A drought is an extended period of months or years when a region notes a deficiency in its water supply.
- A tropical cyclone is a storm system characterized by a large low-pressure centre and numerous thunderstorms that produce strong winds and heavy rain.
- Earthquakes are caused by a sudden shift or movement deep underground in the Earth's tectonic plates, causing the Earth's crust to shake violently, with vibrations varying in magnitude.
- An earthquake has point of origin underground called 'focus'. The point directly above the focus on the surface is called 'epicentre'.
- Landslides are an extremely frequent geological event. They occur when masses of rock, earth, or debris move down a slope, caused by disturbances in the natural stability of a slope.
- An avalanche is a rapid flow of snow down a slope, from either natural triggers or human activity. Typically occurring in mountainous terrain, an avalanche can mix air and water with the descending snow.
- Avalanches are always caused by an external stress on the snow pack; they are not random or spontaneous events.
- An opening in the surface of the Earth that allows lava, volcanic ash and gases to escape from its magma chamber below the surface is called a volcano.
- A heat wave is prolonged period of excessively hot weather, which may be accompanied by high humidity.
- An unusual drop in the weather over a short period of time can be called a cold wave.
- Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in region. Such conditions which average over a long period at least 30 years is called climate.
- The average temperature of the planet has increased more than 1 degree Fahrenheit since 1900 and the speed of warming has been almost threefold since 1970. This increase in the planet's average temperature is called global warming.
- Ozone is beneficial when it is in the stratosphere as it protects us from the harmful UV rays and harmful in the troposphere as it helps in formation of photo-chemical smog.

1.10 KEY TERMS

- **Disaster**: A disaster is a mishap or hazard which causes huge loss of life and property and also disrupts the balance of the economy.
- **Anthropogenic disasters**: Anthropogenic disasters are threats that have an element of human intent, negligence or error or have witnessed failure of a man-made system.
- **Global warming**: The increase in the planet's average temperature is called global warming.

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1.11 ANSWERS TO 'CHECK YOUR PROGRESS'

1. A disaster is a mishap or hazard which causes huge loss of life and property and disrupts the balance of the economy.
2. An environmental disaster is a mishap or hazardous event which directly influences the environment, bringing serious alterations in the same.
3. Disasters have been categorized as natural and man-made disasters on the basis of their causes.
4. Anthropogenic disasters are threats that have an element of human intent, negligence or error or have witnessed failure of a man-made system.
5. The three types of floods are— flash floods, river floods and storm surge.
6. Some of the factors responsible for causing floods are:
   - Rivers in spate due to heavy and continuous rain for a long period such as few days or weeks
   - Flowing of water much above its danger level due to inadequate capacity within the banks of the river to contain high flows
   - River bank erosion and silting of riverbeds
   - Landslides leading to obstruction of flow and change in the river course
7. A drought is an extended period of months or years when a region notes a deficiency in its water supply.
8. A tropical cyclone is a storm system characterized by a large low-pressure centre and numerous thunderstorms that produce strong winds and heavy rain.
9. The point directly above the focus on the surface is called the epicentre.
10. A lahar is a volcanic mudflow or landslide.
11. An avalanche is a rapid flow of snow down a slope, from either natural triggers or human activity.
12. Effusive eruptions are characterized by the outpouring of lava without significant explosive eruption.
13. A heat wave is prolonged period of excessively hot weather, which may be accompanied by high humidity.
14. An unusual drop in the weather over a short period of time can be called a cold wave.
15. Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in region. Such conditions which average over a long period at least 30 years is called climate.
16. The increase in the planet's average temperature is called global warming.
17. Ozone is beneficial when it is in the stratosphere as it protects us from the harmful UV rays and harmful in the troposphere as it helps in formation of photo-chemical smog.
18. Depletion of ozone layer will lead to increase in the flux of UV radiation over the biosphere of the earth. This ultimately will lead to:
    - Skin cancer
    - Eye and lung irritation
    - Reduced photosynthesis
    - Lower crop productivity
    - Changed weather patterns through interference with oxygen

1.12 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the categories of anthropogenic disasters?

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2. Write a short note on the three types of floods.
3. What are the common consequences of drought?
4. Write a short note on the different types of volcanic eruptions.
5. What is the impact of heat waves?
6. What are the causes of global warming?

Long-Answer Questions

1. Distinguish between natural and man-made disasters. What are the causes of environmental disasters?
2. What are the causes behind the occurrence of cyclones? Discuss the effects of cyclones.
3. Explain the various ways of preventing avalanches and the search and rescue equipment required to rescue victims.
4. Discuss the consequences of global warming.

1.13 FURTHER READING

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UNIT 2 MAN-MADE DISASTERS AND POLLUTION

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Structure

2.0 INTRODUCTION

In this unit, you will study about the different types of man-made disasters and their impact on the environment. Their sources of occurrence of different types of pollution and their impact on the environment have been discussed in detail. This unit also explores accidents of various kinds.

2.1 UNIT OBJECTIVES

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

- Discuss the different types of man-made disasters
- Explain the different types of fire
- List the sources of air and water pollution
- State the impact of controlling noise, thermal, marine, soil and nuclear pollution
- Understand the concept of deforestation and the reasons behind occurrence of different types of accident

2.2 MAN-MADE DISASTERS

Man-made disasters are those that may be lesser in enormity but higher in frequency. These are the risks that are caused due to carelessness, or because of human activities which are not able to endure the forces of nature.

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Accidents are a form of man-made disasters that result in loss of life and property. Mining disasters affect the environment. The Bhopal Gas tragedy in India and the Chernobyl nuclear disaster in what was previously known as the Soviet Union, can be listed as a few of the man-made disasters. The recent Tsunami that struck Japan was a natural disaster which got converted into a colossal man-made disaster when it came in contact with the nuclear reactors there.

2.2.1 Nuclear Disaster

Nuclear disasters can take place as a result of military action as well. This will affect biodiversity. Back in 2006, the Lebanese coast was badly polluted by 15,000 tons of oil slicks following the bombing of an oil reserve by Israel in the southern part of Beirut. Many rare species of birds, turtles and seals had completely disappeared.

In 1986, the first and one of the worst nuclear power plant disasters took place at the Chernobyl Nuclear Power Plant in Ukraine. As a result of this disaster, many deaths occurred due to radiation poisoning resulting from the radioactive release into the atmosphere, which spread over a large geographical area. The massive power excursion destroyed the reactor. The fallout was said to have been four hundred times more than what was released by the atomic bombing of Hiroshima. Some nuclear rain fell even as far away as Ireland. The contamination affected large areas in Russia, Ukraine and Belarus. For many years thereafter, the expansion of the nuclear power industry slowed down considerably. Russia, Ukraine and Belarus have been bearing the expenses of decontamination over the years.

A similar tragedy took place in India, at Bhopal when the Union Carbide pesticide plant released methyl isocyanate into the atmosphere. Lakhs of human lives were lost. Even now, children are being born with defects and when they grow up are suffering from various fatal diseases and physical deformities. Even after twenty-five years, hundreds of tonnes of toxic chemicals abandoned at the plant continue to leak and pollute the region's ground water, which has affected thousands of residents.

Following the Bhopal Gas Tragedy, the Disaster Management Institute was established by the MP Government to offer training to people. The Institute also conducts research and provides consultancy services on the prevention, mitigation and management of disasters. The Institute organizes training sessions for working managers and government officials in the areas of management of natural disasters.

The most challenging task of the post-Chernobyl recovery was the integrated radiological and socio-economic rehabilitation of the affected areas. The chief objective being rehabilitation and economic recovery and sustainable development of the affected areas.

Development and implementation of the state strategy in the field of overcoming the Chernobyl accident consequences is done under direct participation of the President of the Republic of Belarus. The President and his administration strictly controlled the implementation of the state program for overcoming the Chernobyl accident consequences in accordance with the Chernobyl legislation. The system of control includes visits of the President to regions contaminated by radionuclides and making on-site decisions on the most urgent problems affecting the concerned population.

Under the primary countermeasures of radiation protection, it has been possible to completely resettle the inhabitants from the most contaminated areas. The country successfully operates the radiation control and monitoring measures. All the affected people are covered by a system of social protection which has been implemented successfully and medical care is being provided to those residing in the regions contaminated by radionuclides.

The system being followed for radiation protection of the population includes development of legislative documents dealing with rules pertaining to radiation safety, sanitary regulations for radiation safety, permissible levels of radiocesium and radiostrontium concentration in foodstuff, agricultural products, water. Liming of acidic soils, application of phosphate and potassium fertilizer to the whole contaminated region of agricultural land, improvement of pastures and grassland for private and state farms is being strictly followed. A number of new techniques of agricultural production were worked out. Thanks to these measures practically all agricultural materials and foodstuff produced on contaminated Belarusian territories correspond to standards of radionuclide concentration.

Agricultural facilities have been re-oreinted. The modified facilities ensure that there is lesser accumulation of radionuclides in the resulting products. An effective system of radiation-ecological monitoring and radiation control has also been set up with environmental monitoring units spread

across the country. Radiation-ecological monitoring and research activity are being conducted to prevent the spread of radio radionuclides to less contaminated territories.

2.2.2 Chemical Disaster

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Chemicals are used by most industries in production. Some industries even produce chemicals. On the basis of the source of their origin, chemicals are divided into two categories – organic and inorganic. Organic chemicals exist in nature or are extracted from it. Inorganic chemicals are produced in laboratories. Irrespective of their source of origin, a number of chemicals used in industries, may be harmful to the things they are exposed to. In some cases, the effects of chemicals on human or environment can be severe. On the basis of the kind of damage harmful chemicals can cause, they are categorized as reactive, corrosive, flammable and toxic.

Chemical disasters consist of any kind of spills, leaks or explosions involving harmful industrial chemicals. The leaked chemicals react with the surroundings and in some cases causes severe adverse effects including large number of deaths as had happened in the Bhopal gas leak in December 1984. These disasters are harmful to all elements in the environment – be it social, economic or natural. Sometimes, chemical accidents may occur even after adhering to all the precautions.

Chemical disasters may vary in magnitude depending on the nature of the chemical and the vulnerability of the surroundings. When chemicals are being stored or transported, a number of signals and colour codes are used to enable the people dealing with them to identify the type of chemicals and know about their adverse effects. This helps in alerting the disaster management team about any chemicals-related disaster. The colour codes used are based on the kind of effects associated with different chemicals. These colour codes are as follows:

- Blue for health damage
- Red for extremely flammable products
- Yellow for reactive chemicals
- White for special notices about chemicals which can cause a combination of damages

The hazards caused by chemicals have also been divided into a number of classes on the basis of chemicals. This categorization helps researchers take precautions to avoid these hazards or launch rescue and recovery operations in case of chemical disasters. This hazard class categorization is as follows:

- Hazard Class 1: Explosives
- Hazard Class 2: Gases
- Hazard Class 3: Flammable liquids
- Hazard Class 4: Flammable solids
- Hazard Class 5: Oxidizer and organic peroxide
- Hazard Class 6: Toxic/poisonous and infectious substances
- Hazard Class 7: Radioactive
- Hazard Class 8: Corrosive
- Hazard Class 9: Miscellaneous dangerous goods

In view of the past chemical disasters, it is essential to exercise extreme caution while, dealing with hazardous chemicals.

Source of occurrence

- Chemical disasters mostly occur due to a combination of mechanical and human failures in dealing with dangerous chemicals. Any factory, industry or workshop where dangerous chemicals are used is prone to such accidents.
- The main cause of chemical disasters is a chemical leak or spill in the environment. The leaked chemical then reacts with the surroundings, leading to severe adverse effects for humans and the environment. It is for this reason an industry is required to put in place a number of precautions before it is allowed to use certain chemicals. Also a number of legal procedures and restrictions

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check the exposure of these chemicals under control to ensure that no damage results from their use.

- A human error due to lack of information can also lead to a chemical disaster. However, many times chemical disasters occur due to poor planning and application of faulty emergency and safety procedures. One reason for this could be a particular industry's bid to reduce the cost involved in following foolproof safety procedures. When an industry is not equipped to properly handle chemicals or to take urgent steps to deal with any chemical spill or leak, it can lead to a disaster which could threaten the industry workers as well as those in the vicinity.
- Mostly, chemical disasters occur during chemicals' transportation. This could be the result of improper facilities provided for transporting a chemical or lack of coordination between the sender and the receiver of the chemical. In such cases, the chemical may be left unattended outside an industrial campus for a long time and that can lead to its reaction with the environment.

To ensure proper protection against any damage from spills or leakage during chemical handling, stringent protection procedures are outlined and implemented. However, errors in the design of protection procedures can also lead to chemical disasters. If these designs are not in tune with the kind of technology being used, it could lead to chemicals evaporating from the machinery or storage devices. Thus, it is essential to develop such designs and procedures that allow one to carry out handling of chemicals. Moreover, the designs need to be compatible with the machinery and procedures being used in industries. The designs should be regularly upgraded with change in procedures or machinery so as to be able to give a quick emergency response and begin an effective rescue procedure.

Impact on the environment

Chemical disasters affect all elements of the environment adversely. They could lead to death and destruction and heavy expenditures to set right the damage caused to the elements of the environment. In the environmental context, a grave concern is that the effects of chemical disasters are not restricted only to the time of the occurrence of disaster. These effects may linger on years after the occurrence. It is for this reason that these effects have been categorized as immediate effects, short-term effects and long-term effects to analyse their true implications. Some dangerous impacts of chemical disasters on the environment are as follows:

- **Exposure to carcinogens:** Chemical disasters like spills or leakage expose living tissues in humans, animals or plants to carcinogens. This exposure may not show an immediate effect, but it could be a major reason of cancer affliction among the disaster-affected people in future. Carcinogens damage living tissues by causing cancer. The exposure to high levels of carcinogens (for example, asbestos or ionizing radiation) can occur at the workplace. Occupational exposure may give rise small epidemics of unusual cancers, for example, an increase in angiosarcoma of the liver in 1974 among American workers who cleaned vinyl chloride polymerization vessels.
- **Fires:** If the escaping chemical is flammable and is not dispersed far and wide in the atmosphere immediately, it could lead to large fire outbreaks which would release toxic substances in the atmosphere. The escaping chemical would also affect the living beings if they came in its contact, apart from causing huge damage to infrastructure and equipment. Fires can either be a trigger to a number of chemical explosions or they could be the end result of the same. The fire damage could be immediate. However, the resulting atmospheric pollution could cause illness and environmental deterioration as a short-term effect. For example, two research scientists were killed in an accidental fire caused due to reaction of chemicals in a laboratory at Bhabha Atomic Research Centre (BARC) in Trombay.
- **Toxic penetration:** Following a chemical disaster, a number of toxins, e.g., arsenic, can penetrate soil or water bodies around industrial units which can cause immediate, short-term and long-term effects. The immediate effect could be the death of animals and plants. The short-term effects would be deterioration of the water quality, making it unfit for use, or the deterioration of soil leading to a drop in the crop yield. The long-term effect would be outbreak of diseases or slow growth of children.
- **Radioactive fallout:** It occurs when chemical reactions following a chemical disaster lead to radioactive changes in the environment. These reactions may lead to explosions and fires and also release carcinogens. The radioactive fallout costs the environment dearly. In 2011, a tsunami

flooded and damaged the five active reactor plants in Japan. It led to very dangerous radioactive fallout.

- **Corrosion:** It occurs when chemicals cause deterioration of things by contact. It can damage equipment, mechanisms and human tissues. The effects are mostly immediate but some short-term effects may surface leading to disability. Nitric acid, for instance, in reaction with skin forms a yellow burn. Sulfuric or sulphuric acid reacts with skin moisture resulting in severe burns. Hydrofluoric acid acts relatively slow but causes painful deep burns hours after the exposure.
- **Compensation costs:** These need be incurred to compensate people for the effects of chemical disasters. The need to be provided proper treatment depending on the damage caused to them. Costs are also incurred to set right the damage to the infrastructure. Besides, there is also need for the restoration of vegetation and crops. For instance, the victims of the Bhopal Gas Tragedy got monetary compensations.

2.2.3 Biological Disaster

A biological disaster is a kind of natural disaster that is associated with the devastating effects, mostly caused by an enormous spread of a certain kind of biological agent or bacterium or virus. This disaster is also characterized by a sudden growth of the population of a certain kind of plant or animal, for example, a locust plague. A biological disaster may also be defined as the sudden outbreak of an epidemic or disease which travels from one living being to another. It can affect either plants or animals and can cause deaths as well as disability on a large scale. Biological disasters are most dangerous for humans because they take a heavy toll on human health and development.

The death rate in an economy shoots up drastically during a biological disaster. It can wipe out huge population in a very short time. Sometimes biological disasters prove to be more damaging economically than other natural disasters. Therefore, it becomes crucial to monitor any development which could lead to a biological disaster.

Biological disasters are categorized as natural and man-made depending on the agent that causes them. Natural biological disasters are those epidemics which are caused by naturally-induced bacteria or viruses. During the occurrence of natural biological disasters, a large number of people contract a disease simultaneously, leading to death of many. Man-made biological disasters are those wherein the health of living organisms deteriorates because of biological agents that have been induced into the natural consumption cycles of living beings by human intervention. A number of species show a bottleneck in their DNA constitution which indicates the presence of a plague, causing the death of a large number of species members, thus leading to the extinction of the species.

The most common example of biological disaster, caused by human interference, is the Spanish influenza which spread because of movement of people after World War I. The influenza spread among healthy people when they came in contact with those who were ill.

Source of occurrence

However, naturally occurring pathogens are found at many places, thus exercising precaution is the only way to escape their adverse impact.

- The main sources of pathogens or biological agents and the outbreaks caused by them are hospitals and medical facilities. At these places there are lots of patients and other people who carry contagious biological agents. Besides, the bodies of patients who have died due to some disease also serve as sources of deadly pathogens.
- Contamination of food or water being supplied to people can be another cause of a biological disaster. If the main supply of these products gets infected with pathogens or toxins, then a number of people who would consume these products would contract a similar disease simultaneously.
- Mass panic can also lead to more people coming under the grip of a biological disaster. Sometimes people contract a disease but are not aware of it due to the absence of particular symptoms of the disease. But, these people, overcome by mass panic created by the spread of the disease at their place of residence decide to relocate. Moreover, at their new location, they infect many others with the disease.

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- Sometimes people have no knowledge of the potential biological disasters and the accompanying hazards from which they can suffer. Here again it is expected of the authorities to educate and make people aware of the potential biological disasters and the precautions they can take against these disasters.
- The insect and rodent population can serve as a means for the faster spread of a biological disaster in an area. They become the carriers of the disease or the pathogens that can cause the disease.

Impact on the environment

The loss of human lives due to a biological disaster is a heavy price for an economy. The rising death toll not only hampers the economic development but also prevents the recovery from the disaster fallout which requires active involvement of valuable human resource.

The spread of an outbreak animals leads to deterioration of the livestock in the economy along with plaguing the human food chain. Humans may fall ill by eating the meat of infected animals. This accelerates the spread of the disease, making the disease containment increasingly difficult.

The spread of diseases from one species to the other can lead to environmental deterioration, causing imbalance in the ecosystem. If a species becomes endangered or extinct during a biological disaster, it is almost impossible for the ecosystem to regain balance prior to the disaster.

Mitigation measures

- The biomedical waste, generated in hospitals, contains potentially harmful toxic and infectious pathogens. Thus, it is essential to expand and upgrade medical facilities to prevent an outbreak turning into a biological disaster. It is better to build vast hospital complexes having spaced out blocks for dealing with patients of different diseases. It would help in preventing the fast spread of a disease through infected patients.
- To prevent an outbreak of some suspected pathogen, the public health authorities should carefully analyse food and water supplies before allowing them to reach humans.
- It is essential for the authorities to disseminate all relevant information about a disease outbreak to enable people behave rationally without panicking.

Check Your Progress

1. When and where did the first nuclear power plant disaster took place?
2. Mention the two categories of chemical disasters.
3. Define a biological disaster.

2.3 BUILDING FIRE

The combustion of fire always depends upon the burning materials and its chemical characteristics. Due to the nature of combustion material, the fire is extinguished by different types of extinguishing media. This depends upon cooling starvation and smothering effect. Hence, the following are important to comprehend the nature and principle of fire:

- **Flash point:** The temperature, which under a given set of conditions a solid or liquid, first gives off sufficient vapour for a flame to be propagated across its surface by a small pilot flame.
- **Fire point:** The fire point of a liquid is the temperature at which the liquid evolves vapours in sufficient amount for a continuous generation of flame. The fire point is usually several degrees above the flash point for a given liquid.
- **Ignition temperature:** It is the temperature at which a substance will begin to burn or explode or the temperature at which it has been claimed that a substance will ignite when heated, without naked light or flame applied to it. Some of the examples of the ignition temperatures are as follows:
  - Ignition temperature of yellow phosphorous is 33°C; thus, the heat of the hand is enough to inflame the substance.

- Ignition temperature of carbon disulphide is about 120°C; thus, a heated glass rod is held in the vapour of carbon disulphide so that the latter catches fire.

- **Spontaneous combustion:** It refers to the outbreak of fire in a combustible material without application of an external source of heat. In such substances, fire usually breaks out because of atmospheric oxidation of the combustible material.
- **Oxygen:** It is the gas that facilitates combustion. Combustion will occur as long as the three factors (fuel such as wood, oxygen and heat) of fire are present.
- **Fuel:** It is any material that produces heat or power, usually when it is burnt. The fuel may be solid, a liquid or a gas. The burning of most materials produces a flame. This is caused by ignition of the gases or vapours given off by a liquid or a solid.
- **Heat**: It may be defined as energy possessed by a substance due to motion of molecules. Total heat contained by a body is equal to the product of its mass, temperature and its specific heat. In the particular circumstances encountered at the time of combustion, heat is necessary to raise the temperature of the fuel to its ignition temperature. The amount of heat needed will depend on various factors, such as, physical state, whether it is a powder, or a solid lump, or liquid or a gas, the concentration of supporter of combustion and the chemical nature of fuel. The heat may come from spark, a flame or an exothermic chemical reaction
- **Chemical chain reaction:** The three basic ingredients of fire are fuel, oxygen and heat. When these three factors are present, under most circumstances, combustion will occur. The actual chemical processes of combustion involve a very complicated series of chain reactions at the molecular level. Normally, these chain reactions will continue to occur as long as there is an adequate supply of fuel and oxygen and sufficient heat. One way to extinguish a fire is to interrupt the sequence of chemical chain reactions by introducing other chemicals.

Principle of fire propagation

A spreading fire or the propagation of fire can be analysed at many scales. For instance, an incident commander working to control a large fire comes across the fire at a level of spatial resolution, which is no more comprehensive than a single watershed. A firefighter quelling the same fire has less of an understanding of how the fire is behaving through various watersheds in the area and in its place thinks about only on the behaviour of that part of the fire front, which is most nearby and (potentially) frightening. It is not practical to discuss the physics of fire propagation from either of these scales. As an alternative, an idealized explanation of the fire and fuel bed is helpful.

Physical description of fire propagation

Energy coming from the combustible fuel particles at the fire front gets transferred to an un-ignited fuel volume which lies ahead of the fire front through the following three heat transfer mechanisms:

- Radiation
- Convection
- Conduction

The energy transferred in this way to the un-ignited fuel volume increases its temperature from ambient to ignition and thus, volatilizes all the water present in the fuel.

The radiant energy is emitted from the following two sources during the time of the onset of ignition and the reduction of the fuel particles in the fuel volume to char or tar:

- The surface oxidation of the glowing fuel particles within the fuel bed
- A flame linked to the upper surface of the fuel volume

If wind is present, simultaneous to the conditions explained above, heated gas and soot particulates would appear from the oxidizing fuel particles and flame, which would relocate the air around the un-ignited fuel bed thus, creating physically powerful temperature gradients between the fuel particles and the nearby air. This process is repeated by the energy discharged when the flame is present; the fuel particles are combusting and heated gases are releasing from the fuel is transferred to neighbouring un-ignited fuel. Thus, the fire propagates.

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Classification of fire

Various materials and inflammable substances can cause fires. They can be solids, liquids and gaseous. In addition, fire is also caused by intense energy such as electricity. To understand the nature of fire better, it is necessary to know the classification of fire.

Fires are classified in the following main four categories or classes for the purpose of its extinguishing:

- **Category A:** The fires in ordinary solid combustible material such as wood, paper, fabrics where most effective method of extinguishing is by cooling with water
- **Category B:** Fire in flammable liquids, such as oil, organic solvents, petroleum, liquids, paints, varnishes. This type of fire is extinguished by smothering mainly.
- **Category C:** Fires involving gaseous substances such as cooking gas, acetylene, methane, butane.
- **Category D:** Fires involving combustible metals, such as magnesium, titanium, sodium, potassium, etc., where the burning metals is reactive to water and which require special extinguishing agents and techniques
- **Category E (Electrical fire):** As per the latest study, this type of fire does not constitute a particular class or category. This type of fire can be a fire of category A, B or C. The normal procedure of extinguishing this kind of fire is by cutting off the electricity and using an extinguishing method appropriate to the burning material, which are non-conductors of electricity and non-damaging to the equipment such as vaporizing liquids. Dry powders and carbon dioxide, water should in no case be used on electric fires.

2.3.1 Precautions Required for Each Class of Fire

The following precautions are taken to manage each kind of fire:

Class A (Ordinary combustibles)

- Keep storage and working areas free of trash; place oily rags in covered containers
- Ensure proper house keeping
- Dispose off the stacks of these materials on regular basis
- Do not smoke or otherwise throw naked fire around the disposal bins

Class B (Flammable liquids or gases)

- Do not refuel gasoline-powered equipment in a confined space, especially in the presence of an open flame such as a furnace or water heater
- Do not refuel gasoline-powered equipment while it is hot
- Keep flammable liquids stored in tightly closed, self-closing, spill-proof containers. Pour from storage drums only what you will need
- Store flammable liquids away from sources that produce spark
- Use flammable liquids only in well-ventilated areas

Class C (Chemical and gaseous substances)

- Do not allow gas to leak
- Keep naked flames away unless controlled burning is allowed such as in kitchens
- Ensure there are no naked electric fire and short-circuiting in the general area, where the inflammable gases are stored
- There is a need to understand the characteristics of LPG and take precautions to see that the same are treated in sensitive manner and kept in authorized containers that are properly sealed
- Take necessary precautions while transporting them
- Do not try to extinguish as the gas is leaking
- Try to cool the cylinder; use maximum water
- Do not throw water of the safety valve, as the same may not open, when cooled

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- Use gas masks and gloves
- Provide adequate ventilation
- Do not switch off or switch on any electrical equipment when fire is burning
- Allow cylinder to burn in an open area
- Stay away from the cylinder, as it can move in uncontrolled directions when burning
- Water in the form of spray can also be used; also, cool the containers to avoid explosion

Class D (flammable metals)

- Flammable metals such as magnesium and titanium generally take a very hot source to ignite; however, once ignited they are difficult to extinguish as the burring reaction produces sufficient oxygen to support combustion, even under water
- In some cases, covering the burning metal with sand can help contain the heat and sparks from the reaction. Class D extinguishing agents are available, generally as a dry powder in a bucket or box, which can be quite effective, but these agents are rarely found in homes or other places
- If you are planning a research project using a large amount of flammable metals, you should consider purchasing a five or ten pound container of Class-D extinguishing agent as a precaution
- Pure metals such as potassium and sodium react violently (even explosively) with water and some other chemicals, and must be handled with care. Generally, these metals are stored in sealed containers in a non-reactive liquid to prevent decay (surface oxidation) from contact with moisture in the air
- White phosphorus is air-reactive and burns/explodes when in contact with room air. It must be kept in a sealed container with a non-reactive solution to prevent contact with air
- All of these metals are not uncommon in chemistry labs, but are generally only found in small quantities and accidental fires/reactions can be controlled or avoided completely through knowledge of the properties of the metals and using good judgment and common sense

Class E (electrical equipment)

Although you have already read about the management of electrical fire, here are some additional points to remember in case of electrical fire:

- Look for old wiring, worn insulation and broken electrical fittings. Report any hazardous condition to your supervisor
- Prevent motors from overheating by keeping them clean and in good working order. A spark from a rough-running motor can ignite the oil and dust in it
- Utility lights should always have some type of wire guard over them. Heat from an uncovered light bulb can easily ignite ordinary combustibles
- Do not misuse fuses. Never install a fuse rated higher than specified for the circuit
- Investigate any appliance or electrical equipment that smells strange. Unusual odours can be the first sign of fire
- Do not overload wall outlets. Two outlets should have no more than two plugs

Fire triangle

As discussed earlier, three entities are needed in suitable combination prior to ignition and combustion — heat, oxygen and fuel:

- There must be fuel to burn.
- There must be air to supply oxygen.
- There must be heat (ignition temperature) to begin and carry on the combustion process.

Combustion and the triangle of combustion

Ordinary combustion is a chemical reaction involving a fuel and oxygen in the existence of heat. In other words, it may be stated that three things are essential for combustion, which can be represented by the three arms of a triangle, viz., heat, combustible substance and the supporter of combustion or oxygen. A fire cannot take place in absence of any one of these three factors.

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In extinguishing a fire, all that is done is to break any of the arms of the 'Triangle of Combustion' (Figure 2.1). Heat may be removed and brought below the ignition point of the substance involved by pouring water (i.e., by cooling), or the supply of oxygen to the fire maybe stopped by smothering the fire by foam or dry sand (smothering) or the fire may be extinguished by removing the combustible substance from the scene of the fire (i.e., by isolation). Thus, whatever may be the equipment or the extinguishing media for fire-fighting, cooling, smothering and isolation or starvation are the three processes for fire extinction.

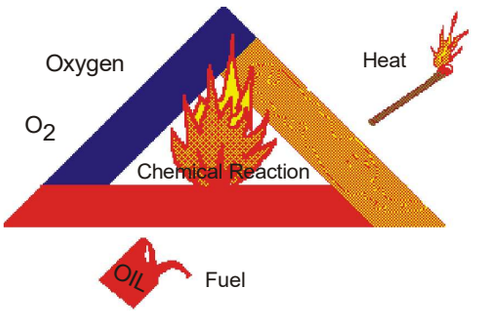

Fig. 2.1 *Fire Triangle*

Role of fuel in burning: Most of the fuels have a temperature (flash point) at which they give off flammable vapour. Burning takes place when these vapours mixed with air (oxygen) in the presence of ignition temperature. Practically, all fuel must vapourize before it burns. When these vapours reach the auto ignition temperature, the fuel vapour gets ignited automatically and burns.

Role of oxygen in burning: When correct amount of oxygen combines with flammable vapour at the flash point, burning takes place. For practical purpose, when sufficient oxygen is not present, a fire cannot burn. When oxygen supply is limited, hydrogen has a greater affinity for oxygen to form water vapour, leaving insufficient oxygen to produce carbon dioxide. Some of the carbon will remain unburned in the form of dense black smoke. Some of the carbon will find sufficient oxygen to form carbon monoxide.

Role of heat in burning: The combination of oxygen with fuel vapour, in burning, releases heat energy. This heat then goes on to vapourize more-and-more fuel, which in burning releases more heat in a rapidly accelerating process.

The experiments have, in fact, revealed that the oxidation process is complicated and takes place in various stages in the form of a chain reaction. It is the continuous, branched chain reaction in which free radicals are continuously generated and multiplied to propagate or spread the fire. Therefore, apart from aforementioned three elements, the fourth element, i.e., continuous branched chain reaction is also very essential to start and propagate a fire.

Fire protection at high-rise buildings

All the multi storey buildings and other premises are exposed to many fire hazards. As such, there is a requirement of ensuring that the hazards are minimized and those that exist are kept under control, such as oil, LPG, electrical appliances.

While construction of the building, it is for architects and designers to ensure design to minimize hazards, and install requisite fixed and portable fire-fighting equipment, ventilation and alarm systems. Fire detection panels are also installed in the buildings. Along with detectors, they are a formidable fire warning system. They are connected to alarms/ detectors, which when activated, send a signal to this fire detection panel. This enables the control room staff to identify the location of fire.

Construction and provisioning of fire-fighting measures

When different material are exposed to or come in contact with fire, the time taken for complete collapse or disintegration and the rate of flame through the material vary in each case. The factors, which largely effect these variations are as follows:

(a) Nature of materials, i.e., whether these are combustible or not

(b) Ignition temperature of the material if it is combustible

(c) Size, particularly thickness of the material

(d) Intensity of fire to which the material is exposed

(e) Physical load stresses which set on the structural component of which the concerned material form a part

In the last case, it follows the rate of growth and intensity of fire in a building, and its consequent collapse or resistance to fire depends upon the nature, quantity and distribution of combustible materials used in its construction and of those which are housed in it.

Fixed fire-fighting installations in buildings

The objective of providing fixed fire fighting water supply dry and wet systems in any building/ premises is to extinguish the fire immediately as it starts and to localize it at its place of origin till other extinguishing steps are taken and requisite help is available. Some of the fire-fighting installations are as follows:

- Wet riser
- Dry risers
- Down comer
- Sprinklers
- Roof drenchers
- Wall drenchers
- Window drenchers

Smoke and ventilation

At any building fire of even moderate intensity, the most serious obstacle to the rapid and successful attack on the fire has been the presence of impenetrable smoke and gases. This is more so in the case of fires occurring in the night. The volume of smoke prevents the firefighters from rapid attack on fire or for effecting rescues. It also does not give a true indication of the extent and severity of the fire. Therefore 'ventilating a fire' i.e., releasing the held up smoke and hot gases into the outside atmosphere is very important.

Improper ventilation is very dangerous. The problem becomes more acute in tall multi -storied buildings with air-conditioning systems. The smoke and the fumes might be carried throughout the building via air conditioning ducts, and, therefore, air conditioning plant needs to be stopped immediately in the event of a fire with release of smoke. Improper ventilation can be very dangerous.

Principle of fire extinguishers and fire at various urban settings

The specific instructions given should be followed on a fire extinguisher. Persons should be trained in the use of extinguishers to optimise their success.

General guidelines for using a fire extinguisher are as follows:

- Raise the alarm and call for help
- Keep your escape path at your back. Never allow the fire to get between you and the escape path
- Select the exact extinguisher for the various classes of fire
  - Remember **P.A.S.S**
  - **Pull** the pin
  - **Aim** the extinguisher nozzle at the base of flames
  - **Squeeze** trigger when holding the extinguisher upright
  - **Sweep** the extinguisher or nozzle from side to side covering the base of the fire
  - Watch fire after initial extinguishment, it may rekindle
  - The contents of small fire extinguishers may last as little as 8 seconds and in larger extinguishers, they may last up to 60 seconds. The time to discharge an extinguisher is based on the type and size of the extinguisher

2.3.2 Coal Fire

A coal seam fire or mine fire is the underground smouldering of a coal deposit. This kind of mishap often takes place in a coal mine. This kind of fire has economic, social and ecological impact. They are

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often started by lightning, forest fires, and grass. They continue to smoulder underground even after surface fire has been extinguished, sometimes for many years, before flaring up and restarting forest and brush fires nearby. They spread along mine shafts and cracks in geologic structures.

Coal fires pose serious threats to health and safety. They adversely affect the environment by releasing toxic fumes, reigniting bush, or forest fires, and grass, causing surface infrastructure such as roads, bridge, buildings, pipelines, and electric lines to subsidize. It can be started by both natural and man-made causes. It continues to burn for decades or even centuries until the source of fuel is exhausted, it encounters a permanent groundwater table, depth of the burn becomes greater than the capacity of the ground to subside and vent, or humans intervene. Since they burn underground, they are extremely difficult to extinguish and involve high costs.

2.3.3 Oil Fire

The raging oil tank fires in Jaipur have highlighted the condition of disaster preparedness and response mechanisms in India. It is frightening to note that several such oil depots are probably spread across the country with hardly any regulatory body and low levels of awareness about the magnitude of storage, risks and vulnerabilities amongst the residents around the area.

Oil well fires can cause loss of millions of barrels of crude oil per day. Combined with the ecological problems caused by large amounts of smoke and unburnt petroleum falling back to earth, oil well fires such as those seen in Kuwait can cause enormous economic losses. Smoke from burnt crude oil contains many chemicals, including sulfur dioxide, carbon monoxide, soot, benzopyrene, poly aromatic hydrocarbons and dioxins. Exposure to oil well fires is commonly cited as a cause of the Gulf War Syndrome, however, studies have indicated that the firemen who capped the wells did not report any of the symptoms suffered by the soldiers.

Gulf War oil spill

The Gulf War oil spill is regarded as the worst oil spill in history, resulting from actions taken during the Gulf War in 1991 by the Iraq military. It caused considerable damage to wildlife in the Persian Gulf especially in areas surrounding Kuwait and Iraq. Estimates on the volume spilled range from 42 to 462 million gallons; the slick reached a maximum size of 101 by 42 miles and was 5 inches thick. Despite the uncertainty surrounding the size of the spill, figures place it 5 to 27 times the size (in gallons spilled) of the Exxon Valdez oil spill, and more than twice the size of the 1979 Ixtoc I blow-out in the Gulf of Mexico.

According to a study sponsored by UNESCO, Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates and the United States, the spill did little long-term damage. About half the oil evaporated, a million barrels were recovered and 2 million to 3 million barrels washed ashore, mainly in Saudi Arabia. On 21 January 1991, Iraqi forces opened valves at the Sea Island oil terminal and dumped oil from several tankers into the Persian Gulf. The apparent strategic goal was to foil a potential landing by US Marines. The oil moved southward, ending up on the north coast of Saudi Arabia, endangering the fragile inter-tidal zones and mangrove forests and destroying wildlife habitats. The immediate reports from Baghdad said that American air strikes had caused a discharge of oil from two tankers. Coalition forces determined the main source of oil to be the Sea Island terminal in Kuwait. American airstrikes on 26 January destroyed pipelines to prevent further spillage into the Persian Gulf. Several other sources of oil were found to be active—tankers and a damaged Kuwaiti oil refinery near Mina Al Ahmadi, tankers near Bubiyan Island, and Iraq's Mina Al Bakr terminal.

Check Your Progress

4. Name the three heat transfer mechanisms.
5. What are the factors which affect the variation in the rate of flame?
6. Name some of the fire-fighting installations.
7. Which oil spill is regarded as the worst oil spill in history?

2.4 POLLUTION

The term pollution is derived from the Latin word *pollutioneum* meaning to 'make dirty'. Pollution can thus be defined as 'an undesirable change in physical, chemical and biological characteristics of air,

water and soil due to anthropogenic activities, which may harmfully affect the life or create a potential health hazard to all living organisms in the biosphere.' The extraneous materials and energy that cause pollution are termed as pollutants.

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Air Pollution

In this section, the different types of pollution will be discussed in detail.

Air pollutants are substances that when introduced into air can cause harm to the environment including human beings. These pollutants may be biological material or chemical substances that can be seen with naked eyes or can be in an invisible form.

There are many types of air pollutants that can cause a lot of damage to the environment. Apart from global warming, there are other severe damages that are caused to the ecosystem and which can harm the living beings. One such damage is the damage caused due to ozone layer depletion. The ozone molecule that contains three oxygen molecules reacts with carbon monoxide resulting in the formation of carbon dioxide and oxygen. Carbon monoxide is a highly reactive and an unstable molecule that is generated from vehicular exhaust.

The dense layer of ozone present in the upper atmosphere is responsible for filtering the harmful ultraviolet (UV) rays from the sun. The depletion of this important layer removes the protective support and exposes every living being to the harmful rays of the sun. There is no method by which ozone can be produced artificially as it is highly unstable and will react almost immediately with carbon monoxide.

When the ozone molecule absorbs the UV rays it gets converted into diatomic oxygen and a free radical.

The chlorofluorocarbon (CFC) emitted from refrigerators is another molecule that is very hazardous to the environment. The effect of electromagnetic radiation on CFC releases chlorine that is highly reactive with ozone. The chlorine molecule that is displaced will react with the ozone and lead to its depletion. The chlorine oxide is unstable and will react with one more molecule of ozone to release two diatomic oxygen and one chlorine molecules. This chlorine molecule will react with more ozone molecules and lead to reduction in the number of ozone molecules. On an average, every chlorine molecule takes about two years to find a stable compound with elements like hydrogen to form hydrogen chloride. During this period, it converts numerous molecules of ozone into diatomic oxygen molecules. CFC was initially used for air conditioners and for cleaning engineering equipment. Its use is now restricted to refrigerators and increased awareness is created to reduce its use. Substances like CFC that affect the ozone layer are called ozone-depleting substances (ODS). Other ODS include sulphuric acid, freons and so on. Aerosols also contain ODS and should be used sparingly.

The evidence that the ozone layer has been depleted is ascertained using the Total Ozone Mapping Spectrometer (TOMS), which helps in determining the thickness of the ozone layer. A hole in the ozone layer is evident over the Arctic region during spring, which gets bigger during summer and may extend over countries like Australia, New Zealand and Chile. This hole in the ozone layer exposes living beings to the harmful effects of the UV radiation and could increase the risk for certain forms of cancer, cortical cataracts and increase the production of vitamin D.

The effects of air pollution extend beyond contaminating the air that one breathes and can lead to further harm when these pollutants descend on land in the form of acid rain. The major pollutants that come down with acid rain are carbon dioxide, sulphur dioxide and nitrogen oxides. Certain industrial processes produce sulphur dioxide but government restrictions have made the treatment of sulphur dioxide mandatory. This has considerably reduced emissions of sulphur dioxide from the industrial sources but volcanic eruptions dispel sulphur dioxide in the atmosphere. Nitrogen oxides are produced as a result of lightning strikes. When rain mixes with sulphur dioxide it gets converted into sulphuric acid that affects clothes, statues and even paint. Acid rain and its effect on the ecosystem have prompted government to take stringent action against air pollution and to find ways to reduce harmful emissions from industries.

Air pollution is a critical form of pollution that requires immediate attention and guidelines that will helping curb, it. The best way to fully understand this form of pollution is to identify the sources of pollution.

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Sources of air pollution

Some major sources of air pollution are as follows:

Industrial sources

- Fossil fuel power plants generate a lot of carbon monoxide and sulphur dioxide
- Manufacturing units contribute largely to air pollution. Many industries use incinerators to dispose their waste that leads to air pollution

Mobile sources

- Motor vehicles are mobile sources of air pollution as their use leads to the emission of carbon monoxide that is a potent air pollutant
- Steam engines and airplanes are other mobile sources that contribute significantly to air pollution

Other sources of air pollution

- The use of firewood for cooking and for warmth is a cause for air pollution and further leads to indoor air pollution reaching very high levels.
- Forest fires and industrial accidents like burning of an oil reserve can lead to tremendous amount of pollution and also lead to the wastage of essential natural resources.
- Smoking of tobacco, especially within confined spaces can lead to passive smoking by other people in the room and is found to be more hazardous to the health of others as compared to the smoker himself.

Types of air pollution

Air pollution can be classified into the following categories depending upon certain possible reasons:

- Air pollution that is accidental
- Air polluted through industrial waste
- Air pollution related to transport
- Air pollution related to dwelling

Accidental air pollution

The reasons for accidental air pollution are:

- Forest fires
- Accidents in petroleum mass transport vehicles
- Blasts or leakages in industries

Industrial air pollution

The reasons for industrial air pollution are:

- Emissions from thermal power plants
- Excessive use of chemical fertilizers, pesticides in farming as well as waste disposal from pharmaceutical industries
- Industrial wastes from industries such as steel, sugar and paper industries Due to cement, steel, paper and sugar industries
- Textile and textile-related industries
- Petroleum and other related industries
- Atomic units are also responsible to a certain extent

Transport related air pollution

Pollution due to:

- All types of terrestrial transport systems
- Urban transport system
- Other modes of transport

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Dwelling related air pollution

Pollution due to:

- Use of aerosols
- High density of population
- Waste disposal system

2.4.1 Water Pollution

Water pollution means the contamination of water bodies with pollutants that are potentially harmful to human beings and other living beings. The unpleasant change in water may lead to changes in the colour, taste and/or even the odour of water, rendering it completely unpalatable because of the high level of toxic compounds present in the water.

Water is an essential resource that is required for many basic functions that include water for drinking, bathing, washing and cooking. A high level of contamination of water will, therefore, affect humans immensely and lead to a host of infections and disorders depending upon the level of contamination of water.

Sources of Water Pollution

Industries

Industries are one of the major causes behind water pollution as waste from factories may be discharged into nearby streams and rivers. This leads to pollution of the water bodies with harmful chemicals that would endanger the aquatic life. Some of the chemicals that are part of the chemical effluents from industries include lead, mercury, asbestos, sulphur and nitrous oxides. These metallic and non-metallic chemicals are hazardous to life and should be treated well before they are let down into streams. Metallic pollutants like mercury are ingested by fish and affect anyone who consumes the contaminated fish. The high toxic levels of such pollutants make it important to ensure that these substances are converted into safe alternatives before they are let out into the environment.

Sewage

Sewage is another source of water pollution, especially in a developing country like India. The lack of proper sewage system that collects all the sewage from a house and drains it in a common pool for treatment is a common phenomenon in developing countries. The sewage from houses contain mostly human faeces and is completely biodegradable but when it is let out into a water body without proper treatment it can cause a lot of harm to the aquatic life. People with illnesses will pass out micro-organisms along with their stool, which will result in these harmful micro-organisms being let out in the sewerage system leading to contamination of the water body. When sewage pipes mix with water meant for drinking, it can cause diarrhoea and illness in people who drink this contaminated water.

Nuclear waste

Nuclear waste is another source of water pollution as the disposed nuclear waste poses a threat to all living beings. Apart from nuclear reactors, nuclear mining also contributes to nuclear waste generation. The nuclear waste that is disposed in water bodies does not disintegrate easily. This has been witnessed in Greenland where traces of nuclear material disposed from reactors in East Europe have been found.

Oil

Oil is a major contaminant that can affect marine life drastically as oil forms a layer over water and prevents contact with air. This affects fish and water plants. Oil also sticks to the feathers of birds that scoop down to pick fish and results in the bird's inability to fly. Oil contamination in seas occurs during the transfer of oil via oil pipes, from ships and other vessels. Though the effect of oil spills is localized, it can lead to drastic loss of marine life.

Marine life is also affected by inconsiderate dumping of waste by tourists who visit beaches and lakes. Styrofoam, paper, plastic, glass and even aluminium are commonly disposed in water bodies that affect fish and other aquatic life.

Acid rain

Acid rain that results from air pollution contains sulphuric acid and nitric acid that could affect marine life. The sulphur dioxide and nitrous oxide from industrial emissions mix with water particles from rain and result in rain that is acidic in nature.

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The increase in air pollution has also been found to affect water bodies in the form of rising water temperatures due to global warming. The increase in the concentration of carbon dioxide in the atmosphere results in the trapping of heat from the sun that leads to an increase in global temperatures. As the temperature increases, snow-capped mountains and glaciers melt leading to an increase in water volume. Moreover, there is also an increase in the water temperature that can disturb marine life.

Water pollution is a threat to the people living in developing nations as there are many water-borne diseases that spread through contaminated water. Apart from man-made causes that lead to water pollution, there are certain natural causes like volcanic eruptions that can lead to the addition of sulphur in the water body. Algal bloom is another natural water contaminant but its effect is very small and inconsiderate in comparison to other causes of water pollution.

Classification of water pollution

The causes of water pollution may be classified into two broad categories—point sources and non-point sources.

Point sources

Direct sources of water pollution like effluents from industries that are let into water bodies without being treated are called point sources. The point sources of water pollution are easy to identify and easier to correct when compared with non-point sources of pollution.

When large volumes of effluents are discharged into water bodies they cause drastic changes to the quality of water and result in complete annihilation of aquatic life in extreme cases.

Point sources of water pollution include:

- Water pollution caused by oil refinery wastewater discharge outlet
- Noise pollution resulting from jet engines
- Seismic vibrations
- Light pollution by intrusive street lights
- Thermal pollution by industrial processes
- Radio emissions from electrical devices

Non-point sources

These sources of water pollution include sources that are multiple and which pass through various channels before they finally reach the water body. Examples of non-point sources include:

- **Rain water from busy roads:** Rain water that is collected from busy roads carries all the dirt and grime of road along with the existing pathogens. When this water is carried off into lakes it is dangerous for the people drinking water from the lake as well as the lake ecosystem.
- **Water from agricultural fields:** Water from the agricultural fields contains chemicals resulting from pesticides and manures. It affects the aquatic life owing to the toxicity of the chemicals from the pesticides. This is a non-point source of pollution as the water runs from many fields till it finally reaches the water body.
- **Emissions from various factories:** These lead to air pollution whose effects finally reach the water bodies when the emission mixes with water or snow and falls as acid rain.

Some important non-point sources of water pollution include:

- Excess fertilizers, insecticides and herbicides from agricultural lands
- Oil, grease and toxic chemicals carried by the urban runoff
- Sediment from the construction sites, crops and forest lands
- Salt from irrigation practices
- Acid drainage from abandoned mines
- Bacteria and nutrients from pet wastes, livestock and defective septic systems
- Atmospheric deposition and hydro-modification

Check Your Progress

8. What are the various types of air pollution?
9. List the reasons for accidental air pollution.
10. What are point sources?

2.5 INDUSTRIAL POLLUTION

Rapid and unplanned industrialization, urbanization, and deforestation cause the release of a variety of extrageneous materials (inorganic, organic, biological or radiological) and energy into the environment in a continuous and uninterrupted manner. Industrial pollution can be in various forms such as air, water, soil, noise. In the previous section air and water pollution has already been discussed. In this section, we will discuss noise, soil, thermal and nuclear pollution in detail.

2.5.1 Noise Pollution

We hear various types of sounds everyday. Sound is a form of mechanical energy emitted from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise.

The CPCB (Central Pollution Control Board) has recommended permissible noise levels for different locations.

Effects of noise

- **Interferes with man's communication**: In a noisy area, communication is severely affected.
- **Hearing damage**: Noise can cause temporary or permanent hearing loss. It depends on the intensity and duration of sound level. Auditory sensitivity is reduced with noise levels over 90 dB in the mid-high frequency, for more than a few minutes.
- **Physiological and psychological changes**: Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), gastro-intestinal and digestive disorders.

Control of Noise Pollution

The various measures which help in controlling noise pollution are mentioned below:

- Reduction in the sources of noise
- Noise making machines should be kept in containers with sound absorbing media. The noise path will be interrupted and will not reach the workers
- Proper oiling will reduce the noise from machinery
- Use of sound absorbing silencers, silencers can reduce noise by absorbing sound. For this purpose, various types of fibrous material can be used
- Planting more trees that have broad leaves
- Legislation can ensure that sound production is minimized at various social functions. Unnecessary blowing of horn should be restricted especially in vehicle-congested areas and areas close to hospitals.

Case study: Pollution in the Rio Grande (Rio Grande)

In 1965, Mexico initiated the Border Industrialization Programme, now widely as the maquiladora programme. Under this programme, foreign companies (primarily from the US and Asia) could construct factories in Mexico and import parts and materials to those factories duty-free. With the growth of this system, however, the potential for water pollution has increased. Several factors have contributed to pollution on the Rio Grande. These include inadequate sewage treatment in many communities on both sides of the border, oxygen-demanding substances and pathogenic micro-organisms and pesticide contamination

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from farming regions around the Rio Grande valley. Finally, there is a threat of toxic chemical contamination due to the operation of the maquiladoras and other industries located on both sides of the border.

In February 1992, the United States and Mexico issued the Integrated Environmental Plan for the Mexican-US Border Area (First Stage, 1992–94). The plan calls for the two countries to work together to solve environmental problems in the border area, specifically, to identify areas where any trans-boundary water source or potential trans-boundary water source is contaminated or where there is an identifiable threat of contamination.

The North American Free Trade Agreement (NAFTA), signed in 1993 between the two countries, has also contributed to greater environmental awareness. Part of the public debate surrounding NAFTA centred on the environment, especially the implications of increased US-Mexico economic integration for the border environment. To address these concerns, NAFTA was accompanied by environmental 'side agreements' setting up new binational and trinational agencies to deal with environmental issues. These included: (i) the lack of waste water treatment and drinking water systems; (ii) problems tracking and accounting for hazardous waste generated by maquiladora plants and (iii) concerns about industrial air and water pollution associated with maquiladora plants.

To deal with these issues more effectively, both the US Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (TNRCC), in conjunction with their Mexican counterparts, have strengthened their border-related operations. The Rio Grande begins in the San Juan Mountains of southern Colorado and follows a 1,885-mile course before it empties into the Gulf of Mexico. Along the way the river and its tributaries drain a land area more than twice the size of California. This drainage area, or basin, covers widely varied landscape in the US and Mexico including mountains, forests, and deserts. The basin is home to diverse native plants and wildlife as well as some 10 million people. For approximately two-thirds of its course, the river also serves as the boundary between the countries.

The river is an important natural resource for industry, agriculture, domestic water supply, recreation and aesthetic enjoyment, and wildlife and aquatic habitat. Most of the major tributaries, and some of the lesser ones, are also of significance in these respects. Substantial agricultural areas are irrigated by the waters of the Rio Grande. The river is the primary source of drinking water for up to 98 per cent of the population in both countries.

NAFTA has brought with it not only the potential for greater economic growth but also a larger population and increased industrialization on the border, and according to a biennial report authorized by the Texas Clean Rivers Act (1991), increased population and industrialization creates greater risk to the quality and quantity of the water that is available.

Population growth has occurred on both sides of the border in the last ten years. NAFTA and the previous Border Industrialization programme have facilitated this growth. The increased population has not only brought with it increased job opportunities, it has also created greater environmental hazards in the form of inadequate sewage treatment, pesticide contamination and chemical contamination.

With respect to waste water treatment, greater priority will be given to projects that deal with water pollution, wastewater treatment and municipal solid waste. A study found that the cost of constructing wastewater treatment plants for Mexican border towns would be about $ 2 billion, but this funding could be the single most important factor in the effort for improved water quality in the basin.

Second, in order to better track waste movements across the border and to conduct monitoring of air and water quality in the region, in 1993 the Texas Natural Resource Conservation Commission established an office of Border Affairs and Environmental Equity. This office coordinates the Texas Natural Resource Conservation Commission's efforts and tracks federal activities with respect to border environmental issues and works with state environmental departments in the four Mexican states that border Texas.

Finally, to address the problem of pollution caused by the Maquiladora system more effectively, the biennial report from the Texas Clean Rivers Act suggests utilizing local

steering committees to encourage public input about the specific problems or concerns they have regarding their communities. Examples of this include the Dia del Rio, a citizen-led event organized by the Rio Grand/Rio Bravo Basin in October 1995 and the Clean Rivers Program Water Quality Issues Meeting in January 1996.

Source: Adapted from Patrick Sanders, 'Pollution in the Rio Grande', TED Case Studies No. 382, 18 December 96.

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2.5.2 Thermal Pollution

Thermal pollution is defined as the presence of excessive heat in the water which may bring about undesirable changes in the natural environment. Industries like thermal power plants, nuclear power plants, refineries and steel mills produce large volumes of heat and therefore contribute majorly to thermal pollution.

Effects of thermal pollution

- Since oxygen solubility is much less at higher temperatures, the dissolved oxygen content of water comes down due to thermal pollution
- Raised temperatures prevent penetration of oxygen into cold water at the depths of the water body
- Higher temperatures lead to an increase in the toxicity of pesticides, detergents and chemicals in the effluents
- Raised temperatures of water lead to change in the overall composition of flora and fauna as more temperature-tolerant species thrive and those that cannot take warm temperatures slowly die out.
- Aquatic organisms become more active metabolically at high temperatures and thus need more oxygen for survival.
- Presence of excessively hot water close to the shores disrupts fish spawning patterns and may even lead to young fishes dying
- Fish migration patterns also change because of the formation of various thermal zones

Control of Thermal Pollution

The following techniques may be used for controlling thermal pollution:

- Cooling ponds
- Spray ponds
- Cooling towers

2.5.3 Marine Pollution

Marine pollution is largely caused by:

(1) Rivers: They bring up pollutants from drainage basins

(2) Catchment areas and coastlines where human activity is large-scale such as, in the form of hotels, industry and agricultural practices

(3) Oil drilling and shipping

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Rivers mostly end up in oceans. Along with the water, pollutants mixed into the river also go into the seas. Pollutants include agro-chemicals, industrial effluents, sewage sludge, synthetic detergents, plastics, solid wastes, waste heat and metals released by industries.

Once the pollutants have been secreted into the sea, they are diluted and broken down. However, there are some chemicals that either remain as is or become even more toxic, thereby leading to marine pollution.

Some industries that contribute to marine pollution include petroleum refinery, metal and paint industries, automotive waste refineries, and any other industry that uses lubrication oil. Besides industries, tankers and other large ships, ship accidents and offshore production also cause marine pollution. When there is an oil spill in the sea, the oil slick spreads over a large part of the sea and remains dispersed until it is chemically removed. This kind of oil slick is very harmful for marine life.

Control of marine pollution

Marine pollution can be controlled to a large extent if following measures are undertaken:

- Industries and sewage treatment plants should take care that their toxic waste is not being discharged into coastal waters.
- Random oil spills caused by accidents should be stopped from reaching coastal waters
- Sewer and rainwater pipes should be maintained separate so that there is no sewage overflow into the clean water
- There should be a ban on dumping of toxic, hazardous wastes and sewage material
- Coastal areas should be kept as clean and as minimally commercialized as possible
- Oil and grease from service stations should not be dumped into the sea and instead, processed for reuse
- Drilling should not be allowed in ecologically sensitive coastal areas

2.5.4 Soil Pollution

Soil is formed by the weathering of rocks and forms the topmost layer of the earth's crust. Soil contains organic matter which means it is a good medium for living organisms to grow. When toxic materials and chemical waste is dumped on soil, it gets polluted. Some common waste that is dumped on soil includes garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers and paint varnishes. Some more harmful chemicals that cause soil pollution are leachates from dumping sites and sewage tanks.

Soil is also commonly polluted by fly ash which is a by-product of thermal power plants. Most industrial effluents contain certain organic and inorganic compounds which are non-biodegradable. Human and animal excreta also reach the soil and pollute it because sewage contains worms, bacteria, viruses and pathogenic organisms that cause pollution of the soil.

Effects of Soil Pollution

When soil gets polluted by sewage and industrial effluents, ultimately human health gets adversely affected. Chemicals such as acids, alkalis, pesticides and insecticides found in the industrial discharges harm the fertility of the soil fertility by bringing about changes in its chemical, physical, biological attributes. The persistent chemicals, especially, which do not get broken down become toxic, accumulate in the food chain and ultimately affect human health.

Control of soil pollution

Soil pollution can be controlled in the following ways:

- Before they are discharged into the soil, effluents should be properly treated
- Solid waste should be carefully broken down and disposed by appropriate methods and as far as possible, reusable portions should be recovered from the waste material

- Biogas should be generated from the biodegradable organic waste rather than the waste just being dumped into the soil
- Methane should be generated from cattle dung. Likewise, night soil may be used to produce methane gas
- Soil pollution can also be reduced by the technique of microbial degradation of biodegradable substances

2.5.5 Nuclear Hazards

Radioactive substances naturally exist and keep undergoing gradual radioactive decay, wherein unstable isotopes spontaneously give out high energy radiations and fast moving particles, or both, at a specific rate, until a new stable isotope is formed.

These particles and rays have the ability to penetrate paper and wood but are blocked by concrete wall, lead slabs or water. Different types of radiations may cause different levels of damage, depending on where the source of radiation is and how strong is its penetration power.

Control of nuclear pollution

Nuclear pollution can be controlled in the following ways:

- Setting up of nuclear power plants must be carried out only after carefully studying long-term as well as short-term effects.
- Proper disposal of wastes from laboratories using radioisotopes should be done.

2.5.6 Impact of Industrial Waste on the Environment

Materials which are mainly generated through anthropogenic activities and are discarded as useless or unwanted are called wastes. The waste may be solid, liquid and gaseous wastes. On the basis of the source of generation, they are classified as (i) domestic waste (2) commercial wastes (3) institutional waste (4) agricultural waste (5) biomedical waste and (6) industrial waste. The waste generated from the industrial sectors are known as industrial wastes. The industrial wastes are organic or inorganic in nature. Some of the wastes are biodegradable or non-biodegradable in nature. The wastes are also known as hazardous or non-hazardous waste.

These wastes are generally discharged from chemical industries, refineries, textile industries, drug industries, fertilize plants. All the wastes that are generated from industries have a greater effect on all living organisms and especially the victims are the organisms in the local environment.

Wastes polluting air

The major air pollutants are carbon oxides (CO and CO_2); sulphur oxides (SO_2, SO_3); nitrogen oxides (NO, NO_2, N_2O). Particulate matter are root, smoke, very fine particles, such as lead, manganese, asbestor, arsenic, copper, zinc, etc. Proxy acyl nitrate (PAN), Ozone (O_3).

The industrial wastes polluting the air mainly come from the burning of fossil fuels in industries. The industries that produce various products, such as textile industry which produces cotton dust, nitrogen oxides, chlorine, smoke, sulphur dioxide; fertilizer plants produce oxides of sulphur, particulate matter, ammonia nitrogen oxides, hydrocarbon steel plants produce carbon monoxide, carbon dioxide, sulphur dioxide, fluorine, particulate matter.

The following are the effects of the major air pollutants:

- Carbon monoxide combines with blood haemoglobin and forms stable carboxy haemoglobin, disturbing oxygen transportation and might cause death
- Oxides of nitrogen causes respiratory irritation, impairment of lung defence, bronchitis, loss of appetite.
- Sulphur dioxide causes suffocation, respiratory irritation, asthma and chronic bronchitis
- Particulate matter causes respiratory diseases, neural disorders and depending on the nature of element it might lead to cancer. If lead is present in the particulate matter and inhaled it might lead to mental retardation in children

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- Ground level O_3 causes headache, suffocation and in extreme cases can be fatal
- Proxy acyl nitrate (PAN) is produced nearer to the industry producing NO_2, volatile organic compound; through some mechanism this might be formed and affects local people severely by causing eye irritation, sore throat, respiratory irritation, headache.
- When lot of sulphur oxide particulate matter is formed then sulphurous smog might be formed which might lead to chronic bronchitis and acute respiratory problems

Wastes polluting water

The major sources of water pollution is industrial discharges especially from manufacturing plants. These industries discharge organics, such as toxic metals, pesticides, nitrate salts. Ground water pollution can occur when industrial waste is discharged into pits, ponds or lagoons, thereby enabling wastes to percolate down to the water table. The oxygen demanding wastes are introduced from paper industry, textile industry, food processing plants, toxic metals, such as Hg, Pb, Cd, Cr, Ni, from the electroplating industry. The ground water pollution stems from disposal of wastes on or into the ground. The wastes, mainly in the rainy season, precolate into the ground and contaminate it. The typical pollutant sources are industrial waste water impoundments, sanitary land files, storage piles which are improperly constructed. The pollutants in water are limitless, some of them can be biochemical oxygen demand wastes, antimony, cadmium, chromium, lead, cobalt, mercury, etc. Generally, many industries, such as steel, paper industries are situated on the banks of rivers, as they require huge amounts of water in their operations. Such industries dump their wastes which contains acids, alkalis, dyes into the rivers. Many of these materials are poisonous for living organisms and causes serious water pollution problems.

Some of the effects of various pollutants are as follows:

- **Oxygen demanding wastes:** With the increase of oxygen demanding wastes, the dissolved oxygen in water drops and this threatens aquatic life. Water loses its life-giving quality and helps in the growth of pathogens making it completely unusable.
- **Nutrients:** The industry, especially fertilizer industry, discharges a lot of nitrogen oxide which goes to water bodies through acid rain, and if larger concentration accumulates and local people use this water, their children might be affected with blue baby syndrome.
- **Thermal pollution:** Steel industry, nuclear reactors, electric power plants use huge amount of water for cooling processes. The water discharged is very hot and causes thermal pollution. The high temperature depletes oxygen level, and thus fish and aquatic organisms get affected. The local people who depend on these water resources also become affected. Again the cooling water produces waste water with salts.
- **Heavy metals, Cd like Hg, Pb, As:** Heavy metals have great effect on human health as they may lead to kidney damage, disorder of liver, brain, genetic modifications, skin cancer and cirrhosis.

Wastes polluting land

Industrial wastes polluting land are generally wastes, such as office and cafeteria wastes, packing wastes, tannery wastes, dying wastes, food processing wastes; plastic wastes, metal scraps, pesticides, from the respective industrial establishments. These wastes represent a health hazard due to their content in toxic substances, such as heavy metals, lead and cadmium, pesticides, solvents and used oil. The pollutants discharged into the soil can alter the chemical and biological properties of the soil. The toxic elements, such as lead, mercury, cadmium, pose a detrimental threat, as they get into the food chain. The coal-based thermal power plants generates fly ash which gets deposited in the soil and causes serious pollution by changing the characteristics of the soil. The fly ash so formed covers the leaves of plants. And when the fly ash is inhaled, it causes serious health problems. An ideal example is the Kolaghat thermal power plant in Midnapore, where people are seriously affected. Discarded plastics affect water resources in the local environment.

Wastes creating noise pollution

Noise is an unwanted sound energy and is considered as pollutant when it exceeds permissible limits. Noise pollution has been growing steadily mainly due to industrialization. Noise pollution has tremendous effect on the local environment. It disturbs and distracts. If the local people are exposed to it for a long

enough time, it causes physiological effects that may lead to deafness. Noise pollution may lead to cardiovascular problems like heart diseases and with blood pressure.

Sources of Urban and Industrial Wastes

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Urban and industrial wastes consist of medical waste from hospitals, municipal solid waste from homes, offices, markets (commercial waste) small cottage units, and horticultural wastes from parks, gardens and orchards.

The urban solid waste materials that can be degraded by micro-organisms are called biodegradable wastes; for example, vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves, are solid wastes. Wastes that cannot be degraded by micro-organisms are called non-biodegradable wastes such as polyethene bags, scrap metal, glass bottles.

Industrial waste consists of a large number of materials, including factory rubbish, packaging material, organic waste and acids. There are large quantities of hazardous and toxic materials which are also produced during industrial processing.

Effects of solid wastes

Municipal solid waste heaps up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings, which affects the community, including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms, besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in the physiochemical and the biological characteristics, thereby affecting the productivity of soils. Toxic substances may leach or percolate and contaminate groundwater.

Managing industrial waste

It takes a lot of valuable energy and materials to create and manufacture products and the resulting industrial waste can be difficult to manage. New laws have been brought into effect by many cities and countries to impose tax on companies that generate excessive waste or have the potential to harm the ecosystem. The extra taxes compensate for the damage caused to the environment such that the money can be used for the protection and restoration of the environment and for spreading information about this issue among the general public. It is important that every citizen and all companies are aware of the importance of preservation of the environment and the things which may threaten it. For example, the general public should be aware that only traffic is not responsible for causing smog; factories also emit harmful gases into the air we breathe. It is the responsibility of every organization to be responsible about industrial waste management and especially hazardous waste management. In fact, most local governments are now providing consulting and recommendation advisories to manufacturing organizations on how they can manage their waste in a better way and opt for environment-friendly production processes. In the modern context, it is important that disciplinary action is immediately taken against companies that are casual about waste management and thus damage the environment. Regular monitoring and speedy action will ensure that gradually the emission of harmful gases into the environment is sufficiently controlled and waste materials are disposed correctly.

Law-making agencies in most countries are now formulating terms and conditions for acceptable levels of waste and waste management. This is making most industries realize the harmful impact their processes have on the environment and that they need to manage their waste better. Industry leaders are stepping up to take responsibility for the preservation of the environment. Likewise, the average citizen also needs to become more aware and show support for the companies that are responsible and environment-conscious. The key ways in which every company can manage waste better include using energy more efficiently, reducing hazardous waste emissions into air and soil and recycle and compost.

There are many companies that cannot avoid producing hazardous waste due to the nature of the work they do but for these companies, it is important to dispose that waste prudently and also be honest to the public and government about the contents of the waste they are producing and how they are managing it. The government, through provisions in the environmental protection Acts can support and reward companies that take responsibility and put in maximum efforts to minimize the harmful effects on the environment. Many cases have been identified where companies have deliberately misrepresented information and contaminated natural water bodies with hazardous waste. It is important for the general

public and government to push companies to reform and make them realize their role in protecting the environment.

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Check Your Progress

11. Define thermal pollution.
12. Name the methods that can be employed for controlling thermal pollution.
13. What are the main sources of marine pollution?
14. List the two measures useful in controlling nuclear pollution.

2.6 DEFORESTATION

The total forest area of the world in 1990 was estimated to be 7000 million hectares which was reduced to 2890 million hectares in 1975 and fell down to just 2300 million hectares by 2000. Deforestation rate is relatively less in temperate countries, but it is very alarming in tropical countries where it is as high as 40-50 percent and at the present rate is it estimated that in the next 60 years we would lose more than 90 percent of our tropical forests.

The forested area in India seems to have stabilized since 1982 with about 0.04 per cent decline annually between 1982-90. Food and Agricultural Organization of the United States or FAO (1983) estimated that about 1.44 million hectares of land were brought under afforestation during this period leading to stabilization. As per FAO estimates, the deforestation rate per unit population in India is the lowest among the major tropical countries, despite the fact that we have a huge population size and very low per capita forest area (0.075 ha per capita). However, we are still far behind the target of achieving 33 per cent forest areas, as per our National Forest Policy. We have only 19.27 per cent of our land area (63.38m ha) covered by forests based on satellite data (MoFF, 1998).

Major causes of Deforestation:

- **Shifting cultivation**: There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supported so clear more than 5 lakh ha of forests for shifting cultivation annually. In India, we have this practice of North-East and to some extent in Andhra Pradesh, Bihar and M.P. which contribute to nearly half of the forest clearing annually.
- **Fuel requirements**: Increasing demands for fuel wood by the growing population in India alone has shooted up to 300-500 million tons in 2001 as compared to just 65 million tons during independence, thereby increasing the pressure on forests.
- **Raw materials for industrial use**: Wood for making boxes, furniture, railway-sleepers, plywood, match boxes, pulp for paper industry have exerted tremendous pressure on forests. Plywood is in great demand for packing tea for tea industry of Assam while fir tree wood is exploited greatly for packing apples in J & K.
- **Development projects**: Massive destruction of forests occur for various development projects like hydroelectric projects, big dams, road construction, mining.
- **Growing food needs**: In developing countries this is the main reason for deforestation. To meet the demands of rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.
- **Overgrazing**: The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into the grazing lands. Overgrazing by the cattle leads to further degradation of these lands.

Major consequences of deforestation

Deforestation has far reaching consequences, which may be detailed as below:

- It threatens the existence of many wild life species due to destruction of their natural habitat
- Biodiversity is lost and along with that genetic diversity is eroded
- Hydrological cycle gets affected, thereby influencing rainfall

- Problems of soil erosion and loss of soil fertility increase
- In hilly areas it often leads to landslides

Major activities in Forests

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- **Timber extraction:** Logging for valuable timber, such as teak and Mahogany not only involves a few large trees per hectare but about a dozen more trees since they are strongly interlocked with each other a by vines. Also construction of roads causes further damage to the forests.
- **Mining:** Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas. Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining. More than 80000 ha of land of the country is presently under the stress of mining activities. Mining and its associated activities require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.

  Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminating mining of various minerals over a length of about 40 km. The forested area has declined at an average rate of 33 per cent and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.

  Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas has caused extensive deforestation in Jharkhand. Mining of magnesite and soap stones have destroyed 14 ha of forest in hill slopes of Khirakot, Kosi valley, Almora. Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation. The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

2.6.1 Road and Rail Accidents

Society today faces major land transport problems. Human and financial costs of road accidents and rail incidents are increasing. Road accidents have been predicted to become the third largest cause of death and injury globally by 2020. Several social trends pose threats to safety, including increasing traffic congestion and vehicle ownership, complex technological advancement at the human-vehicle interface, failure to maintain lane or yield to oncoming traffic when turning are prime causes of accidents on four lane, non-access controlled National Highways. In India, a general lack of respect for traffic rules is a contributing factor for road accidents.

The frequency of traffic collisions in India is amongst the highest in the world. A National Crime Records Bureau (NCRB) report revealed that every year, more than 135,000 traffic collision-related deaths occur in India. According to road traffic safety experts, the actual number of casualties may be higher than what is documented since many traffic accidents go unreported. The *Global Status Report on Road Safety* published by the World Health Organization (WHO) identified the major causes of traffic collisions as driving over the speed limit, driving under the influence, and not using helmets and seat belts. The report noted users of motorcycles and motor-powered three-wheelers constitute the second largest group of traffic collision deaths.

Similarly, in railways the rate of accident is near about 300 each year. It requires immediate attention. Though incidents of collision and derailment have reduced to a great extent but human error and fire continue to be the major reasons behind occurrence of accidents. Indian railways lack new technologies; hence, chances of human error are more. Studies have revealed that a number of times safety measures are compromised. Another cause of rail accidents is the presence of unmanned crossings. In India there are 50,000 crossings, out of which 15,000 are unmanned. Road users do not take proper precautions and cross lines even if the signal is red leading to accidents.

2.6.2 Air and Sea Accidents

The Convention on International Civil Aviation Annex 13 defined aviation accident as an occurrence associated with the operation of an aircraft, which takes place between the time passenger boards the aircraft until all of them have disembarked, where a person is fatally or seriously injured, the aircraft sustains damage or structural failure or the aircraft is missing or is completely inaccessible. According to Aircraft Crashes Record Office (ACRO), a non-government organization based in Geneva, recent years

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have been considerably safer for aviation with fewer than 140 accidents every year between 2009 and 2013, compared to as many as 211 as recently as 1999.

A maritime disaster is an event which usually involves a ship or ships and can involve military action. Owing to the nature of maritime travel, there is often a substantial loss of life. A number of times, maritime disasters happen outside the realms of war. All ships are vulnerable to changing weather conditions, human error and even faulty design which results in accidents.

Check Your Progress

15. List two consequences of deforestation.
16. Define maritime disaster.

2.7 SUMMARY

- Man-made disasters are the risks that are caused due to human ambitions or carelessness, or because of human designs which are not able to endure the forces of nature.
- Accidents are another form of man-made disasters that result in loss of life and property.
- In 1986, the first and one of the worst nuclear power plant disasters took place at the Chernobyl Nuclear Power Plant in Ukraine.
- On the basis of the source of their origin, chemicals are divided into two categories – organic and inorganic.
- Chemical disasters affect all elements of the environment adversely. They could lead to death and destruction and heavy expenditures to set right the damage caused to the elements of the environment.
- A biological disaster is a kind of natural disaster that is associated with the devastating effects, mostly caused by an enormous spread of a certain kind of biological agent or bacterium or virus.
- Three entities are needed in suitable combination prior to ignition and combustion — heat, oxygen and fuel— there must be fuel to burn, there must be air to supply oxygen, there must be heat (ignition temperature) to begin and carry on the combustion process.
- The Gulf War oil spill is regarded as the worst oil spill in history, resulting from actions taken during the Gulf War in 1991 by the Iraq military.
- The causes of water pollution may be classified into two broad categories: point sources and non-point sources.
- Direct sources of water pollution like effluents from industries that are let into water bodies without being treated are called point sources.
- Non-point sources Non-point sources are the sources of water pollution include sources that are multiple and which pass through various channels before they finally reach the water body.
- The extraneous materials and energy that cause pollution are termed as pollutants.
- Thermal pollution can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.
- The main sources of marine pollution are 1) rivers, which bring pollutants from their drainage basins 2) catchment areas, and, coastlines where human settlements in the form of hotels, industry, agricultural practices have been established and 3) oil drilling and shipping.
- Several social trends pose threats to safety on roads, including increasing traffic congestion and vehicle ownership, complex technological advancement at the human-vehicle interface, failure to maintain lane or yield to oncoming traffic when turning are prime causes of accidents on four lane, non-access controlled National Highways. In India, a general lack of respect for traffic rules is a contributing factor for road accidents.
- Human error and fire continue to be the major reasons behind occurrence of accidents. Indian railways lack new technologies; hence, chances of human error are more. Another cause of rail accidents is the presence of unmanned crossings.

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2.8 KEY TERMS

- **Biological disaster**: A biological disaster is a kind of natural disaster that is associated with the devastating effects, mostly caused by an enormous spread of a certain kind of biological agent or bacterium or virus.
- **Pollutants**: The extraneous materials and energy that cause pollution are termed as pollutants.
- **Thermal Pollution**: Thermal pollution can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.

2.9 ANSWERS TO 'CHECK YOUR PROGRESS'

1. In 1986, the first and one of the worst nuclear power plant disasters took place at the Chernobyl Nuclear Power Plant in Ukraine.
2. On the basis of the source of their origin, chemicals are divided into two categories – organic and inorganic.
3. A biological disaster is a kind of natural disaster that is associated with the devastating effects, mostly caused by an enormous spread of a certain kind of biological agent or bacterium or virus.
4. The three heat transfer mechanisms are:
   - Radiation
   - Convection
   - Conduction
5. The factors which affect the variation in the rate of flame are:
   - Nature of materials, i.e., whether these are combustible or not
   - Ignition temperature of the material if it is combustible
   - Size, particularly the thickness, of the material
   - Intensity of fire to which the material is exposed
   - Physical load stresses, which set on the structural component of which the concerned material form a part
6. Some of the fire-fighting installations are as follows:
   - Wet riser
   - Dry risers
   - Down comer
   - Sprinklers Roof drenchers
   - Wall drenchers
   - Window drenchers
7. The Gulf War oil spill is regarded as the worst oil spill in history, resulting from actions taken during the Gulf War in 1991 by the Iraq military.
8. Air pollution can be classified into the following categories depending upon certain possible reasons:
   - Air pollution that is accidental
   - Air polluted through industrial waste
   - Air pollution related to transport
   - Air pollution related to dwelling
9. The reasons for accidental air pollution are:
   - Forest fires

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- Accidents in petroleum mass transport vehicles
- Blasts or leakages in industries

10. Direct sources of water pollution like effluents from industries that are let into water bodies without being treated are called point sources.
11. Thermal pollution can be defined as the presence of excessive heat in the water which can cause undesirable changes in the natural environment.
12. The following methods can be employed for control of thermal pollution:
    - Cooling ponds
    - Spray ponds
    - Cooling towers
13. The main sources of marine pollution are 1) rivers, which bring pollutants from their drainage basins 2) catchment areas, and, coastlines where human settlements in the form of hotels, industry, agricultural practices have been established and 3) oil drilling and shipping.
14. Nuclear pollution can be controlled in the following ways:
    - Setting up of nuclear power plants should be carefully done after studying both long-term and short-term effects.
    - Proper disposal of wastes from laboratories using radioisotopes should be undertaken
15. Deforestation has many far reaching consequences, two of which are:
    - It threatens the existence of many wild life species due to destruction of their natural habitat.
    - Biodiversity is lost and along with that genetic diversity is eroded.
16. A maritime disaster is an event which usually involves a ship or ships and can involve military action.

2.10 QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is the impact of a biological disaster on the environment?
2. State the reasons for industrial air pollution.
3. Write a short note on acid rain.
4. What are the effects of noise pollution?
5. How can soil pollution be controlled?
6. What are the major causes of road and rail accidents?

Long-Answer Questions

1. Discuss the sources of occurrence of chemical disasters and their impact on the environment.
2. Explain the various precautions undertaken to manage each classification of fire.
3. Distinguish between point and non-point sources of water pollution.
4. Discuss the impact of industrial waste on the local environment.
5. What are the major causes of deforestation? Explain the major activities that take place in forests.

2.11 FURTHER READING

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UNIT 3 DISASTER RELIEF OPERATIONS

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Structure

3.0 INTRODUCTION

Disasters take a toll on human lives and property resulting in losses in several ways to people and the country as a whole. The primary reason for the loss of lives is poor communication and delay in help arriving at the disaster scene. To save more lives, relief and salvage operations need to be activated in response to the disaster as soon as possible. The government, NGOs and several local agencies play critical roles in the effective management in terms of rehabilitation of the affected population. It is important to formulate risk reduction plans and implement them effectively.

India has been traditionally vulnerable to natural disasters due to its unique geo-climatic conditions. Floods, droughts, cyclones, earthquakes and landslides are frequent phenomena. Disaster management occupies an important place in this country's policy framework because, it is primarily the poor and the underprivileged who are the worst affected by these calamities/disasters.

3.1 UNIT OBJECTIVES

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

- Analyse disaster preparedness with special reference to India
- Discuss disaster mitigation and prevention
- Explain disaster information system
- Understand the role of various agencies in disaster mitigation at the national and state levels

3.2 DISASTER PREPAREDNESS

One of the main objectives of development programs in many developing countries of the world for the past several decades has been poverty reduction. Over the years, the definition of poverty has shifted

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from calculating people's income to taking a more holistic view of their overall well-being. Enhanced access to public health facilities, increased life expectancy and gender equity have become the essential pointers of success of the poverty reduction programs. This has led to increased stress on better integration of poverty reduction programs with other sectoral issues like environmental management, gender development and public health. However, the instances of systematic long-term integration of poverty reduction programs within disaster management have been very few. Development efforts have focused on helping the poor in dealing with the various risks they face on a daily basis, such as in employment, health care, transport, education, water and sanitation.

Traditionally, the development agenda did not include disaster. When carefully laid development plans are drastically interrupted by disasters, the international community relied on organizations such as the United Nations and the Red Cross to step in with relief services. When the emergency work is over, reconstruction efforts are initiated to get the country back on the development track. Most poverty reduction programs leave a lot to be desired in terms of integration with disaster management.

Paradigm Shifts—From Relief and Response to Disaster Risk

The paradigm shift in poverty reduction programs, from income poverty to human poverty, has almost been matched in the disaster management sector. Disasters are no longer seen as extreme events, created entirely by natural forces, but also as manifestations of unresolved problems of development.

Disaster management practices have evolved from a largely top-down relief and response approach to a more intersectoral risk management approach. In current risk management approaches, there is scope for addressing the issues of risk reduction for the poor. Till a few decades ago, disasters were viewed as one-off events and responded to by the governments relief agencies without taking into consideration the social and economic implications and causes of these events. However, nowadays, by following an improved understanding of the natural processes that underlie hazardous events, a more technocratic paradigm has emerged i.e., the only way to deal with disasters was by public policy application of geophysical and engineering knowledge. Disasters were regarded as exceptional events, not related to the ongoing social and developmental processes. Gradually this attitude changed towards preparedness measures, such as:

- Stockpiling of relief goods
- Preparedness plans
- Growing role for domestic and international relief agencies

Such measures, also known as 'contingency planning' approaches, not only improved the efficiency of relief agencies, but also did a lot in terms of the appropriateness and effectiveness of the relief work done.

From the 1960s to the 1990s, although there was no clear indication that that the frequency of extreme hazard events had increased; it was observed later that there was a huge increase in human and material losses from disaster events. This showed that the increase in disasters and their consequences was due to increased vulnerability of people all over the world, possibly as a result of development due to human action. This increase in vulnerability showed variations across regions, nations, provinces, cities, communities, socio-economic classes, castes and even gender.

For example, when an earthquake of magnitude 6.4 occurred in San Fernando, California in 1971 only 58 deaths were reported out of over seven million people. Two years later, a similar earthquake, registering a magnitude of 6.2 on the Richter scale, in Managua, reduced the center of the city to rubble and killed over 6,000 people. Similar patterns can be seen in other recent disasters.

For realization that people's vulnerability is a primary factor in affecting the impact of disasters, emphasis moved to using 'vulnerability analysis' as a disaster management tool. Recently, there has been the emergence of a wide-ranging approach known as disaster risk management.

Disasters are no longer viewed as extreme events created entirely by natural forces but as unresolved problems of development. It is a known fact that risks of any type—physical, social or/and economic, when not managed for a long time, result in the occurrence of disasters. This evolution of approaches, from relief and response to risk management, has begun to influence the way disaster management programs are now being planned and financed. There are initiatives aimed at reducing social and economic vulnerability and investing in long-term mitigation activities. Unfortunately such initiatives are poorly funded and trivial in comparison to the money spent by donors and development

banks on humanitarian assistance, relief and on post-disaster reconstruction. An additional weakness is that these initiatives are primarily undertaken in the formal sector of the economy, while the poor and the most vulnerable sections of the society are neglected. As Maskrey (1999, p. 86) points out, 'in the year or so between the occurrence of a disaster and approved national reconstruction plans, many vulnerable communities revert to coping with risk, often in the same or worse conditions than before the disaster actually struck'. There is more need than ever to address the issues of risk reduction for the poor. As is the case in mainstream development, there is not only the need to focus on good governance, but also on accountability and bottom-up approach.

The new and innovative approaches to decrease disasters and poverty share several common features such as the following:

- Approaches developed must be more people-centric
- Development of a multisectoral approach in planning and decision-making
- Ever-increasing importance of improving ways and means to access resources
- Overall involvement and contribution to the development process

Despite the common elements, the poverty and disaster reduction efforts have developed as parallel processes rather than as integral processes probably due to a lack of thorough understanding of their linkage and the benefits deriving from this.

Poverty and vulnerability

While the poor are often the most affected by a disaster, it is naïve to assume that there is a direct and absolute association between poverty and vulnerability. Poverty which refers to the lack of access to resources and income opportunities is one of the several dimensions of vulnerability.

While discussing the association between poverty and vulnerability, Blakie et al. (1994) point out that, 'vulnerability is a combination of characteristics of a person or group, expressed in relation to hazard exposure which derives from the social and economic conditions of the individual, family, or community concerned. High levels of vulnerability imply a grave outcome in hazard events, but are a complex descriptive measure of people's lack or need. Vulnerability is a relative and specific term, always implying a vulnerability to a particular hazard.' In addition to economic dimension, other aspects of social positioning such as class, ethnicity, community structure, community decision-making processes and political issues, are key factors for establishing the poor people's vulnerability. A poor community although economically vulnerable, may have social, cultural and political capacities to deal and survive disasters. This was evident in the rare and isolated tribes of the Andaman and Nicobar islands who though economically weak, were able to save themselves from the deadly tsunami that hit South Asian countries in December 2004.

Risk reduction strategies for the poor should aim at decreasing the economic susceptibility and at the same time capitalize on (and perhaps nurture) the intrinsic social and cultural capacities of poor communities. It is vital that while enhancing the economic resilience of such communities, the physical, social and political risks are also identified and managed.

Another aspect of vulnerability of the poor (which is commonly ignored) it that it is generally, local in nature. Disaster statistics collected and aggregated at provincial and national levels are unable to detect the miseries of the poor and the most vulnerable. Impact assessments are able to identify only the formal and well-defined sectors of the economy.

Gradually, now there is clarity that the nature of vulnerability of the poor is complex and diverse. Hence, reducing the vulnerability and risk to the poor will require multidimensional approaches and innovative institutional arrangements.

Integrating poverty reduction programs with disaster

There have been relatively few examples of systematic integration of poverty reduction and disaster reduction programs. This section provides three approaches that have evolved over the last several years.

- First, is the livelihood framework developed in the context of bilateral development aid?
- Second, is the community-based disaster management evolved in the disaster management sector?
- Third, are the detailed and exact financial instruments to deal with risk transfer, encouraged by multilateral agencies?

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An integrated approach using all the three perspectives is best to address disaster preparedness and management.

Recognizing the vulnerability context of the poor within the development framework

In the last few years, a more holistic framework to assess the sustainability of livelihood strategies adopted by poor people has emerged. The five elements to analyze the sustainability of livelihood approach are as follows:

- Vulnerability context of poor people
- Assets such as human, social, physical, natural and financial capital
- The economic structures such as government, private sector as well as administrative guidelines and processes such as laws, institutions
- Livelihood strategies
- Livelihood outcomes

This approach encompasses the dynamic and complex nature of people's vulnerability. The vulnerability context also includes the external environment comprising of trends (population trends, resource trends), shocks (natural hazards, disease outbreak) and seasonality (market prices, employment opportunities).

This framework does not consider at the vulnerability context in isolation, but links it with transforming structures and processes. Practical application of such a framework means that it not only describes the different aspects of people's vulnerability but also points to social, political and economic structures and processes, transformations that facilitate in the reduction of vulnerability, and thus help ensure a sustainable livelihood for the poor.

Disasters adversely affect the livelihoods of poor people by damaging their means of earning (destruction of the factory, loss of land due to erosion in flooding, destruction of the shop) and/or tools (loss of drought animals, plowing tools). Mainstream disaster management responses frequently neglect the rehabilitation of people's means of livelihood. Families, who lose their means of livelihood during a disaster, find their recovery from adverse effects becoming more unlikely and their vulnerability to future disasters is increased accordingly. It is also assumed that if people have better sources of livelihoods and higher incomes, they will spend more on disaster risk management to save their property because, due to higher incomes, they have funds to spend for this purpose. However, in case they do not have savings, spending on disaster management becomes the lowest priority in contrast to the chronic issues of survival. Diversity in the source of livelihoods is vital for boosting the people's capacity to cope and recover. If a family, for example, has two different sources of income, a tract of land and a shop, the family still has the shop if it loses a drought animal or a crop. The family will obviously be in a better position than a family that has only one tract of land and loses the standing crop.

The government should make extra efforts to strengthen and diversify the means of livelihood of people who are living in disaster prone areas. This would be a big help in reducing the risk factor of an actual disaster. Initiatives of this kind have been taken by The Asian Disaster Preparedness Center (ADPC) in many South Asian countries in collaboration with other partner agencies.

Community-based disaster management (CBDM)

Sometimes it becomes difficult for top government officials to correctly gauge the kind of disaster relief that would be effective in a certain region and as a result, the approaches they devise prove largely wasteful. Studies reveal that it is better to involve communities themselves in disaster risk reduction planning because they are much better aware of ground realities and exactly what kind of relief is required during a disaster. Besides this, it has been noted that rather than planning for only major disasters, small and medium-sized disasters should also be taken seriously and their relief measures planned. The community-based approach was widely appreciated by the general public because they could share their concerns and make decisions pertaining to their own well-being.

How does the community-based disaster management (CBDM) approach work?

The basic objective of CBDM is to provide people with resources to cope with hazards and in the process, reduce their vulnerabilities. In order to make people aware of disaster management and ultimately reduce disaster risk, a careful study of a community's susceptibility to hazards and of their specific vulnerabilities and capacities is carried out. From the study emerges information that is employed in

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creating disaster management activities, projects and programs for the community. Since all citizens of a community are closely involved in the process, they are able to voice actual needs and apprehensions and how these can be best fulfilled using available resources. The process becomes more rational and grounded in reality in this way. The involved citizens discuss process as well as the content of the disaster management program. Awareness that the community gains in this process in turn leads to a progression towards safer conditions, security of livelihood and sustainable development.

Experts believe that there is a difference between community participation and community involvement. While community participation means that the community is wholly responsible for all stages of a program, including planning and implementation, community involvement is a 'less than ideal' scenario where the community is expected to participate in an existing program formulated by someone else. CBDM implementation indicates the following key features:

Implementation of CBDM points to the following essential features:

- The focus is on long-term and short-term disaster management that must be followed by the local community.
- The primary content of disaster management activities revolve around reducing vulnerable conditions and the root causes of vulnerability. The primary strategy of vulnerability reduction is to increase a community's capacities, resources and coping strategies.
- Disasters are viewed as unmanaged development risks and unresolved problems of the development process.
- CBDM should lead to a general improvement of the quality of life of the majority of poor people and of the natural environment.
- CBDM contributes to people's empowerment—to possess physical safety; to have more access and control of resources; to participate in decision-making that affects their lives; to enjoy the benefits of a healthy environment.
- Community as a key resource in disaster risk reduction.
- The community is the key factor as well as the primary beneficiary of disaster risk reduction. Within the community, prior attention is given to the conditions of the most vulnerable as well as to their mobilization in disaster risk reduction.
- The community participates in the whole process of disaster risk management from situational analysis to planning to implementation.
- Application of multi-sectoral and multidisciplinary approaches.
- CBDM brings together the massive community stakeholders for disaster risk reduction to expand its resource base. The local community level links up with the intermediate and national and even international level to address the complexity of vulnerability issues.
- A wide range of approaches to disaster risk reduction are employed.
- CBDM as an involving and dynamic framework. Lessons learnt from practice continue to build into the theory of CBDM. The sharing of experiences, methodologies and tools by communities and CBDM practitioners continues to enrich practice.

Before implementing CBDM it is important to know who in the community should be involved. The most vulnerable are the primary actors in a community. The focus should be at the household level. As all individuals, houses, organizations and services stand a chance of being affected, they should all be involved. But before working on disaster risk reduction, differing perceptions, interests, and methodologies have to be recognized and a broad consensus on targets, strategies and methodologies have to be reached. To enrich the community's involvement in risk reduction, it is important to first assess the risk with the help of the community. There are specific tools and methods that can make the process of community risk assessment most effective.

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There are a number of strategies for community based risk reduction:

- **Enabling self-insurance**
  - o *Improving existing occupations to enhance or continue current production and income levels:* Some techniques include irrigation (expansion, improvement in water management), soil fertility improvement, draft animal dispersal, and livestock and seed dispersal. These techniques are most useful for refugees returning to lands they had abandoned after a disaster, for farmers who cultivate lands, and in for those cases where irrigation systems are in the condition to be restored after typhoons, earthquakes, and floods. The benefit of this technique is that food shortage is overall reduced by a large percentage.
  - o *Enabling people to cope better with risks:* As per this strategy, crops grown are diversified and more disaster-resistant crops are grown along with the regular crops and even if the regular crop is destroyed, the alternate one can be used for sustenance.
  - o *Enhanced social support structures, and better storage facilities for the harvested crops:* With the use of this technique, every household will have larger reserves of food at their homes or within the community as a whole and the problem of food shortage will be mitigated.
- Performing season-based disaster management activities: Many disasters, like floods are usually seasonal and therefore predictable. Some effective cyclical methods that can be used every season include planting disaster-resistant crops, reinforcing storage facilities, maintaining seed banks, and mobilizing resources.
- **Promoting long-term investments**
  - o There should be contingency resources in every community, including forest reserves, trees planted around the house, a village pharmacy, trained village health workers, spread of literacy for awareness sake. All these methods require sustained investment and implementation
  - o Mitigate long-term vulnerability of the people by better land use and management planning in the community.

3.2.1 Disaster Preparedness in India

The institutional and policy mechanisms in India for carrying out response, relief and rehabilitation have been well-established since Independence. These mechanisms have proved to be robust and effective as far as response, relief and rehabilitation are concerned. The changed policy/approach, however, mandates a priority to pre-disaster aspects of mitigation, prevention and preparedness and new institutional mechanisms are being put in place to address the policy change.

Mitigation, preparedness and response are multi-disciplinary functions involving a number of ministries/departments. Institutional mechanisms which would facilitate this inter-disciplinary approach are being put in place. It is proposed to create disaster management authorities, both at the national and state levels, with representatives from the relevant ministries/departments to bring about this coordinated and multi-disciplinary with experts covering a large number of branches. The National Emergency Management Authority is proposed to be constituted. The organization will be multi-disciplinary with experts covering a large number of branches. The National Emergency Management Authority is proposed as a combined Secretariat/Directorate structure—a structure which will be an integral part of the Government while, at the same time, retaining the flexibility of a filed organization. The authority will be headed by an officer of the rank of Secretary/Special Secretary to the Government in the Ministry of Home Affairs with representatives from the Ministries/Departments of Health, Water Resources, Environment & Forest, Agriculture, Railways, Atomic Energy, Defence, Chemicals, Science & Technology, Telecommunication, Urban Employment and Poverty Alleviation, Rural Development and Indian Meteorological Department as members. The authority would meet as often as required and review the status of warning systems, mitigation measure and disaster preparedness. When a disaster strikes, the authority will coordinate disaster management activities. The authority will be responsible for:

- Providing necessary support and assistance to state governments by way of resource data, macro-management of emergency response, specialized emergency response teams, sharing of disaster related data base.
- Coordinating/mandating government's policies for disaster reduction/mitigation
- Ensuring adequate preparedness at all levels
- Coordinating response to a disaster when it strikes
- Assisting the provincial government in coordinating post disaster relief and rehabilitation
- Coordinating resources of all national government department/agencies involved
- Monitor and introduce a culture of building requisite features of disaster mitigation in all development plans and programmes
- Any other issues of work which may be entrusted to it by the Government

The organization structure for disaster management in India has been illustrated in Figure 3.1.

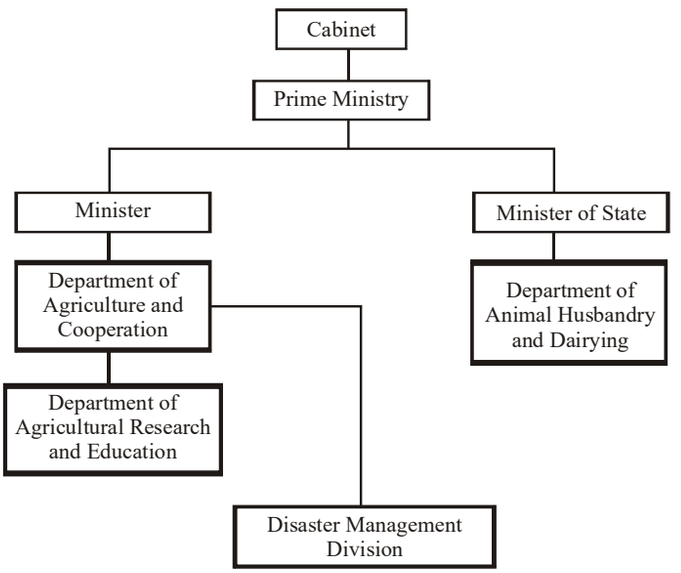

Fig. 3.1 *Disaster Management Organizations in India*

Source: http://www.sristi.org/

The Yokohama message emanating from the International Decade for Natural Disaster Reduction in May 1994 underlined the need for an emphatic shift in the strategy for disaster mitigation. It was stressed that disaster prevention, mitigation, preparedness and relief are four elements which contribute to and gain, from the implementation of the sustainable development policies. These elements along with environmental protection and sustainable development are closely inter-related and it was therefore, recommended that nations should incorporate them in their development plans and ensure efficient follow up measures at the community, sub-regional, regional, national and international levels. The Yokohama Strategy also emphasized that disaster prevention, mitigation and preparedness are better than disaster response in achieving the goals and objectives of vulnerability reduction. Disaster response alone is not sufficient as it yields only temporary results at a very high cost. Prevention and mitigation contribute to lasting improvement in safety and are essential to integrated disaster management.

Check Your Progress

1. What are the features of new and innovative approaches to decrease disasters and poverty?
2. List the five elements that analyze the sustainability of livelihood approach.
3. State the aim of CBDM approach.
4. Define community involvement.

3.3 DISASTER MITIGATION AND PREVENTION

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The Government of India has adopted mitigation and prevention as essential components of their development strategy. The Tenth Five-Year Plan document has a detailed chapter on disaster management. The Plan emphasizes the fact that development cannot be sustainable without mitigation being built into developmental process. Each state is supposed to prepare a plan scheme for disaster mitigation in accordance with the approach outlined in the plan. In brief, mitigation is being mainstreamed into developmental planning.

Financial arrangement: The Finance Commission makes recommendations with regard to devolution of funds between the Central Government and State Governments as also outlays for relief and rehabilitation. The earlier Finance Commissions were mandated to look at relief and rehabilitation. The Terms of Reference of the Twelfth Finance Commission have been changed and the Finance Commission has been mandated to look at the requirements for mitigation and prevention apart from its existing mandate of looking at relief and rehabilitation. A memorandum has been submitted to the Twelfth Finance Commission after consultation with the states. The memorandum proposes the creation of a disaster mitigation fund which will assist the states in taking mitigation measures like retrofitting of lifeline buildings, coastal shelter and belt plantation.

The Government of India have issued guidelines that where there is a shelf of projects, projects addressing mitigation will be given a priority. It has also been mandated that each project in a hazard prone area will have disaster prevention/mitigation as a term of reference and the project document has to reflect as to how the project addresses that term of reference.

Flood preparedness and response: In order to respond effectively to floods, Ministry of Home Affairs have initiated National Disaster Risk Management Programme in all the flood-prone states. Assistance is being provided to the states to draw up disaster management plans at the state, district, block/taluka and village levels. Awareness generation campaigns are implemented to sensitize all the stakeholders on the need for flood preparedness and mitigation measures. Elected representatives and officials are being trained in flood disaster management under the programme. Bihar, Orissa, West Bengal, Assam and Uttar Pradesh are among the 17 multi-hazard prone states where this programme is being implemented with assistance from UNDP, USAID and European Commission.

Earthquake risk mitigation: A comprehensive programme has been taken up for earthquake risk mitigation. Although, the BIS has laid down the standards for construction in the seismic zones, these were not being followed. The building construction in urban and suburban areas is regulated by the Town and Country Planning Acts and Building Regulations. In many cases, the building regulations do not incorporate the BIS codes. Even where they do, the lack of knowledge regarding seismically safe construction among the architects and engineers as well as lack of awareness regarding their vulnerability among the population led to most of the construction in the urban/sub-urban areas being without reference to BIS standards. In the rural areas, the bulk of the housing is non-engineered construction. The mode of construction in the rural areas has also changed from mud and thatch to brick and concrete construction, thereby increasing the vulnerability. The increasing population has led to settlements in vulnerable areas close to the river bed areas which are prone to liquefaction. The government have moved to address these issues.

National Core Group for earthquake risk mitigation: A National Core Group for Earthquake Risk Mitigation has been constituted consisting of experts in earthquake engineering and administrators. The Core Group has been assigned with the responsibility of drawing up a strategy and plan of action for mitigating the impact of earthquakes; providing advice and guidance to the states on various aspects of earthquake mitigation; developing/organizing the preparation of handbooks/pamphlets/type designs for earthquake resistant construction; working out systems for assisting the states in the seismically vulnerable zones to adopt/integrate appropriate Bureau of Indian Standards codes in their building by-laws; evolving systems for training of municipal engineers as also practicing architects and engineers in the private sector in the salient features of Bureau of Indian Standards codes and the amended by-laws; evolving a system of certification of architects/engineers for testing their knowledge of earthquake resistant construction; evolving systems for training of masons and carry out intensive awareness generation campaigns.

Review of building by-laws and their adoption: Most casualties during earthquakes are caused by the collapse of structures. Therefore, structural mitigation measures are the key to make a significant impact towards earthquake safety in our country. In view of this the states in earthquake prone zones have been requested to review, and if necessary, amend their building by-laws to incorporate the BIS seismic codes for construction in the concerned zones. Many states have initiated necessary action in this regard. An Expert Committee appointed by the Core Group on Earthquake Risk Mitigation has already submitted its report covering appropriate amendments to the existing Town & Country Planning Acts, Land Use Zoning Regulations, Development Control Regulations & Building by-laws, which could be used by the state governments and the local bodies thereunder to upgrade the existing legal instruments. The Model Building by-laws also cover the aspect of ensuring technical implementation of the safety aspects in all new constructions and upgrading the strength of existing structurally vulnerable constructions. To facilitate the review of existing building by-laws and adoption of the proposed amendments by the state governments and UT administrations, discussion workshops at regional level in the country are being organized. It is expected that all planning authorities and local bodies will soon have development control regulations and building byelaws which would include multi-hazard safety provisions.

Development and revision of codes: There are Bureau of Indian Standard (BIS) codes which are relevant for multi-hazard resistant design and construction. Some of the codes need to be updated. There are some areas for which codes do not exist. An action plan has been drawn up for revision of existing codes, development of new codes and documents/commentaries, and making these codes and documents available all over the country including online access to these codes. An apex committee consisting of representatives of Ministry of Consumer Affairs, BIS and MHA has been constituted to review the mechanism and process of development of codes relevant to earthquake risk mitigation and establish a protocol for revision by BIS.

3.3.1 Disaster Preparation

Preparation for a disaster can reduce losses, fear, and anxiety that it causes. One should be know how to treat basic medical problems. Regardless of the amount of warning offered, the safety precautions that one can take to reduce or prevent injury include:

- Personal safety
- Home and worksite preparation
- Community preparation

Prior preparation is the key to survival in a disaster or emergency. Structural and non-structural hazards during a disaster can be minimized if individuals, families, and worksites take steps to facilitate escape, and promote survival in the period immediately following the event. Injuries can be easily prevented as well. The community can also prepare to face disaster by establishing Community Emergency Response Teams to respond quickly in the aftermath of a disaster.

Check Your Progress

5. What does the Tenth Five-Year Plan emphasize?
6. State the responsibility of the National Core Group for Earthquake Risk and Mitigation.

3.4 DISASTER INFORMATION SYSTEM GIS

A GIS is defined as a system that is designed to gather, store, manipulate, analyse, manage and present all types of geographical data. The combination of GIS and geography has led to the emergence of a new approach, *geographic approach*, to problem solving. The *geographic approach* allows us to apply the geographical knowledge to the way we design, plan and change our world.

Through GIS we can map where and how things move over a period of time to get insight into how they behave. For example, a meteorologist might study the paths of hurricanes to predict where and when they might occur in the future. GIS helps us view, interpret, visualize and understand data in many ways. To see certain patterns or trends in the data, it can be converted into maps, globes, reports and charts. This data transformation helps us get answers to our questions easily.

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GIS captures, interprets and transforms geographical data into graphical outcomes using advanced hardware and software technology. GIS can be used to map useful information such as: places with specific tourist attractions; high-income customers of a departmental store; availability of physicians per 1,000 people in a region to check adequacy of healthcare infrastructure; change in an area to anticipate future conditions and decide on a course of action.

Government agencies, businesses, scientists, researchers, environmental experts and natural resource groups all use GIS to predict the effects on or the reaction of the environment to the activities they wish to carry out. This helps them make their activities more environment-friendly.

Some major advantages of GIS are as follows:

- **Better decision making:** GIS is often used to assist in decision-making so as to be able to take fast and better decisions. For example, it helps select better routes during travel, find out where natural resources are available in abundance, locate and select a property with desired features and identify evacuation routes in case of a disaster.
- **Better communication:** GIS helps teams, troops, organizations to coordinate and communicate in a better manner. The collected data can be interpreted in a way so as to facilitate good communication among organizations or individuals for understanding situations in a better way.
- **Better record keeping:** Organizations keep a track record of the geographical changes that occur in and around an area, particularly those changes which take place because of their own activities. GIS facilitates better record keeping. It allows easy collection, organization, analysis, interpretation, storage and convenient access of data.
- **Predicting geographical events:** Apart from giving a detailed account of the current situation of geography, GIS also helps researchers predict the likely events in the near future. Such predictions prove quite useful in taking safeguards to minimize damage in case of potentially dangerous geographical changes.

GIS learning is now being integrated into a number of study courses to allow students to understand its utility and be able to use the same in the future. New techniques for collection of geographical data are being developed to facilitate maximum GIS use for common good.

Geoinformatics application users in India

- In healthcare sector, GIS is used for marketing, promotion, research and development
- The Central and state governments use GIS for development in economy, legislative reforms, administration registration of voters, emergency management
- In agriculture, it is used for analysis of production, pollution control and targeted agrarian production
- In environmental management, GIS is used in natural resource management, water quality, waste management, groundwater modeling, climate change
- Public safety units utilize GIS as a constitutional part of emergency response systems formulated for man-made and future disasters
- Forest department uses GIS for the mapping of flora and fauna and biodiversity

Remote Sensing

Acquiring information about a remote object or phenomenon, without making physical contact with the object is called remote sensing. Aerial sensor technologies are used to get information about remote objects on the earth surface or in the atmosphere and oceans. In these technologies, electromagnetic radiation, emitted from aircraft or satellites, is used to gather the required information. Remote sensing is used in combination with GIS to get images of the earth's geographical features. Remote sensing is of two types—active sensing and passive sensing.

- Passive sensors detect objects through natural radiation or energy that is emitted or reflected by the objects or surrounding areas. In other words, passive sensors can only be used to detect energy when the naturally occurring energy is available. The most common example of natural energy is the reflected sunlight. Therefore, passive sensing is possible only when the sun is illuminating the earth. Examples of passive remote sensors include film photography and

radiometers. The biggest advantage of passive sensing is that it can be used in inaccessible areas. It is the lifeline of archaeological investigation, military observations and city planning.

- Contrary to passive sensors, active sensors provide their own energy for illuminating the objects to be investigated. An active sensor emits radiation which is directed toward the target object. The radiation reflected from the target is detected and measured by the sensor. Active sensors can obtain measurements anytime in day or night. Active sensors can be used to better control the way a target is illuminated. They can examine wavelengths that are not sufficiently provided by the sun, such as microwaves. However, active systems need to generate a fairly large amount of energy to adequately illuminate targets. RADAR and LiDAR are examples of active remote sensing where the time delay between the emission and return is measured, establishing the location, height, speed and direction of an object.

A camera can serve as an active sensor as well as passive sensor. On a sunny day, enough sunlight illuminates the targets and gets reflected towards the camera lens. The camera simply acts as a passive sensor and records the reflected radiation. On a cloudy day or inside a room, there is often not enough sunlight for the camera to record the targets adequately. So, it acts as an active sensor and uses its own energy source—a flash—to illuminate the targets and record the radiation reflected from them.

Remote sensing is a very useful tool of GIS. Without remote sensing, researchers would have to wait for long times for the planets and their satellites to align in suitable formations so as to get the desired images about weather conditions and other natural phenomena. However, using remote sensing it becomes easy for researchers to capture the desired images when needed. Remote sensing also works well to study the surface of the earth under water. The use of altimeters is common to see the shifts and changes in the seabed and how humans are responsible for those changes. Ocean waves are also studied through remote sensing to establish their normal cycle and detect any unpredicted changes in the same. This is particularly useful in predicting a tsunami.

Among other remote sensing applications is the use of radars for monitoring aircraft movements to control air traffic. It is also helpful in controlling satellites. Hyper spectral imaging is used to get large pixel images highlighting intricate details of the image object. This is commonly used in biology.

The results of remote sensing depend on the location of the platform on which the sensing device is installed, the location of the target object and the orientation of the two. Remote sensing allows researchers to pre-set the changes they wish to track and every time the target object undergoes those changes, the sensing device becomes active and automatically gathers the required information about the changes.

Table 3.1 *Levels of Processing of Remote Sensing Data*

Level	Description
0	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts
1a	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters computed and appended but not applied to the Level 0 data
1b	Level 1a data that have been processed to sensor units; level 0 data is not recoverable from level 1b data.
2	Derived geophysical variables at the same resolution and location as Level 1 source data.
3	Variables mapped on uniform spacetime grid scales, usually with some completeness and consistency
5	Model output or results from analyses of lower level data

Source: http://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products/ Accessed on 5 June 2012

Table 3.1 depicts the data collected through remote sensing, which is processed at a number of levels.

3.4.1 Mapping of Disaster Prone Zones

Maps are images that depict different aspects of the earth's geography in two dimensions. Maps are quite useful in the context of disasters. Pre-disaster and post-disaster maps depict the potential changes and the actual changes, respectively, associated with a disaster, and the areas of these changes. Maps are designed according to latitudinal and longitudinal measures of concerned areas. However, maps are difficult to prepare and their assumed scale may also be difficult to adhere to in all conditions. It is for this reason that GIS technology is now being used to automatically generate the required mappings of geographical areas. Many countries have issued vulnerability atlases which highlight the areas that can be struck by disasters. These atlases also specify the nature of disasters and their consequences.

Mapping of any kind is done following a four-step basic procedure. The first step of the mapping procedure is the collection of data. This data could be about situational, social, geographic, climatic and economic conditions prevailing in the area. In the second step, the collected data, particularly the one gathered through GIS, is verified with ground realities to ensure accuracy. After reference and matching, in the third step, the data is plotted as a map either on paper or on an electronic display device. In the fourth and last step, the required information is added to the map to facilitate its easy understanding and interpretation. These maps are very important for researchers for predicting any kind of disaster and hence prepare an area to face the disaster. The disaster warning maps can help in preventing large damage. Mapping is an integral part of urbanization planning. It is a great help in natural resource estimation.

Some types of mapping related to natural or manmade disasters are—mapping of seismic activity, mapping of industrial sector, mapping of floods and cyclones, mapping of volcanic eruptions and fires, mapping of earthquakes and landslides.

- **Mapping of seismic activity:** This is done after analysing the history of tectonic activities in the concerned area. The analysis of the data on tectonic activities reveals how these activities have substantially or marginally altered the area. The intensity of each activity is carefully analysed to understand its effect on the area. Presence of indicators like ridges or cracks is considered to be of critical importance. Seismic mapping has to be updated regularly after every minor or major tectonic activity to record any resultant changes. Seismic mapping is carried out on a regional scale because it affects a large area.
- **Mapping of industrial sector:** In case of industrial accidents, disaster mapping is done at the micro level, not at the regional level, because the effect of a disaster is not widespread. Industrial mapping takes into account factors such as industrial growth and development, equipment, processes and raw materials. The storage and transportation patterns in and around the industrial area are closely monitored. Any previous industrial accidents are also carefully studied. Once risk zones are identified, then the risk cause — air pollution, water pollution or noise pollution — is identified. Air pollution effects would be widespread while others are mostly localized.
- **Mapping of floods and cyclones:** The first step in this mapping is the collection of data regarding past floods and the extent of devastation caused by them. This mapping also needs to highlight the amount of rainfall in the past years apart from highlighting the points where natural water bodies after receiving rain water caused the heavy floods. The last two decades have seen great technological strides in the study of floods. Now, high-resolution satellite images are used to pinpoint the places where floods are most likely to occur and where embankments can be made to prevent floods. This mapping also helps in highlighting the areas which would be prone to soil erosion and taking steps to avert it.
- **Mapping of volcanic eruptions and fires:** Information is collected about the duration for which a volcano remains dormant and the intensity of its eruption. Also, satellite imaging is used to track the flow of lava during a volcanic eruption and assess its reach in the surrounding areas. In case of fires, fire frequency and intensity through day and night are monitored in a number of areas to assess their susceptibility to fire disasters and decipher the causes of these disasters. Mapping of fires also suggests the ways to avoid fires and how to protect people in the vicinity of raging fires.
- **Mapping of earthquakes:** In this mapping, data on the earthquake history in an area is collected. The data on the epicentres of recurring earthquakes is also analysed and plotted on seismic maps to highlight the points of maximum seismic activity. Mapping of earthquakes also highlights how

soil is shifted from a place and how buildings in the area have been modified to withstand earthquakes better. This mapping greatly helps in city planning and development and in formulating safety procedures against earthquakes.

- **Mapping of landslides:** The first step in this type of mapping is to identify areas with varying degrees of slopes and the stability or instability of slopes. The data obtained on these aspects is then compiled with aerial photographs and with the data about changes that might have occurred in land and soil composition in the past. The results from this exercise help in identifying landslide-prone areas and caution people not to build houses in such areas. This mapping also helps in assessing the feasibility of an area for construction of dams and canals and in taking appropriate steps to prevent landslides.

It is impossible to think about doing the disaster mappings and make relevant disaster predictions without using remote sensing and GIS. Researchers need to use both these systems to make reasonable predictions about the disaster vulnerability of an area and suggest appropriate defences.

Generally, floodplain management studies have been extensive, expensive and cumbersome because most of the analysis performed 'by hand' using paper maps. Presently, latest technologies like GIS, GPS and remote sensing have enabled the floodplain managers to generate precise and latest floodplain maps with improved efficiency and speed at a practical cost. Precise floodplain maps form very sophisticated tools of floodplain management.

Digital maps contain multiple, potentially infinite information layers. Information is usually the most valuable resource after a disaster, so such maps possess the ability to save thousands of lives. These maps are a product of the GIS software and have already been used in Haiti, Japan and West Africa with great effect.

Emergency management personnel generally require comprehensive information regarding building layout, pipelines, sewer systems, electrical distribution. With the help of a GIS system, the concerned departments can share information through databases on computer-generated maps in one location only.

Three-dimensional models within a GIS are used to more realistically analyse the effect of the Earth's terrain. A GIS can present the Earth in three-dimensional, realistic perspective. Such views and animations present the information more effectively and to larger audiences in comparison to static, two-dimensional maps.

Advantages of Spatial Technology in Disaster Management

Spatial technology is an integrated hardware and software system which brings together GIS and remote sensing to use satellites for a number of uses. Spatial technology plays an important role in disaster management. Rather, it has become an integral part of disaster management. Through spatial technology, every step and stage of a disaster management plan can be modified and monitored to minimize the damage from a disaster.

The advantages of spatial technology in disaster management are—early warning, disaster magnitude estimation, communication, city planning, monitoring and mitigation, models and demonstrations.

- **Early warning:** Spatial technology allows scientists and researchers to critically study the patterns of the earth's atmosphere. Any changes in these patterns can be spotted easily in the images formed by using spatial technology. These changes are then used to track any disaster which might be becoming active to hit a particular area in future. Early detection of changes in the atmosphere patterns help researchers and administrators to make arrangements to escape the drastic effects of the speculated disaster.
- **Disaster magnitude estimation:** Looking through the changes occurring on the earth's surface or under the ocean bed, and combining them with the data about the history of disaster occurrence in the same area can help estimate the magnitude of a future disaster. An estimate of the disaster magnitude allows people to work for their protection individually and also lets the government make arrangements to protect the economy of an area from the drastic effects of a disaster.
- **Communication:** Spatial technology takes communication to a new level where information can flow more easily and more information can be sent quickly. This helps in alerting people about a disaster more quickly, thus taking precautionary steps well in time. This also enables the authorities

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to plan and take appropriate steps for the desired coordination during disaster recovery and rehabilitation.

- **City planning:** When planners and developers turn to spatial technology, they are able to understand the potential risks in an area where they wish to build a city. This helps them build the city in a way that would enable it to withstand the disasters that are most likely to occur. Taking preventive measures to keep a population protected against disasters is one of the basic steps in disaster management.
- **Monitoring and mitigation:** Spatial technology allows authorities to monitor an oncoming disaster while also planning mitigation strategies to relieve the stress that the economy would suffer from the same. Constant monitoring and study of relevant parameters helps analyse the extent of potential damage and assess the need for preventive measures.
- **Models and demonstrations:** The images and data generated through spatial technology can be used to produce models and demonstrations which would help the authorities and people understand how the disaster would strike and how the environment and its elements would react to the same. These models help one to draw accurate inferences regarding the action and reaction after a disaster.

3.4.2 Tsunami

A tsunami warning system (TWS) is a system to detect tsunamis and issue warnings to prevent loss of life and property. It consists of two equally important components—a network of sensors to detect tsunamis and a communications infrastructure to issue timely alarms to permit evacuation of coastal areas.

There are two distinct types of tsunami warning systems—international and regional. Both depend on the fact that, while tsunamis travel at between 500 and 1,000 km/h (around 0.14 and 0.28 km/s) in open water, earthquakes can be detected almost at once as seismic waves travel with a typical speed of 4 km/s (around 14,400 km/h). This gives time for a possible tsunami forecast to be made and warnings to be issued to threatened areas, if warranted. Unfortunately, until a reliable model is able to predict which earthquakes will produce significant tsunamis, this approach will produce many more false alarms than verified warnings. In the currect operational paradigm, the seismic alerts are used to send out the watches and warnings. Then, data from observed sea level height (either shore-based tide gauges or DART buoys) are used to verify the existence of a tsunami.

Other systems have been proposed to augment the warning paradigm. For example, it has been suggested that the duration and frequency content of t-wave energy (which is earthquake energy trapped in the ocean SOFAR channel) is indicative of an earthquake's tsunami potential. The first rudimentary system to alert communities of an impending tsunami was attempted in Hawaii in the 1920s. More advanced systems were developed in the wake of the April 1, 1946 (caused by the 1946 Aleutian Islands earthquake) and May 23, 1960 (caused by the 1960 Valdivia earthquake) tsunamis which caused massive devastation in Hilo, Hawaii.

Source: (Wikipedia, http://en.wikipedia.org/wiki/ Tsunami_warning_system)

3.4.3 Earthquake

An earthquake warning system is a system of accelerometers, communication, computers, and alarms that is devised for regional notification of a substantial earthquake while it is in progress. This is not the same as earthquake prediction, which is currently incapable of producing actionable event warnings.

Time lag and wave projection

An earthquake is caused by the release of stored elastic strain energy during rapid sliding along a fault. The sliding will start at some location and progress away from this hypocenter in each direction along the fault surface. The speed of the progression of this fault tear is slower than and distinct from the speed of the resultant pressure and shear waves, with the pressure wave travelling faster than the shear wave. The pressure wave will generate an abrubt shock while the shear waves can generate a periodic motion (at about one cycle per second) that is the most destructive in its effect upon structures, particularly buildings that have a similar resonant period, typically buildings around eight floors in height. These waves will be strongest at the ends of the slippage, and may project destructive waves well beyond the fault failure. The intensity of such remote effects are highly dependent upon local soils conditions

within the region and these effects are considered in constructing a computer model of the region that determines appropriate responses to specific events.

Configuration

Earthquake warning systems consist of arrays of seismic motion sensors arranged throughout a region. High speed communication systems and computers collect the sensor readings and the computers are programmed to detect the likely strength and progression of the seismic event. If a dangerous event is detected then alarms can be signalled through the region likely to be affected, allowing warnings before local ground motion of up to and beyond twenty seconds. While short, such warnings would be sufficient to allow many persons to move to safer areas or to take shelter under substantial furnishings.

Transit safety

Such systems are currently implemented to determine appropriate real-time response to an event in determining train operator response for urban rail systems such as BART (Bay Area Rapid Transit). The appropriate response will be highly dependent upon the warning time, the local right–of–way conditions, and the current speed of the train.

BART: BART is a rapid transit system serving the San Francisco Bay Area. The heavy-rail public transit system connects San Francisco with cities in the East Bay and suburbs in northern San Mateo County. BART operates five lines on 104 miles (167 km) of track with 43 stations in four counties. With average weekday ridership of 346,504 passengers, BART is the fifth busiest heavy rail rapid transit system in the United States.

BART is operated by the San Francisco Bay Area Rapid Transit District, a special-purpose transit district that was formed in 1957 to cover San Francisco, Alameda County, and Contra Costa County. The name BART is an acronym and is pronounced as a word, not as individual letters. In some ways, BART is the successor to the Key System, which ran streetcars across the lower deck of the San Francisco–Oakland Bay Bridge until 1958.

BART has served as a highly successful rapid transit and commuter rail system, and it has provided a valuable alternative transportation route to highway transportation. Due to the success and the number of commuters depending upon the rail system, BART has been undergoing a vast modernization to improve the quality of the system and its ability to serve the public's transportation needs. These modernization moves have included overhauls of the stations, the purchase of new and refurbished rolling stock, and extensions to the area covered by the BART lines.

Deployment

Japan, Taiwan and Mexico have earthquake early-warning systems. The most advanced is Japan's Earthquake Early Warning system, which was put to practical use in 2006. Its scheme to warn the general public was installed on October 1, 2007. It was modeled partly on the Urgent Earthquake Detection and Alarm System (UrEDAS) of Japan Railways, which was designed to enable automatic braking of bullet trains.

Accelerometer

An accelerometer measures the proper acceleration it experiences relative to freefall. Single- and multi-axis models are available to detect magnitude and direction of the acceleration as a vector quantity, and can be used to sense orientation, vibration and shock. Micromachined accelerometers are increasingly present in portable electronic devices and video game controllers, to detect the orientation of the device or provide for game input.

An accelerometer measures the proper acceleration it experiences relative to freefall. This is equivalent to inertial acceleration minus the local gravitational acceleration, where inertial acceleration is understood as acceleration with respect to a Newtonian inertial reference frame, which the Earth can be considered to approximate.

As a consequence, quite counter-intuitively, an accelerometer at rest with respect to the Earth's surface will indicate 1 g upwards. To obtain the acceleration due to motion with respect to the earth, this 'gravity offset' should be subtracted. No such subtraction is necessary along horizontal directions. Conversely, the device's output will be zero during free fall, where the acceleration exactly follows gravity. This includes use in an earth orbiting spaceship, but not a (non-free) fall with air resistance, where drag forces reduce the acceleration until a terminal velocity is reached, at which point the device would once again indicate 1 g vertically upwards.

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Earthquake prediction: An earthquake prediction is a prediction that an earthquake of a specific magnitude will occur in a particular place at a particular time (or ranges thereof). Despite considerable research efforts by seismologists, scientifically reproducible predictions cannot yet be made to a specific hour, day, or month but for well-understood faults, seismic hazard assessment maps can estimate the probability that an earthquake of a given size will affect a given location over a certain number of years.

Once an earthquake has already begun, early warning devices can provide a few seconds' warning before major shaking arrives at a given location. This technology takes advantage of the different speeds of propagation of the various types of vibrations produced. Aftershocks are also likely after a major quake, and are commonly planned for in earthquake disaster response protocols.

Experts do advise general earthquake preparedness, especially in areas known to experience frequent or large quakes, to prevent injury, death, and property damage if a quake occurs with or without warning.

Prediction techniques

In the effort to predict earthquakes, people have tried to associate an impending earthquake with such varied phenomena as seismicity patterns, electromagnetic fields (seismo-electromagnetics), ground movement, weather conditions and unusual clouds, radon or hydrogen gas content of soil or ground water, water level in wells, animal behaviour, and the phases of the moon.

Many pseudoscientific theories and predictions are made, which scientific practitioners find problematic. The natural randomness of earthquakes and frequent activity in certain areas can be used to make 'predictions' which may generate unwarranted credibility. These generally leave certain details unspecified, increasing the probability that the vague prediction criteria will be met, and ignore quakes that were not predicted. Rudolf Falb's 'lunisolar flood theory' is a typical example from the late 19th century.

Evaluation of prediction theories

Official earthquake prediction evaluation councils have been established in California (the California Earthquake Prediction Evaluation Council) and the federal government in the United States (the National Earthquake Prediction Evaluation Council), but have yet to endorse any method of predicting quakes as reliable.

Scientific evaluations of prediction claims look for the following elements in a claim:

- A specific location or area
- A specific span of time
- A specific magnitude range
- A specific probability of occurrence

Attribution to a plausible physical mechanism lends credibility, and suggests a means for future improvement. Reproducibility and statistical analysis are used to distinguish predictions which come true due to random chance (of which a certain number are expected) versus those that have more useful predictive capability, and to validate models of long-term probability. Such models are difficult to test or validate because large earthquakes are so rare, and because earthquake activity is naturally clustered in space and time. 'Predictions' which are made only after the fact are common but generally discounted.

Radon

Emission of radon as a quake precursor was studied in the 1970s and 1980s, with no reliable results. It is still under study at NASA as of 2009.

The VAN method

VAN is a method of earthquake prediction proposed by Professors Varotsos, Alexopoulos and Nomicos in the 1980s; it was named after the researchers' initials. The method is based on the detection of 'seismic electric signals' (SES) via a telemetric network of conductive metal rods inserted in the ground. The method stems from theoretical predictions by P. Varotsos, a solid-state physicist at the National and Capodistrian University of Athens. It is continually refined as to the manner of identifying SES from within the abundant electric noise the VAN sensors are picking up. Researchers have claimed to be able to predict earthquakes of magnitude larger than 5, within 100 km of epicentral location, within 0.7 units of magnitude and in a 2-hour to 11-day time window.

Foreshock predictions

Foreshocks are medium-sized earthquakes that precede major quakes.

An increase in foreshock activity (combined with purported indications like ground water levels and strange animal behaviour) enabled the successful evacuation a million people one day before the February 4, 1975 M7.3 Haicheng earthquake by the China State Seismological Bureau.

While 50 per cent of major earthquakes are preceded by foreshocks, only about 5-10 per cent of small earthquakes turn out to be foreshocks, leading to many false warnings.

Fractoluminescence

This was briefly considered a possible technique to predict earthquakes, but never gained widespread acceptance. It came into the public knowledge after the 1995 Kobe earthquake in Japan, when many victims reported that they had seen glimpses of red and blue light in the sky for about an hour prior to the earthquake. After these reports, studies were carried out at the Chugoku National Industrial Research Institute and they showed that when it is broken, silica emits red and blue light for about 100 milliseconds duration. The explanation for this was supposed to be that when there was stress within the rock, silicon-oxygen bonds were broken and unstable oxygen atoms and free bonds were released which appeared as blue and red flashes.

Satellite observations

Demeter microsatellite: The 'Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions' satellite was constructed by CNES. It has observed that there are strong correlations between certain types of low frequency electromagnetic activity and the highly seismically active zones on the Earth, and have shown a sharp signal in the ionospheric electron density and temperature near southern Japan seven days before a 7.1 magnitude took place there (on August 29 and September 5, 2004, respectively).

QuakeSat nanosatellite: QuakeSat is an earth observation nanosatellite based on 3 CubeSats. It collects extremely low frequency earthquake precursor signals from space. Its main instrument is a magnetometer set up in a 2 foot (0.6 m) telescoping boom.

The ESPERIA project: ESPERIA is an equatorial space mission, concerned with scoping out any tectonic and pre-seismic signals. Besides earthquake prediction, it is used for more general purposes like defining the near-Earth electromagnetic, plasma, and particle environment, and for monitoring perturbations and instabilities in the ionosphere- magnetosphere transition region. To study earthquake preparation processes and anthropogenic impacts in the Earth's surface, a phase 'A' study has been realized for the Italian Space Agency.

Flood Warning and Forecasting

Flood forecasting and flood warning and closely interlinked. However, they are different in the sense that flood forecasting involves estimating the channel flows or river levels at various places while flood warning involves making decision regarding which section of the population should be warned, or evacuated. The flood warning exercise is divided into two parts:

- Making the decision regarding whether the level of alert is to be raised or cancelled or changed to the flood warning service provider, since this also includes partner organizations that are activated during an emergency, such as medical teams.
- Making the decision regarding whether general public is to be issued flood warnings. Someone who is making this decision needs to take care of the following important factors:
  - How reliable are the available forecasts and whether there are likely to be changes with time.
  - How much time should the public be given to respond to the warning.
  - If there can be a delay between when the warning was initiated and when it was received by the public.
  - If the warning proves to be unnecessary or exaggerated, the efforts of respondents will be wasted and the general public will not take future warnings seriously.
  - If the warning is cancelled and then re-issued, this brings down the credibility of the flood warning agency and will lay waste the efforts made by the public and partner agencies.

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A flood warning computer system will also contain sub-systems for:

- Flood forecasting
- Automatic alerts for internal personnel
- Regular monitoring of alert messages and received acknowledgements
- Means to divert received messages to others if no acknowledgement is received from original recipient.

Flood forecasting is the 'use of real-time precipitation and stream-flow data in rainfall-runoff and stream-flow routing models to forecast flow rates and water levels for periods ranging from a few hours to days ahead, depending on the size of the watershed or river basin.'

Flood forecasting uses forecasts of rain with the aim to extend the lead-time available. Advanced flood forecasting systems also take into account the effects of:

- Snowmelt
- Flood plains and washlands
- Flood defences like control-gates
- Effect of tides in the sea and sea-surges

In order to do this, forecasting models will have to include suitable snowmelt models, and the stream-flow models that are appropriate for simple applications would also require hydrodynamic models.

3.4.4 National Flood Warning Services

The nature of flood warning services in one country varies greatly from those in another country. Sometimes, a particular location may receive flood warnings from more than one source. The type of flood warning service available varies greatly from country to country, and a location may receive warnings from more than one service.

United Kingdom

In the UK, for instance, the Met Office would issue flood warnings if their forecasts indicate heavy rainfall but this warning may not be specific to an area and just a general warning, issues 6-24 hours before the incidence of rain. Such warnings are usually just a caution for the citizens. Besides this rainfall warning, when an area is likely to be flooded, specific agencies in various regions would issue short-term warnings—the Scottish Environment Protection Agency (covering Scotland) and the Environment Agency (covering England and Wales)—and perform the flood forecasting exercise, based on:

- Recent rainfall patterns
- Rainfall expected in the next 6 hours
- Existing and past river conditions

In the UK, flood warning service has evolved into being issued automatically by phone to those who are likely to be affected by the flood. Warnings are also issued by local radio stations and Internet pages. These pages will contain names of areas likely to be affected and the severity of the warnings:

- Environment Agency (EA) Flood Watch (live warnings) - England/Wales
- EA scheme description
- Scottish Environment Protection Agency (SEPA) Live Flood Warning Information

United States

In the US, the National Weather Service issues flood watches and warnings for large-scale, gradual river flooding. The watches are issued when there is likelihood of a flood within the next 12–48 hours, and warnings are disseminated when there is likelihood of large-area flooding. Watches as well as warnings may be issued separately for counties or as per towns situated along a river. For rapid flooding from intense rainfall or dam failures, flash flood watches and warnings are disseminated.

In USA and Canada, issuing of flood warnings is made through Specific Area Message Encoding (SAME) code FLW, which is used in the US Emergency Alert System and NOAA Weatheradio network and in Canada's Weatheradio Canada network.

Australia

The Bureau of Meteorology provides a flood warning service for most major rivers in Australia. This service is provided with the cooperation of other government authorities, such as the State Emergency Service (S/TES) in each State/Territory, water agencies and local Councils. The Bureau delivers this service through Flood Warning Centres and Regional Forecasting Centres in Bureau Regional Offices in each State and the Northern Territory.

The Flood Warning Service provides different types of information that depends on the type of flooding and the flood risk. The range of information, which may vary between states and areas within a state, includes:

An alert, watch or advice of possible flooding, if flood producing rain is expected to happen in the near future. The general weather forecasts can also refer to flood producing rain.

A generalised flood warning that flooding is occurring or is expected to occur in a particular region. No information on the severity of flooding or the particular location of the flooding is provided. These types of warnings are issued for areas where no specialized warnings systems have been installed. As part of its Severe Weather Warning Service, the Bureau also provides warnings for severe storm situations that may cause flash flooding. In some areas, the Bureau is working with local councils to install systems to provide improved warnings for flash flood situations.

Warnings of 'minor', 'moderate' or 'major' flooding in areas where the Bureau has installed specialized warning systems. In these areas, the flood warning message will identify the river valley, the locations expected to be flooded, the likely severity of the flooding and when it is likely to occur.

Predictions of the expected height of a river at a town or other important locations along a river, and the time that this height is expected to be reached. This type of warning is normally the most useful in that it allows local emergency authorities and people in the flood threatened area to more precisely determine the area and likely depth of the flooding. This type of warning can only be provided where there are specialized flood warning systems and where flood forecasting models have been developed.

3.4.5 Tropical Cyclone and Hurricane Cyclone Warnings

Cyclone warnings are disseminated through a variety of communication media, such as, radio, television, print media, telephones, fax, telex, telegrams, police wireless network. A specially designed Cyclone Warning Dissemination System which works via the INSAT satellite provides area-specific service even when there is a failure of conventional communication channels. Warnings are issued for general public, fishermen, farmers and different categories of users such as central and state government officials responsible for disaster mitigation and relief, industrial and other establishments located in the coastal areas, railways, aviation, communications and power authorities.

North Atlantic systems

The US National Hurricane Center uses the following terminology for classifying storms etc. and which is also used as standard terminology for countries around the North Atlantic, the Caribbean basin, except Cuba as well as for the Pacific coasts of Mexico, Central America, southern California, and Hawaii.

Tropical storms

Prior to the 1987 Atlantic hurricane onset, tropical storm warnings were known as Gale Watches/Warnings, thus, no different from warnings for non-tropical storms.

Tropical storm watch

This kind of warning is issued in case of tropical storm conditions, including winds from 39 to 73 mph (35 to 64 knots, 63 to 117 km/h) threaten to cause damage to a particular coastal area within the next 36 hours. This warning is symbolized by a single square red flag.

Tropical storm warning

This kind of warning is issued in case of the same storm conditions as above are expected within the next 24 hours or less. This warning is symbolized by two square red flags.

Hurricanes

This type of warning is issued when a hurricane is expected to hit a specific area sometime during the next 36 hours. This watch is symbolized by a single square red flag with a black square in the middle. This

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watch is issued to prepare residents of the area to evacuate their homes, collect supplies and rush to hurricane shelters.

Hurricane warning flags (USA): In USA, a hurricane warning is made when it is estimated that a hurricane with sustained winds of 74 mph (65 knots, 118 km/h) or higher would be hitting a particular coastal area within the next 24 hours. This warning is symbolized by two square red flags, each with a black square in the middle.

The hurricane warning remains valid even after wind speed has subsided below hurricane intensity but there is danger of dangerously high water level or a combination of dangerously high water and extremely high waves.

In case it is not possible determine the intensity or track of a forecast cyclone (when a tropical storm is imminent of nearly hurricane intensity or it is on the edge of a track), a Tropical Storm Warning and a Hurricane Watch are issued at the same time along various portions of the coastline. These are indicated by two square red flags with a black square in the middle on only one of them.

Inland advisories: Such alerts are issued for areas lying away from the coastline but are likely to be affected by the tropical storm or hurricane force wind and/or rain conditions. Such advisories were first issued in 2005. All warnings come with Emergency Alert System event codes HWA and HWW, employed for high wind watches and warnings, despite their being under the same codes and standard tropical cyclone advisories. Earlier, standard High Wind Warnings and Watches were issued. These refer to tropical storm force or worse. For inland regions, watches and/or warnings are issued for tropical storm or hurricane intensity winds. Listed here are the older watches and warnings:

Inland tropical storm watch

This is issued for inland regions when there is prediction of sustained winds of 39 to 73 mph (62 to 117 km/h) associated with a tropical storm even if the actual occurrence, timing and location are still not known exactly.

Inland tropical storm warning

These are issued for inland counties when there is prediction of tropical storm conditions in the coastal areas within the next twelve hours or less.

Inland hurricane watch

Issued in anticipation of sustained winds of 74 mph (118 km/h) or greater associated with a hurricane in inland counties even if the actual occurrence, timing and location are not known exactly.

Inland hurricane warning

Such warnings are issued for inland counties when sustained hurricane intensity winds are forecast beyond the coastal areas within the next twelve hours or less.

3.4.6 Drought Warning System

A colour-coded early warning system is developed and proposed for drought management on the real-time reservoir operation. The system consists of three essential elements, namely, (1) drought watch, (2) water consumption measure, and (3) policy making. A new drought alert index is used to characterize the alert level of drought severity. For demonstration the drought warning procedures were effectively applied to a real-world two-parallel-reservoir region in northern Taiwan. The implementation of such a system proves that the decision support-like system can help the water authorities concerned take a timely action while confronting drought threats.

3.4.7 Megha-Tropiques Satellite

Megha-Tropiques is an Indo-French Joint Satellite Mission. The main objective of this mission is to understand the life cycle of convective systems that influence the tropical weather and climate and their role in associated energy and moisture budget of the atmosphere in tropical regions.

Megha-Tropiques will provide scientific data on the contribution of the water cycle to the tropical atmosphere, with information on water vapour in the atmosphere condensed water in clouds, evaporation, and precipitation. With its circular orbit inclined 20 degrees to the equator the Megha-Tropiques is a unique satellite for climate research that should aid scientists seeking to refine prediction models.

Check Your Progress

7. Define GIS.
8. What is remote sensing?
9. Name the two types of remote sensing.
10. What is an earthquake warning system?
11. Define flood warning.

3.5 ROLE OF VARIOUS AGENCIES IN DISASTER MITIGATION: NATIONAL LEVEL AND STATE LEVELS

The general role of states (or governments) can be enumerated as follows:

- To provide relief to the people for the loss incurred due to disaster and to expedite rehabilitation and reconstruction and to ensure that all sections of the population are covered by efforts of the government
- The government also needs to put in place some social and economic activities for quick restoration of the situation
- To make efforts to minimize the impact of disasters by adopting precautionary measures and mechanisms
- To analyze and study the reasons for the occurrence of disasters and to suggest the remedies to avoid or minimize the effects of such natural calamities
- To make the best use of the funds, grants, donations and assistance received from the central government and other foreign countries or from other institutions/individuals for prevention of such natural calamities or for reconstruction and rehabilitation; to obtain loans and make proper use of the obtained funds

Institutional arrangements

In countries with federal system of government, various roles are distributed among the central and state governments. State governments further delegate their responsibilities down to the district authorities, block level as well as the village level. In fact, the Panchayat Raj Institutions in India are vested with specific roles in many administrative and developmental activities. However, the subject of disaster management has not been specifically mentioned in any of the three lists in the 7th schedule of the Indian Constitution, where subjects under the central and state governments that come under both are specified. On the legal front, there is no enactment either of the central or of any state government to deal with the management of disasters of various types in a comprehensive manner.

As a response to the numerous natural as well as man-made disasters, the governments of almost all the world nations have put institutional arrangements in place. India, too, has has an integrated administrative machinery for management of disasters at the national, state, district and sub-district levels. The basic responsibility of undertaking rescue, relief and rehabilitation measures in the event of natural disasters, as at present, is that of the state governments concerned. The central government supplements the efforts of the states by providing financial and logistic support.

Central level

The level of response at the central government level is determined as per the current policy of relief expenditure fund and looking at factors like:

- Seriousness of the disaster
- Required scale of the relief and rescue operation
- Required central assistance as support for state-funded financial help and logistic support

The Contingency Action Plan (CAP) lists the initiatives that need to be taken by different central ministries and public departments after a natural disaster has taken place. The Plan will contain the procedures and identify the focal points in the administration to enable immediate launch of relief and rescue operations.

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The ministry of home affairs is the nodal ministry for coordination of relief and response and overall natural disaster management, and the department of agriculture and cooperation is the nodal ministry for drought management. Other ministries are assigned the responsibility of providing emergency support in case of disasters that fall in their purview.

The following decision-making and standing bodies are responsible for disaster management at the central level:

- Union Cabinet, headed by the Prime Minister
- Empowered Group of Ministers, headed by the Deputy Prime Minister
- National Crisis Management Committee (NCMC), under the chairmanship of the Cabinet Secretary
- Crisis Management Group (CMG): Under the chairmanship of the Central Relief Commissioner comprising senior officers from the various Ministries and other concerned departments which reviews contingency plans, measures required for dealing with a natural disaster, and co-ordinates the activities of the Central Ministries and the state governments in relation to disaster preparedness response and relief
- Technical organizations such as the Indian Meteorological Department (cyclone/earthquake), Central Water Commission (floods), Building Material and Technology Promotion Council (construction laws), Bureau of Indian Standards (norms), Defence Research & Development Organization (nuclear/biological), Directorate General Civil Defence provide specific technical support to coordination of disaster response and management functions
- The setting up of a National Disaster Management Authority (NDMA) is being contemplated by the Ministry of Home Affairs as the proposed apex structure within the government for the purpose. Amongst other major organizational initiatives, it is proposed to:
  - o Establish a specialised and earmarked response team for dealing with nuclear/biological/ chemical disasters
  - o Establish search and rescue teams in each state
  - o Strengthen communication systems in the North-eastern region

Various agencies play various roles in disaster management-governments, NGOs, local agencies and the corporate sector. Some of these roles are overlapping. In addition, these agencies need to work in close cooperation with each other. In large countries like India, the government bodies function at many levels and through many different agencies. Therefore, coordination of their efforts is another challenge that needs to be met satisfactorily. Here, you will study about the roles of various agencies in disaster management.

State level

The responsibility to cope with natural disasters is essentially that of the state government. The role of the central government is supportive in terms of supplementation of physical and financial resources. The chief secretary of the state heads a state level committee which is in overall charge of the relief operations in the state and the relief commissioners who are in charge of the relief and rehabilitation measures in the wake of natural disasters in their states function under the overall direction and control of the state level committee. In many states, secretary, department of revenue, is also in-charge of relief. State governments usually have relief manuals and the districts have their contingency plan that is updated from time to time.

Table 3.2 *Ministries Responsible for Disasters*

Disasters	***Nodal Ministry***
Natural Disasters Management (Other than Drought Relief)	Ministry of Home Affairs
Drought Relief	Ministry of Agriculture
Air Accidents	Ministry of Civil Aviation
Railway Accidents	Ministry of Railways
Chemical Disasters	Ministry of Environment & Forests
Biological Disasters	Ministry of Health
Nuclear Disasters	Department of Atomic Energy

3.5.1 Role of Local Agencies

District and local level: As already discussed, the state governments are responsible for carrying out disaster management activities. However, the state governments get these activities carried out at the local level through district and local authorities. The district administration is the focal point for implementation of all governmental plans and activities. The actual day-to-day function of administering relief is the responsibility of the collector/district magistrate/deputy commissioner who exercises coordinating and supervising powers over all departments at the district level. Though it may not be a common phenomenon, there exists by and large in districts also a district level relief committee consisting of officials and non-officials.

The 73rd and 74th constitutional amendment have accorded the Panchayati Raj Institutions the status of 'Institutions of self-government'. The amendment has also laid down necessary guidelines for the structure of their composition, powers, functions, devolution of finances, regular holding of elections and reservation of seats for weaker sections including women. These local bodies can be effective instruments in tackling disasters through early warning system, relief distribution, providing shelter to the victims, and medical assistance.

Other local level agencies

Other than the national, state, district and local levels, there are various institutional stakeholders who are involved in disaster management at various levels in the country. These include the police and para-military forces, civil defence and home-guards, fire services, ex-servicemen, non-government organisations (NGOs), public and private sector enterprises, media and HAM operators (amateur radio operators), all of whom have important roles to play.

Armed forces

In India, the armed forces are called upon to intervene and take on specific tasks only when the situation goes beyond the control of civil administration. In practice, the armed forces are the core of the government's response capacity and tend to be the first responders of the central government in a major disaster. Due to their ability to organize action in adverse ground circumstances, speed of operational response and the resources and capabilities at their disposal, the armed forces have historically played a major role in emergency support functions such as communications, search and rescue operations, health and medical facilities, transportation, power, food and civil supplies, public works and engineering, especially in the immediate aftermath of disaster. Disaster management plans should incorporate the role expected of them so that the procedure for deploying them is smooth and quick.

International bodies

In the face of disasters, help usually pours in from various institutional and non-institutional agencies form within the nation as well as from outside. Foreign governments, especially the neighbours and other friendly nations are the first ones to offer aid. Many international bodies are vested with the responsibility to mitigate challenges posed by disasters. The Government of India is a member of various international organisations in the field of disaster response and relief. While, as a policy, no requests for assistance or appeals are made to the international community in the event of a disaster, assistance offered suo moto is accepted. Linkages exist with the following organizations:

- UN Office for Coordination of Humanitarian Affairs (UN OCHA), which has been made responsible by UN General Assembly mandate for all international disaster response
- United Nations Development Programme (UNDP), responsible for mitigation and prevention aspects of disaster management
- UN Disaster Assessment and Coordination (UNDAC) System

Community level initiatives

The goal of any disaster management initiative is to build a disaster resistant/resilient community equipped with safer living and sustainable livelihoods to serve its own development purposes. The community is also the first responder in any disaster situation, thereby emphasising the need for community level initiatives in managing disasters. To encourage such initiatives, the following are required:

- Creating awareness through disaster education and training and information dissemination are necessary steps for empowering the community to cope with disasters.

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- Community based approach followed by most NGOs and Community Based Organisations (CBOs) should be incorporated in the disaster management system as an effective vehicle of community participation.
- Within a vulnerable community, there exist groups that are more vulnerable like women and children, aged and infirm and physically challenged people who need special care and attention especially during disaster situations. Efforts are required for identifying such vulnerable groups and providing special assistance in terms of evacuation, relief, aid and medical attention to them in disaster situations.

Management of disasters should therefore be an interface between a community effort to mitigate and prevent disasters as also an effort from the government machinery to buttress and support popular initiatives.

Role of NGOs

The past few decades have witnessed the growth (and proliferation) of numerous NGOs in various fields. Although many NGOs devote their attention to specific issues, most of these swing into action in the face of a disaster. There are NGOs devoted to disaster management, which conduct research, carry out rehabilitation and reconstruction work when immediate help is not required.

NGOs are autonomous non-governmental bodies operating mostly as non-profit organizations. In India, they are very large in number and widely scattered across the country. Therefore, a need was felt to coordinate and streamline the activities of the NGOs so as to have the optimal benefit from their efforts. For this purpose, the National NGO Task Force has been set up. The main objective of this task force is to promote Community Based Disaster Risk Management (CBDRM) in all spheres of disaster management.

Some of the guiding principles of the task force are as follows:

- The National NGO Task Force on disaster management will be guided by CBDRM.
- This will also be the national-level platform for coordinating the activities of both government organizations and non-governmental organizations (GO-NGOs) in the field of disaster management.
- The Task Force will facilitate and support the formation of similar task forces at state and district levels.

Objectives of the task force

The objectives of the task force are as follows:

- Mapping of NGOs at state and district levels
- Training and capacity building of various stakeholders
- Mainstreaming vulnerability reduction through CBDRM in civil society initiatives
- Assisting the transition from relief codes to Disaster Management codes through Policy and Guidelines
- Guidelines for GO-NGO collaboration
- Providing assistance in setting up NGO task forces at state and district levels
- Integrating CBDRM in development programmes
- Strengthening disaster preparedness, mitigation and effective response in state and districts
- Setting up working groups on specific themes to include broad-based participation of civil society organizations

Advisory/advocacy role

- Coordination with government and other stakeholders in the field of disaster management
- Information sharing, documentation and dissemination, knowledge sharing, networking and technical support
- Training and capacity building
- Helping INGOs/NGOs articulate their CBDRM policies

The task force has laid down several criteria for membership. Some of these criteria are as follows:

- A maximum of 20 members in the National Task Force
- The secretariat for the National NGO Task Force will be hosted at NDMA
- International, national, local NGOs and networks which are active at national, state and district level, undertaking disaster management initiatives in preparedness, capacity building, mitigation and response, including reconstruction programmes with potential for replication
- Organizations committed to CBDRM and having scope for wider dissemination and replication of CBDRM practices
- Organizations which have responded to a few major disasters
- Having the ability to dialogue and liaise with government and other stakeholders on disaster management and related policy issues
- Having demonstrated ability in training and capacity building

The list of institutions to be the members of the Task Force

- UNDP
- CARE, India
- OXFAM
- EFICOR
- SEEDS
- PGVS
- ABCD
- TNTRC
- RVC
- RedR India
- CARITAS
- World Vision
- Indian Red Cross Society
- BJS
- UNICEF
- MHA, GoI
- NIDM
- Ramakrishna Mission
- VANI
- SPHERE India

One of the most effective agencies during a disaster are the NGOs operating in the concerned area. These NGOs along with other local bodies (government assistance is desirable) can create community level initiative since community level initiatives are most effective.

3.5.2 Role of Corporate Agencies

Disasters are unforeseen events that cause great damage, destruction and human suffering. They require immediate, coordinated and effective response from multiple sources such as government, voluntary and corporate sector organizations. The corporate sector in India has played a valuable role in relief, recovery, rehabilitation and reconstruction.

An enhanced, expanded, well-defined and pro-active role is expected from corporates in all aspects of the disaster management cycle.

The NDMA recognizes the Indian corporate sector as one of the key stakeholders and envisages the involvement of this sector in awareness generation, disaster preparedness and mitigation planning through sensitization, training and co-opting of the corporate sector and their nodal bodies in planning process and response mechanism.

The corporate sector has the potential of assisting both the business community in protecting itself and the community at large in increasing its resilience to disasters.

Objectives for corporate sector's involvement in disaster management

- To identify the roles of various corporate entities in different areas of disaster management, including disaster preparedness, mitigation, emergency response (relief, rehabilitation, reconstruction) and recovery
- To explore the potential roles of trade associations for mobilizing the corporate sector in disaster management
- To explore the full potential of corporate social responsibility and public private partnership in disaster management in India for professionalizing various aspects of governance
- To set up a national corporate task force on disaster management
- The corporates in India are constantly committed to extending all necessary help toward disaster management. Various corporate bodies coordinate their efforts. Meetings and follow-up meetings are called with other corporate associations such as FICCI, CII, ASSOCHAM and NASSCOM to discuss the modalities on public- private participation in disaster management, to explore the potential roles of trade associations in disaster management initiatives and to make strategies for setting up of a corporate task force for disaster management.

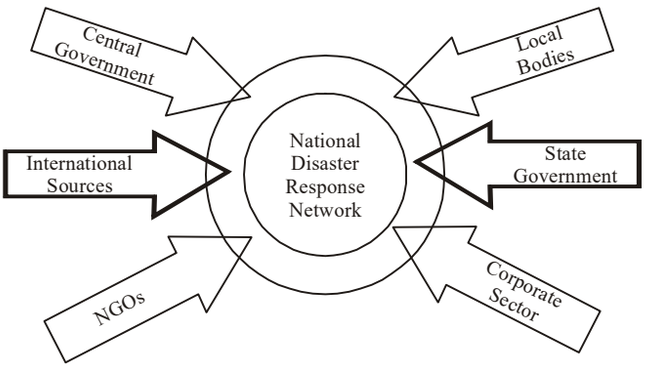

Fig. 3.2 *National Disaster Response Network*

3.5.3 Role of the Armed Forces

India is a very vulnerable nation which is prone to multiple natural disasters owing to its unique topographic and climatic conditions. Considering its size and dimensions, it has various different climates and geographical types. The coastal states, especially the ones on the eastern coast and Gujarat are exposed to cyclones where 40 million hectares (eight per cent) of land mass is flood prone, 68 per cent faces drought threat, 55 per cent of the area is in seismic zones III and IV and falls under earthquakes-prone belt and sub-Himalayan region and Western Ghats are threatened by landslides. India is increasingly getting affected by man-made disasters related to industrialization, transportation, environmental degradation and terrorist attacks. There is no legal ratification either at the central or the state governments level to deal with such disasters as it is not specified under any of the three lists (central, state and concurrent) of Seventh Schedule of the Indian Constitution.

The government of India is well aware that there is an urgent need for better disaster response mechanism, but the overall trend has indicated that the level of preparation to handle such disasters by the centre as well as the states is very unbalanced and unorganized which requires considerable strengthening. The centre and a number of states have started gearing up for such disasters which are becoming common by the day. The nodal agency for coordination of relief, response and overall natural disaster management has been positioned under the Union ministry of home affairs to design strategies to overcome such disasters and their effects. Whenever any disaster occurs in India, the armed forces are requested to intervene and take control of the situation.

Since the Indian civil administration is not adequately equipped for undertaking such urgent disaster response activities, they rely on the support given by the armed forces. On the other hand, Indian armed forces are one of the most technologically developed, dedicated and modernized armed forces in the world, adequately equipped with the necessary technical competence, man power and material resources undertakes rescue and relief operations of any disasters. An instance can be stated

when the tsunami that occurred in December 2004 where the Indian Army, Navy and the Air Force coordinated by the Integrated Defence Staff (IDS) efficiently executed the relief, rescue and evacuation assignments under Operation Sea Wave, and also extended aid to Sri Lanka and Maldives under Operation Rainbow and Operation Castor at the request of their respective governments for assistance. A few other such instances where the defence showed its presence was the Kashmir earthquake of 2005, the cyclone in Bangladesh on 15 November 2007, the fire breakout at Burrabazar in Kolkata on 12 January 2008 or the recent serial blasts at Bangalore and Ahmedabad in July 2008, the role played by the Indian armed forces is commendable.

The primary role being to defend the nation against any external forces the Indian armed forces are inevitably involved in securing the country from diverse unconventional fronts. They are always ready to execute any kind of operation related to any kind of disaster-affected areas and the daring and skill required to be able to work under adverse ground and climatic conditions. This continual performance in quick rescue and response action after disasters has been outstanding and with the ever increasing frequency of disasters in the South-Asian region, they continue to play a major role in the coming years.

In spite of the disaster rescue and relief responsibilities, there is need for decisive modus operandi for operational coordination between the civil administration and the armed forces. The armed forces' instant response depends on the information made available by the state administration, where any delay in information would cause loss of precious time to relieve the situation. In regard to this quick response the state should appreciate the immediate organizing and course of action in which the armed forces function. The armed forces' professional ethics are autonomous in character and do not encourage civil interference. As disaster management plan should incorporate the role of the armed forces so that the procedure for deploying them is well-organized, and there is an interface personnel correlation between the state government and the armed forces for immediate effective delivery of relief to the affected victim.

The armed forces has trained resources locations with rehearsals to:

- Carry out search and rescue operations to save the injured and the disposal of the deceased victims to prevent spread of epidemics
- Mapping of vulnerable areas and escape routes
- Building mechanisms of early warning, educating the public in safety measures are added components to the police functioning

Armed forces rescue hundreds in flood-hit states

New Delhi, Oct 5: Undertaking one of the biggest relief and rescue operations in the flood-ravaged states of Karnataka and Andhra Pradesh, the armed forces have rescued hundreds of marooned people so far.

"1,336 people have been rescued so far by the armed forces in the flood-ravaged states of Karnataka and Andhra Pradesh. The army, air force and the navy are working round-the-clock to rescue the marooned people and provide much needed food in the flood affected areas," a defence ministry spokesperson said Monday.

In the flood fury that hit Andhra Pradesh, Karnataka and other neighbouring states of Goa and Maharashtra Oct 1, following torrential rains under the influence of a low pressure area in the Bay of Bengal, a large number of towns and villages were either submerged or inundated by water from the Krishna, Tungabhadra and Don rivers.

"The army has deployed around 1000 of its men in Karnataka and Andhra Pradesh along with life jackets, boats and medical teams," the spokesperson added.

The flood situation is improving in Mahbubnagar district of Andhra Pradesh.

"The Indian Air Force (IAF) in one of its biggest rescue operations so far has deployed 29 aircraft and helicopters, including seven Chetaks and 10 MI-8s, for rescue and relief

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operations. These aircraft have already carried out 255 sorties and dropped a huge quantity of food packets in the affected areas," an IAF official said.

The Indian Navy also has deployed 15 teams of its divers and experts to rescue the marooned people in the two states. Of these, five teams are at Vijaywada, three at Mahbubnagar, three at Kurnool in Andhra Pradesh, two at Karwar and two at Gadag district in Karnataka. These teams have already rescued more than 500 people from the affected areas.

Source: Reported by IANS : http://www.newkerala.com/nkfullnews-1-125154.html

When such natural calamities such as floods and drought occur they are addressed by the already existing number of plan schemes under which a lot is planned and can be done. The state governments need to implement and make full use of the existing plan schemes and prioritize the implementation of such schemes which would help in overcoming the hard hit situation left behind by the disaster. In certain cases when the damage is colossal, they even imply possible diversion of the funds from other schemes to those schemes which are implemented to ease such situations and provide immediate relief. In such crisis situations there may also be need for certain re-appropriations/reallocations among the different departments.

When the Indian armed forces are called upon to control the situation, they come with the basic requirements of the people in such situations. In practice, the armed forces are the main government's response capacity and are generally the first rescue team in situations of such severe crisis. Because of their ability to organize action in adverse ground circumstances with speed and efficiency, the Armed Forces play a major role in emergency support functions such as communications, search and rescue operations, health and medical facilities, transportation, power, food and civil supplies, public works and engineering, specially in the immediate aftermath of disaster. Disaster management plans should incorporate the role expected of them so that the procedure for deploying them is smooth and quick as displayed by the armed forces.

Although we have very efficient and swift acting armed forces for our rescue, there are some areas of concern that need to be worked upon, streamlined and require improvement urgently. They are:

- Integrated planning for disasters which also includes the intervention and roles of the armed forces formations into disaster management planning at all levels starting from the district level right up to the Central Government.
- Setting up of a permanent modernized well equipped national command centre or operations room, with advanced communications and data links to all state capitals. The national command centre or operations room needs to be operated on a 24-hour basis by professionals for instant response and resource integration. There needs to be a properly equipped operations room at the state level as well.
- A quick action team composed of experienced professionals, from both military and civilian backgrounds drawn from Central and state government staff to respond immediately and be present at the locations when a disaster strikes. This team needs to be organized and run professionally on the same basis as the United Nations Disaster Assessment and Coordination (UNDAC) teams.
- A set of urban search and rescue capacity at all levels, by establishing a fully equipped Search and Rescue team as a part of every fire department unit in all state capitals, with sufficiently trained staff and modern equipment such as thermal imagers, acoustic detection devices. This is of immediate relevance since a major weakness exposed in the Gujarat earthquake was a lack of specialized urban search and rescue capability in India.
- The media policy should be well geared to handle the growing real time television reporting which generates enormous political pressures on the government to respond rapidly and efficiently. This needs attention as it displays the immediate action taken in case of such diverse situations.
- An interface with a better understanding of the international system for disaster response and putting the required systems in place for dealing with international assistance such as customs, immigration, foreign policy implications. A closer weave is required between the Ministry of External Affairs and the relevant inter-national agencies concerned with disaster response.

- The standard procedures for dealing with domestic humanitarian and relief assistance from non-government sources need to be formulated. The procedures need to be laid out to avoid confusion and ensure the best resource utilization being offered, just as it happens in the case of international assistance.
- Modern unified legislation for disaster management. Keeping in mind the current division of responsibilities between the state and Central government, central and concurrent lists, there is a need to create a body of legislation dealing with response to natural disasters and other emergencies, clearly delineating responsibilities and powers of each entity and specifying what powers or actions would need to be triggered on declaration of a disaster by the Government of India or a state government. This legislation also needs to incorporate the current legislation dealing with emergencies caused by chemicals that need to be dealt by the Ministry of Environment so that all emergencies are dealt with under one law. The legislation should include clear definitions of what constitutes a disaster at a national level.

3.5.4 Role of Government Agencies

Each department and government agency involved in disaster management and mitigation will do the following:

- Designate a nodal officer for emergency response who will act as the contact person for that department/agency
- Ensure establishment of fail-safe two-way communication with the state, district and other emergency control rooms and within the organization
- Emphasis on communication systems used regularly during LO with more focus on the use of VHFs with automatic repeaters, mobile phones with publicized numbers, HF radio sets. It should be remembered that SAT phones fail during prolonged emergencies and electric failure if the phones cannot be recharged.
- Work under the overall supervision of the SRC/the district Collectors during emergencies.

Let us look at the way in which various agencies manage disasters:

1. Agriculture

Prevention activities

- Awareness generation regarding various plant diseases, alternate cropping practices in disaster-prone areas, crop insurance, provision of credit facilities, proper storage of seeds
- Hazard area mapping (identification of areas endemic to pest infections, drought, flood, and other hazards)
- Develop database village-wise, crop-wise, irrigation source wise, insurance details, credit facilities
- Regular monitoring at block level; the distribution and variation in rainfall. Prepare the farmers and department officers to adopt contingency measures and take up appropriate course of action corresponding to the different emerging conditions
- Detail response manuals to be drawn up for advising the farmers for different types of disasters, e.g., rain failure in July or September and development of a dynamic response plan taking into account weekly rainfall patterns
- Develop IEC materials to advise the farming communities on cropping practices and precautionary measures to be undertaken during various disasters
- Improving irrigation facilities, watershed management, soil conservation and other soil, water and fertility management measures keeping in mind the local agro-climatic conditions and the proneness of the area to specific hazards
- Promotion of alternative crop species and cropping patterns keeping in mind the vulnerability of areas to specific hazards
- Surveillance for pests and crop diseases and encourage early reporting
- Encourage promotion of agro service outlets/enterprise for common facilities, seed and agro input store and crop insurance

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Preparedness activities

- Review and update precautionary measures and procedures and especially ascertain that adequate stock of seeds and other agro inputs are available in areas prone to natural calamities
- Review the proper functioning of rain gauge stations, have stock for immediate replacement of broken/non-functioning gadgets/equipments, record on a daily basis rainfall data, evaluate the variation from the average rainfall and match it with the rainfall needs of existing crops to ensure early prediction of droughts

Response activities

- Management of control activities following crop damage, pest infestation and crop disease to minimize losses
- Collection, laboratory testing and analysis of viruses to ensure their control and eradication
- Pre-positioning of seeds and other agro inputs in strategic points so that stocks are readily available to replace damage caused by natural calamities
- Rapid assessment of the extent of damage to soil, crop, plantation, irrigation systems, drainage, embankment, other water bodies and storage facilities and the requirements to salvage, re-plant, or to compensate and report the same for ensuring early supply of seeds and other agro inputs necessary for re-initiating agricultural activities where crops have been damaged
- Establishment of public information centres with appropriate and modern means of communication, to assist farmers in providing information regarding insurance, compensation, repair of agro equipments and restarting of agricultural activities at the earliest

Recovery activities

- Arrange for early payment of compensation and crop insurance dues
- Facilitate provision of seeds and other agro inputs
- Promotion of drought and flood-tolerant seed varieties
- Review with the community, the identified vulnerabilities and risks for crops, specific species, areas, which are vulnerable to repetitive floods, droughts, other natural hazards, water logging, increase in salinity, pest attacks and draw up alternative cropping plans to minimize impacts to various risks
- Facilitate sanctioning of soft loans for farm implements
- Establishment of a larger network of soil and water testing laboratories
- Establishment of pests and disease monitoring system
- Training in alternative cropping techniques, mixed cropping and other agricultural practices which will minimize crop losses during future disasters

2. Water Supplies and Sanitation (Public Health Engineering and Rural Water Supply and Sanitation)

Prevention activities

- Provision of safe water to all habitats
- Clearance of drains and sewerage systems, particularly in the urban areas

Preparedness activities

- Prior arrangement of water tankers and other means of distribution and storage of water
- Prior arrangement of stand-by generators
- Adequate prior arrangements to provide water and halogen tablets at identified sites to be used as relief camps or in areas with high probability to be affected by natural calamities
- Raising of tube-well platforms, improvement in sanitation structures and other infrastructural measures to ensure least damages during future disasters
- Riser pipes to be given to villagers

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Response activities

- Disinfections and continuous monitoring of water bodies
- Ensuring provision of water to hospitals and other vital installations
- Provision to acquire tankers and establish other temporary means of distributing water on an emergency basis
- Arrangement and distribution of emergency tool kits for equipments required for dismantling and assembling tube wells
- Carrying out emergency repairs of damaged water supply systems
- Disinfection of hand pumps to be done by the communities through prior awareness activities and supply of inputs

Recovery activities

- Strengthening of infrastructure
- Review and documentation
- Sharing of experiences and lessons learnt
- Training to staff
- Development of checklists and contingency plans

3. Police

Prevention activities

- Keep the force in general and the ODRAF in particular fighting fit for search, rescue, evacuation and other emergency operations at all times through regular drills
- Procurement and deployment of modern emergency equipments while modernizing existing infrastructure and equipments for disaster response along with regular training and drills for effective handling of these equipments
- Focus on better training and equipments for ODRAF for all types of disasters, e.g. diving equipments
- Rotation of members of ODRAF so that the force remains fighting fit
- Ensure that all communication equipments including wireless are regularly functioning and deployment of extra wireless units in vulnerable pockets
- Ensure interchangeability of VHF communication sets of police and OSDMA supplied units, if required.
- Keeping close contact with the District Administration and Emergency Officer
- Superintendent of Police be made Vice Chairperson of District Natural Calamity Committee
- Involvement of the local army units in response planning activities and during the preparation of the annual contingency plans to ensure logistics and other support to armed forces during emergencies

Response plan

- Security arrangements for relief materials in transit and in camps
- Senior police officers to be deployed in control rooms at State and district levels during L 1 level deployment onwards
- Deploy personnel to guard vulnerable embankments and at other risk points
- Arrangement for the safety
- Coordinate search, rescue and evacuation operations in coordination with the administration
- Emergency traffic management
- Maintenance of law and order in the affected areas
- Assist administration in taking necessary action against hoarders, black marketers

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4. Civil Defence

Prevention activities

- Organize training programmes on first-aid, search, rescue and evacuation
- Preparation and implementation of first aid, search and rescue service plans for major public events in the state
- Remain fit and prepared through regular drills and exercises at all times

Response activities

- Act as support agency for provision of first aid, search and rescue services to other emergency service agencies and the public
- Act as support agency for movement of relief
- Triage of casualties and provision of first aid and treatment
- Work in co-ordination with medical assistance team
- Help the police for traffic management and law and order

5. Fire services

Prevention activities

- Development/enforcement of relevant legislations and regulations to enhance adoption of fire safety measures
- Modernization of fire-fighting equipments and strengthening infrastructure
- Identification of pockets, industry which are highly susceptible to fire accidents or areas, events which might lead to fires, building collapse and educate people to adopt safety measures. Conduct training and drills to ensure higher level of prevention and preparedness
- Building awareness in use of various fire protection and preventive systems
- Training the communities to handle fire emergencies more effectively
- VHF network for fire services linked with revenue and police networks
- Training of masons and engineers in fire proof techniques
- Making clearance of building plans by fire services mandatory

Response activities

- Rescue of persons trapped in burning, collapsed or damaged buildings, damaged vehicles, including motor vehicles, trains and aircrafts, industries, boilers and pressure vessels, trenches and tunnels
- Control of fires and minimizing damages due to explosions
- Control of other dangerous or hazardous situations such as oil, gas and hazardous materials spill
- Protection of property and the environment from fire damage
- Support to other agencies in the response to emergencies
- Investigation into the causes of fire and assist in damage assessment

6. Civil supplies

Preventive activities

- Construction and maintenance of storage godowns at strategic locations
- Stockpiling of food and essential commodities in anticipation of disaster
- Take appropriate preservative methods to ensure that food and other relief stock are not damaged during storage, especially precautions against moisture, rodents and fungus infestation

Response activities

- Management of procurement
- Management of material movement
- Inventory management

Recovery activities

- Conversion of stored, unutilized relief stocks automatically into other schemes like Food for Work. Wherever, it is not done leading to damage of stock, it should be viewed seriously

7. Works/Rural development departments

Prevention activities

- Keep a list of earth moving and clearing vehicles/equipments (available with government departments, PSUs, and private contractors) and formulate a plan to mobilize those at the earliest
- Inspection and emergency repair of roads/bridges, public utilities and buildings

Response activities

- Clearing of roads and establishing connectivity. Restore roads, bridges and where necessary make alternate arrangements to open the roads to traffic at the earliest
- Mobilization of community assistance for clearing blocked roads
- Facilitate movement of heavy vehicles carrying equipments and materials
- Identification and notification of alternative routes to strategic locations
- Filling of ditches, disposal of debris, and cutting of uprooted trees along the road
- Arrangement of emergency tool kit for every section at the divisional levels for activities like clearance (power saws), debris clearance (fork lifter) and other tools for repair and maintenance of all disaster response equipments

Recovery activities

- Strengthening and restoration of infrastructure with an objective to eliminate the factor(s) which caused the damage
- Review and documentation
- Sharing of experiences and lessons learnt
- Training to staff
- Development of checklists and contingency plans

8. Energy

Prevention activities

- Identification of materials/tool kits required for emergency response
- Ensure and educate on the minimum safety standards to be adopted for electrical installation and equipments and organize training of electricians accordingly
- Develop and administer regulations to ensure safety of electrical accessories and electrical installations
- Train and have a contingency plan to ensure early electricity supply to essential services during emergencies and restoration of electric supply at an early date
- Develop and administer code of practice for power line clearance to avoid electrocution due to broken/fallen wires
- Strengthen high-tension cable towers to withstand high wind speed, flooding and earthquake, modernize electric installation, strengthen electric distribution system to ensure minimum damages during natural calamities
- Conduct public/industry awareness campaigns to prevent electric accidents during normal times and during and after a natural disaster

Response activities

- Disconnect electricity after receipt of warning
- Attend sites of electrical accidents and assist in undertaking damage assessment
- Stand-by arrangements to ensure temporary electricity supply

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- Prior planning and necessary arrangements for tapping private power plants like those belonging to ICCL, NALCO, RSP during emergencies to ensure uninterrupted power supply to the Secretariat, SRC, OSDMA, Police Headquarters, All India Radio, Doordarshan, hospitals, medical colleges, Collectorate Control Rooms and other vital emergency response agencies
- Inspection and repair of high tension lines /substations/transformers/poles
- Ensure the public and other agencies are safeguarded from any hazards, which may have occurred because of damage to electricity distribution systems
- Restore electricity to the affected area as quickly as possible
- Replace/restore of damaged poles/salvaging of conductors and insulators

9. Water resources department

Prevention activities

- Assess preparedness level
- Annual assessment of danger levels and wide publicity of those levels
- Identify flood prone rivers and areas and activate flood monitoring mechanisms
- Provide water level gauge at critical points along the rivers, dams and tanks
- Identify and maintain of materials/tool kits required for emergency response
- Stock-pile of sand bags and other necessary items for breach closure at the Panchayat level

Response activities

- Monitoring flood situation
- Dissemination of flood warning
- Ensure accurate dissemination of warning messages naming GPs and Tehsils with details of flow and likely damage
- Monitoring and protection of irrigation infrastructures
- Inspection of bunds of dams, irrigation channels, bridges, culverts, control gates and overflow channels
- Inspection and repair of pumps, generator, motor equipments, station buildings
- Community mobilization in breach closure

Recovery activities

- Strengthening of infrastructure and human resources
- Review and documentation
- Sharing of experiences and lessons learnt
- Training of staff
- Development of checklists and contingency plans

10. Fisheries

Prevention activities

- Registration of boats and fishermen
- Building community awareness on weather phenomena and warning system especially on Do's and Don'ts on receipt of weather related warnings
- Assist in providing life saving items like life jackets, hand radios
- Certifying the usability of all boats and notifying their carrying capacities
- Capacity building of traditional fishermen and improvisation of traditional boats which can be used during emergencies
- Train up young fishermen in search & rescue operation and hire their services during emergency

Response activities

- Ensure warning dissemination to fishing communities living in vulnerable pockets

- Responsible for mobilizing boats during emergencies and for payment of wages to boatmen hired during emergencies
- Support in mobilization and additional deployment of boats during emergencies
- Assess the losses of fisheries and aquaculture assets and the needs of persons and communities affected by emergency

Recovery activities

- Provide compensations and advice to affected individuals, community
- Plan for rehabilitation in the long run of the fisherfolk including resettlement, insurance, better boats, nets, etc., improved communication system as a part of the communication hub for warning dissemination, especially for marine fishermen and fishing communities residing in high-risk areas

11. Forest department

Prevention activities

- Promotion of shelter belt plantation
- Publishing for public knowledge details of forest cover, use of land under the forest department, the rate of depletion and its causes
- Keep saws (both power and manual) in working conditions
- Provision of seedling to the community and encouraging plantation activities, promoting nurseries for providing seedlings in case of destruction of trees during natural disasters

12. Transport department

Prevention activities

- Listing of vehicles which can be used for emergency operation
- Safety accreditation, enforcement and compliance
- Ensuring vehicles follow accepted safety standards
- Build awareness on road safety and traffic rules through awareness campaign, use of different IEC strategies and training to school children
- Ensure proper enforcement of safety regulations response activities
- Requisition vehicles, trucks, and other means of transport to help in the emergency operations
- Participate in post impact assessment of emergency situation
- Support in search, rescue and first aid
- Failure to cooperate and misappropriation of relief materials to invite disqualification from the post

Recovery activities

- Provision of personal support services e.g. counselling
- Repair/restoration of infrastructure e.g. roads, bridges, public amenities
- Supporting the GPs in development of storage and in playing a key role and in the coordination of management and distribution of relief and rehabilitation materials the Panchayat Samity and GP members to be trained to act as an effective interface between the community, NGOs, and other developmental organizations
- Provide training so that the elected representatives can act as effectives supportive agencies for reconstruction and recovery activities

13. Panchayati raj

Preventive activities

- Develop prevention/mitigation strategies for risk reduction at community level
- Training of elected representatives on various aspects of disaster management
- President, Zilla Parishad to be made member of District Natural Calamity Committee

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- Public awareness on various aspects of disaster management
- Organize mock drills
- Promote and support community-based disaster management plans
- Support strengthening response mechanisms at the GP level (e.g., better communication, local storage, search & rescue equipments)
- Clean drainage channels, organize through community participation trimming of branches before cyclone season
- Ensure alternative routes/means of communication for movement of relief materials and personnel to marooned areas or areas likely to be marooned
- Assist all the government departments to plan and prioritize prevention and preparedness activities while ensuring active community participation

Response activities

- Train the GP members and support for timely and appropriate delivery of warning to the community
- Clearance of blocked drains and roads, including tree removal in the villages
- Construct alternative temporary roads to restore communication to the villages
- PRls to be a part of the damage survey and relief distribution teams to ensure popular participation
- Operationalize emergency relief centres and emergency shelter
- Sanitation, drinking water and medical aid arrangements
- IEC activities for greater awareness regarding the role of trees and forests for protection during emergencies and also to minimize environmental impact which results owing to deforestation like climate change, soil erosion
- Increasing involvement of the community and NGOs in plantation, protection and other forest protection, rejuvenation and restoration activities
- Plan for reducing the incidence, and minimize the impact of forest fire
- Assist in road clearance
- Provision of tree cutting equipment
- Provision of building materials such as bamboos etc. for construction of shelters

Recovery activities

- Take up plantation to make good the damage caused to tree cover
- Information and Public Relations Department

Prevention activities

- Creation of public awareness regarding various types of disasters through media campaigns
- Dissemination of information to public and others concerned regarding do's and don'ts of various disasters.
- Regular liasioning with the media

Response activities

- Setting up of a control room to provide authentic information to public regarding impending emergencies
- Daily press briefings at fixed times at state and district levels to provide official version (during LO also)
- Media report and feedback to field officials on a daily basis from L1 onwards
- Keep the public informed about the latest of the emergency situation (area affected, lives lost)
- Keep the public informed about various post-disaster assistances and recovery programmes

3.5.5 Role of Media in Disaster Management

Disasters can be both natural and man-made. But the root causes of some of the seemingly natural disasters may also be certain human activities carried on in utter disregard of their consequences to the nature. Such natural disasters are therefore preventable. Since all man-made disasters and some of the so-called natural disasters are preventable, the media can educate and forewarn the people about the consequences of their dangerous actions and operations. More and in-depth education on the subject becomes necessary where the human activities and the natural calamities they lead to, are separated by a period of time. In such cases, though the causal connection is direct, since the consequences occur at a distant point of time, people fail to appreciate the link between the two and continue to indulge in their depredations on nature, digging in turn sometimes slowly, sometimes fast, a grave for humanity.

The floods, droughts and water famine situations are many times directly traceable to the human activity, while drainage mismanagement and air and water-pollution, environmental destruction and global warming are all clearly on account of the man's misdeeds. Some excavations and destruction of forests are responsible for landslides and mudflows, while according to experts some earthquakes are caused by the construction of the large dams and by impounding large quantities of water in them. The dam failures, dam bursts, mine fires, epidemics, food poisoning, chemical and industrial disasters, nuclear disasters and all accident-related disasters are undoubtedly the handiwork of man.

The impending occurrence of some natural disasters whether induced by human actions or otherwise, can now be known sufficiently in advance, thanks to the advances in science and technology. The media, by communicating the information to the people and the concerned authorities sufficiently in advance, can enable them to take the necessary steps to prevent and minimize the losses of lives and property.

While the disaster is on, the media can also play the role of relaying the measures that are being taken and monitoring them, cautioning the affected or to be affected people about the Dos and Don'ts, of scotching rumours and preventing panic and confusion, of establishing contacts, of identifying the needy spots and focusing attention on them, and generally by assisting the authorities, voluntary organizations and volunteers in reaching, informing and assuring the affected ones of the assistance and the measures taken, for their relief. During the onslaught of the disaster, what is of utmost importance is to keep the morale of the people high, to create self-confidence in them, to prevent panic and to maintain order by assuring and making available the necessary help readily and quickly. The media can help in many ways in ensuring these conditions.

The rescue, relief and rehabilitation measures need an integrated and co-coordinated approach and for that purpose all agencies, government and non-government, have to pool their resources together for efficient, expedient and effective work on all fronts. The collection of material resources and the enlisting of man-power are as much important as their efficient utilization. The depiction of devastation and of human misery through the media many times by itself acts as an appeal to the people to come forward to render help in various ways. In addition, the specific appeal made for relief through the columns and the time-slots of the media, brings in sizeable aid in the requisite form. At the same time, it becomes necessary to keep a watch and report on some anti-social elements who try to take advantage of such situations.

Some disasters like floods, cyclones and droughts have become a periodic feature of our national life. The vulnerable spots and the sections of the populace also stand identified over the years. Almost always, the worst sufferers are the weaker sections of the society. They are unable to shift from these places, because there lie their sources of livelihood and all that they have in life to preserve and protect. They constitute a vast section of our society, and in normal conditions they contribute in sizeable proportion to our national wealth. Yet, except in the times of disaster, they are rarely remembered and the measures for the permanent solution of their plight are hardly ever discussed in the media. The media can also focus its attention on this problem.

Not insignificant is the contribution the media can make in countering the damaging, exaggerated and negative reporting and propaganda in the foreign media on the occurrence of the disasters. This country has witnessed such phenomena in the past. A prompt presentation of the real state of affairs by our media including the news-agencies, and the correction of the misrepresentations by them will go a long way in dispelling the wrong impressions created abroad which may otherwise have adverse effects on the administration, the economy and the polity of the country.

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On some occasions in the past the media fulfilled its duties in full measure while on other occasions it was found wanting. However, if the media has to discharge its role properly on such occasions, it is also necessary to have a complete cooperation between it and all governmental and non-governmental agencies. The extent of the co-ordination and co-operation between them determines the nature, the degree and the scale of the preparation to prevent and meet the disasters.

People across the globe are more disaster-conscious today than they ever were, thanks to the media. Countries that have a large geographical extent, house a large population, have a vast coastal strip and many mountainous areas and rivers, are more vulnerable to disasters. Prevention is better than cure and prevention can only happen through education and information dissemination. The role of the media in educating the population and providing information is of immense importance.

It is not just now that the media has come into prominence. Even in the past, Mahatma Gandhi made use of the media, that is, newspapers, to convey the methods of preventing plague. He wrote in the *Amrit Bazar Patrika*, about the techniques of preventing plague with the aim of educating the masses. Not only did he appeal to the people to adopt clean habits and ensure hygiene, he requested the educated groups to spread the word about the importance of hygiene and sanitation. His writings, popularized by the media, encouraged people to collect and dispose off garbage and use the pictures of Gods and Goddesses to prevent people from throwing garbage in public places.

When a calamity strikes, it is the responsibility of the media to motivate people to act collectively. A well-established print media in combination with television and radio can play a significant role in generating mass action during disasters. The media today has at its disposal all the tools and instruments for educating the public and enabling them to discharge their duties as well-informed and responsible citizens.

Media can help in many ways when disaster strikes. It can:

- Make people aware of mitigation efforts
- Guide them to utilize funds properly
- Act as an interface between the government and the people
- Help reduce panic
- Direct people on where essential services are available
- Provide counselling
- Help prevent corruption in the distribution of relief material
- Facilitate two-way communication between the provider of assistance and the affected

In times of a disaster or in any emergency, for that matter, it is very important for the government to maintain good relations with the media. It is important to give reporters information that is timely and accurate. It is also important to allow them access to emergency zones up to a certain limit. This helps them realize that honest efforts are being made to tackle emergency and prevents them from becoming adversarial.

The media can be informed through press releases or press conferences. Nowadays, information is also posted on websites. A press release should be used only when the urgency is not immediate. Otherwise, in fast-moving situations, where the site is swarming with reports and the crowd is getting difficult to handle, it makes more sense to arrange a press conference on the spot.

The information that is conveyed to the population through the media should have the following characteristics:

- It should be clear in stating what the people should expect in the situation and what they are expected to do.
- It should take into account the effect the news would have on the people.
- It should be based on the predicted response of the population.
- It should be able to provide guidance to the people.
- It should be based on valuable inputs from media experts.
- It should have the public good in mind.

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There is a need for journalists to be more proactive in reporting on drought or disaster risk-related issues.

- Journalists need to be given regular training on preparing for disasters and for improving their understanding of the scope of the disaster, its hazards and the relevant key terms.
- The journalists should work closely with the policy makers so that positive stories are broadcast or printed. This, in turn, ensures that some kind of change is brought about and appropriate solutions can be offered to the disaster-prone areas.
- Journalists should be held accountable for what they report and the reactions their reports trigger.
- The advocacy stories that are broadcast or printed should target the ministries so that speedy action takes place.
- Workshops should be arranged for journalists so that they become proactive while reporting from the sites of disaster.
- There should be an exclusive team of editors working online to post the reports/stories, sent by journalists in the field, on to the website.
- Journalists should maintain a database of disaster-prone areas so that the impacts of hazards can be monitored.
- News agencies and magazines should announce contests and awards for disaster stories that are well-researched. This will ensure that the reports are genuine.

Dimensions of communication situations

The media can support or hinder the disaster management activities of the government and relief agencies. Before trying to understand the importance of the media in controlling and mitigating disaster, one must first take a look at the three aspects of communication situations as follows:

- Audience
- Stage
- Level of effect
  - o It is very important to understand the audience what the media is addressing. During a disaster, there are clearly two distinct parts of the population. One part which is actually affected by the disaster and the other which is not.
  - o What is communicated should also take into account the stage of the situation. Before the disaster occurs, the media can communicate to the public, the ways in which disasters should be averted and managed. This information should help prepare the population. During a disaster, the media should give warning message; educate people on how best to handle the disaster if it occurs; and also provide reassurance. After the disaster, once again, the media should be able to provide the sources of help, information and medical aid. It should be able to counsel the affected and help them get over the trauma. At this stage, the media should also analyse the situation, help investigate what went wrong and ensure that some lesson is learnt from the disaster.
  - o The degree to which an individual or the population collectively is affected should be assessed by the media. They should also be able to tell how an individual can contribute to the relief work and how people collectively can not only help manage the situation but also educate others.

Hurdles in working with the media

Although we all know how important a role media can play in managing disasters, it is a fact that the media is not always easy to approach.

- The media may not find a situation as worthy of attention as it may be made out to be by the sources.
- The message may not be put across by the media in the right tone. There is always a chance for distortion.
- The media may not always succeed in painting a trustworthy or credible picture.

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- They may try to interfere where their presence is least required or even unwanted/harmful.
- Instead of being sympathetic, they may choose to be critical and distant.
- At times, they may communicate contradictory risk estimates.
- They may give more importance to sensationalism instead of concentrating on giving serious information.
- Most journalists work with the aim of keeping a critical eye on those wielding power.

Reducing the losses of life and property caused by natural hazards is a compelling objective now receiving worldwide attention. It is now being increasingly believed that the knowledge and technology base potentially applicable to the mitigation of natural hazards has grown so dramatically that it would be possible, through a concerted cooperative international effort, to save many lives and reduce human suffering, dislocation, and economic losses simply by better information, communication and awareness. Timely mass media communication about impending disasters can lead to appropriate individual and community action, which is the key to implementing effective prevention strategies including evacuation and survival of people. Such communications can educate, warn, inform, and empower people to take practical steps to protect themselves from natural hazards.

The role of media, both print and electronic, in informing the people and the authorities during emergencies thus, becomes critical, especially the ways in which media can play a vital role in public awareness and preparedness through educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials; helping relief organizations and the public towards specific needs; and even in facilitating discussions about disaster preparedness and response. During any emergency, people seek up-to-date, reliable and detailed information.

The main principle of information provision, therefore, should be an ethical one and so, during an emergency, the media should be sensitive to the needs of the public in affected areas and should avoid misinforming and broadcasting unconfirmed reports that may lead to despair and panic. Therefore, correct and reliable information disseminated through the media is an important instrument for balancing the possible effects of incorrect, misleading or even willfully distorted information. Reliable and timely information provided through the media can help people overcome any kind of fear and fatalism during and after an emergency. Indeed, the availability of reliable and timely information and knowledge about an event and the resulting needs help to improve solidarity and also creates an atmosphere conducive to collective response for sharing the humanitarian challenges created by disasters. Media today has arguably penetrated every household in the world, in one form or another. Journalists pride themselves in reporting objectively on global events and regard an independent media as one of the pillars of democratic society.

Mass media have certain characteristics that make them powerful instrument of disaster communication as they provide quick and easy access to large number of people located at different places; they highlight the problems and difficulties faced by the people affected by the disasters; they mobilize public opinion for humanitarian assistance. On the other hand, sources dealing with the media know that media can also prove to be difficult channels of communication. There is no direct control over the content and form of information transmitted and sometimes there are competing and even conflicting information which may always be very congenial for mobilizing support for concerted action. Contrary to popular perceptions journalists may not always be independent but may act as 'gate keepers, interpreters and commentators' representing larger business interests of the media owners. A closer examination of the global media illustrates that it is not one homogeneous entity pursuing a uniform method in disseminating their views. On the contrary, there are a small number of large factions which compete with one another to increase their respective audiences and commercial gains. Media ethics, therefore, become an important aspect of media reporting during any disaster event. It assists media workers in determining what is right and choosing the best from several alternatives. Ethics should set guidelines, rules, norms, codes and principles to lead journalists and other media workers to make moral decisions.

Check Your Progress

12. State any three objectives of the National NGO Task force.
13. List any three recovery activities of Water Supplies and Sanitation.
14. Mention any three recovery activities of the transport department.
15. State the ways in which media can help when disaster strikes.
16. What are the three aspects of communication situations?

3.6 SUMMARY

- One of the main objectives of development programs in many developing countries of the world for the past several decades is poverty reduction.
- The aim of Community- based disaster management (CBDM) is to reduce vulnerabilities and strengthen people's capacity to cope with hazards.
- The Government of India has adopted mitigation and prevention as essential components of their development strategy. The Tenth Five Year Plan document has a detailed chapter on disaster management.
- A GIS is defined as a system that is designed to gather, store, manipulate, analyse, manage and present all types of geographical data.
- GIS captures, interprets and transforms geographical data into graphical outcomes using advanced hardware and software technology.
- Acquiring information about a remote object or phenomenon, without making physical contact with the object is called remote sensing.
- Remote sensing is a very useful tool of GIS.
- Spatial technology is an integrated hardware and software system which brings together GIS and remote sensing to use satellites for a number of uses. Spatial technology plays an important role in disaster management.
- An earthquake warning system is a system of accelerometers, communication, computers, and alarms that is devised for regional notification of a substantial earthquake while it is in progress.
- The responsibility to cope with natural disasters is essentially that of the state government. The role of the central government is supportive in terms of supplementation of physical and financial resources.
- The goal of any disaster management initiative is to build a disaster resistant/resilient community equipped with safer living and sustainable livelihoods to serve its own development purposes.
- NGOs are autonomous non-governmental bodies operating mostly as non-profit organizations.
- Three stages of communication situations as follows— audience, stage, and level of effect.
- The role of media, both print and electronic, in informing the people and the authorities during emergencies thus, becomes critical, especially the ways in which media can play a vital role in public awareness and preparedness through educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials, helping relief organizations and the public towards specific needs; and even in facilitating discussions about disaster preparedness and response.

3.7 KEY TERMS

- **Community involvement**: Community involvement refers to a 'less than' ideal situation, where the community is asked to participate in a program that has already been designed by someone else.

- **GIS:** A GIS is defined as a system that is designed to gather, store, manipulate, analyse, manage and present all types of geographical data.
- **Remote sensing**: Acquiring information about a remote object or phenomenon, without making physical contact with the object is called remote sensing.
- **Spatial technology:** Spatial technology is an integrated hardware and software system which brings together GIS and remote sensing to use satellites for a number of uses.
- **Flood warning**: Flood warning is the task of making use of these forecasts to make decisions about whether warnings of floods should be issued to the general public or whether previous warnings should be rescinded or retracted.

3.8 ANSWERS TO 'CHECK YOUR PROGRESS'

1. The new and innovative approaches to decrease disasters and poverty share several common features such as follows:
   - Approaches developed must be more people-centric
   - Development of a multi-sectoral approach in planning and decision-making
   - Ever increasing importance of improving the ways and means to access resources
   - Overall involvement and contribution to the development process
2. The five elements to analyze the sustainability of livelihood approach are as follows:
   - Vulnerability context of poor people
   - Assets such as human, social, physical, natural and financial capital
   - The economic structures such as government, private sector as well as administrative guidelines and processes such as laws, institutions
   - Livelihood strategies
   - Livelihood outcomes
3. The aim of CBDM is to reduce vulnerabilities and strengthen people's capacity to cope with hazards.
4. Community involvement refers to a 'less than' ideal situation, where the community is asked to participate in a program that has already been designed by someone else.
5. The Tenth Five-Year Plan emphasizes the fact that development cannot be sustainable without mitigation being built into developmental process.
6. The National Core Group for Earthquake Risk Mitigation as been assigned with the responsibility of drawing up a strategy and plan of action for mitigating the impact of earthquakes; providing advice and guidance to the states on various aspects of earthquake mitigation; developing/ organizing the preparation of handbooks/pamphlets/type designs for earthquake resistant construction; working out systems for assisting the states in the seismically vulnerable zones to adopt/integrate appropriate Bureau of Indian Standards codes in their building byelaws.
7. A GIS is defined as a system that is designed to gather, store, manipulate, analyse, manage and present all types of geographical data.
8. Acquiring information about a remote object or phenomenon, without making physical contact with the object is called remote sensing.
9. Remote sensing is of two types— active sensing and passive sensing.
10. An earthquake warning system is a system of accelerometers, communication, computers, and alarms that is devised for regional notification of a substantial earthquake while it is in progress.
11. Flood warning is the task of making use of these forecasts to make decisions about whether warnings of floods should be issued to the general public or whether previous warnings should be rescinded or retracted.

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12. Any three objectives of the National NGO Task force are:
    - Mapping of NGOs at state and district levels
    - Training and capacity building of various stakeholders
    - Mainstreaming vulnerability reduction through CBDRM in civil society initiatives
13. Any three recovery activities of Water Supplies and Sanitation are:
    - Strengthening of infrastructure
    - Review and documentation
    - Sharing of experiences and lessons learnt
14. Any three recovery activities of the transport department are:
    - Provision of personal support services e.g. Counselling
    - Repair/restoration of infrastructure e.g. roads, bridges, public amenities
    - Provide training so that the elected representatives can act as effectives supportive agencies for reconstruction and recovery activities
15. Media can help when disaster strikes in the following ways:
    - Make people aware of mitigation efforts
    - Guide them to utilize funds properly
    - Act as an interface between the government and the people
    - Help reduce panic
16. Three aspects of communication situations are:
    - Audience
    - Stage
    - Level of effect

3.9 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Write a short note on poverty and vulnerability.
2. Distinguish between community participation and community involvement.
3. What are the advantages of GIS?
4. Distinguish between active and passive remote sensing.
5. Write a short note on BART.
6. List the factors which influence flood warnings.
7. Enumerate the general role of states in managing disasters.
8. Write a short note on the role of corporate agencies in disaster management.

Long-Answer Questions

1. Analyse disaster preparedness in India.
2. What is the usefulness of GIS? Discuss the advantages of spatial technology in disaster management.
3. Explain the role of government agencies involved in disaster management and mitigation.
4. Explain the role of armed forces in disaster management.
5. Discuss the role of media in disaster management.

3.10 FURTHER READING

NOTES

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UNIT 4 DISASTER RESPONSE

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Structure

4.0 INTRODUCTION

Responding to a natural disaster is the most important phase of a disaster management plan. Many a times, a quick response to a disaster can mean the difference between life and death for the victims of the disaster. Responding to a disaster does not only mean the mobilization of first responders to a disaster site, it also entails responding to the effects of disasters that are not immediately known, for example, the psychological impact of the disaster on the victims.

India has a long history of responding to natural disasters and rendering relief in an organized fashion in times of drought and famine. State governments have antiquated relief codes which deal with the general principles of administration of relief. Although huge progress has been made in recent times in updating these codes, much more needs to be done. Relief starts with the responsibility of the government for combating distress, defining the scope of objective of such measures, and so on. India, with a vast agrarian economy, had in the past focused on distress relief mainly related to agricultural activities. Preparedness included collection of statistical data on the rainfall, weather conditions, crop pattern activities relating to management of cattle. The relief work focused on departmental work and village work for generation of employment during drought. With the changing pattern of disaster and with the introduction of technology, material and new financial terms into disaster management, several modifications have been incorporated in the administrative measures for relief work.

4.1 UNIT OBJECTIVES

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

- Describe how disaster response plans are formulated
- Understand disaster medicine and explain disaster site management
- Discuss rehabilitation, reconstruction and recovery programs

4.2 DISASTER RESPONSE AND RECOVERY

The response phase of disaster management encompasses the mobilization of necessary emergency services and first responders to the disaster site. This entails mobilizing the first responders, i.e.,

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firefighters, police and medical crews. When such a response if conducted with military precision, it is termed Disaster Relief Operation (DRO). The first responders can be supported by a number of secondary emergency services, such as specialist rescue teams.

If a disaster response plan has been prepared and rehearsed earlier, it allows proper coordination of rescue and relief operations. Quick and efficient relief operations are extremely important since research has found that depending upon the nature of injury and weather conditions, as well as the availibility of water and food, a victim of a disaster is likely to within 72 hours after the occurrence of a disaster.

The response phase of an emergency may commence with search and rescue, but in all cases the focus quickly turns to fulfilling the basic humanitarian needs of the affected population. This assistance may be provided by national or international agencies and organizations. Effective coordination of disaster assistance is often crucial, particularly when many organizations respond and local emergency management agency capacity has been exceeded by the demand or diminished by the disaster itself.

On a personal level, the response can take the shape either of a shelter in place or an evacuation. In a shelter-in-place scenario, a family would be prepared to fend for themselves in their home for many days without any help from outside. In an evacuation, a family leaves the area by automobile or other mode of transportation, taking with them the maximum amount of supplies they can carry, possibly including a tent for shelter. If mechanical transportation is not available, evacuation on foot would ideally include carrying at least three days of supplies and rain-tight bedding, a tarpaulin and a bedroll of blankets being the minimum.

4.2.1 Institutional Arrangements for Disaster Response

Institutional arrangements for disaster response constitute the heart of any disaster management system. There is no dearth of personnel, both civilian and military, experienced in handling situations arising out of natural disasters. However, there certainly is a pressing need for improvement and strengthening of existing institutional arrangements and systems in this regard to make the initial response to a disaster more effective and professional. Most of the resources and expertise needed already exist with the government. What needs to be streamlined is how they should be integrated, trained and deployed. Some of the areas where improvement is urgently needed are:

- Integrated planning for disasters including the integration of relevant Armed Forces formations into disaster management planning at all levels from district to state and Central Government.
- Setting up of a modern, permanent national command centre or operations room with redundant communications and data links to all state capitals. The national command centre or operations room needs to be manned on a 24-hour basis by professionals to cater for instant integrated response. There needs to be a properly equipped operations room at the state level as well.
- Establishment of a national stand by, quick reaction team composed of experienced professionals, both military and civilian, drawn from central and state government staff to respond immediately by flying in a matter of hours an experienced response team to the locations when a disaster strikes. This team can be organized and run professionally on the same lines as the United Nations Disaster Assessment and Coordination (UNDAC) teams.
- Creation of urban search and rescue capacity at all levels, by establishing a fully equipped Search and Rescue unit, as part of the fire service in all state capitals, with trained staff and modern equipment such as thermal imagers, and acoustic detection devices. This is of immediate relevance since a major weakness exposed in the Gujarat earthquake was a lack of specialized urban search and rescue capability in India.
- Media policy geared to handling the growing phenomenon of real time television reporting, which generates enormous political pressures on a government to respond rapidly and efficiently. This needs attention since the effect is going to increase not decrease in future.
- Closer interface with and better understanding of the international system for disaster response and putting in place systems for dealing with international assistance once it comes in e.g., customs, immigration, foreign policy implications and so on. A greater appreciation is needed of the speed and automation of modern international response to a natural disaster. Closer interaction is required between the ministry of external affairs and the relevant international agencies concerned with disaster response.

- Standard procedures for dealing with domestic humanitarian and relief assistance from non-government sources. Procedures and systems need to be set out to avoid confusion and ensure best utilization of the assistance being offered, just as in the case of systems for international assistance.
- Modern unified legislation for disaster management. In view of the current division of responsibilities between the state and central government into state, central and concurrent lists, there is a need to create a body of legislation dealing with response to natural disasters and other emergencies, clearly delineating responsibilities and powers of each entity and specifying what powers or actions would need to be triggered on declaration of a disaster by the government of India or a state government. This legislation should also incorporate the current legislation dealing with chemical emergencies that has been created by the ministry of environment so that all emergencies are dealt with under one law. The legislation should include clear definitions of what constitutes a disaster at a national level.

Response and Recovery

Usually the first response to a disaster comes from the local government body. Such efforts are spearheaded by the district authority. Some of the local agencies that spring into action immediately are municipalities, gram panchayats, block authorities and district administration. In a catastrophic disaster, aid and assistance from the central government is mobilized.

Here, it would be interesting to learn about the response and recovery mechanisms formulated by the governments in the United States of America. In the United States, the Department of Homeland Security's Federal Emergency Management Agency (FEMA) is vested with the responsibility for search and rescue, electrical power, food, water, shelter and other basic human needs. It is the long-term recovery phase of disaster which places the most severe financial strain on a local or state government. Damage to public facilities and infrastructure, often not insured, can overwhelm even a large city. In the United States, a request from a state's governor for a major disaster could mean an infusion of federal funds, but the governor must also commit significant state funds and resources for recovery efforts.

A major disaster could result from a hurricane, earthquake, flood, tornado or major fire which the U.S. President determines warrants supplemental federal aid. The event must be clearly of the magnitude that makes it impossible for local or state governments to handle alone. If declared, funding comes from the President's Disaster Relief Fund, which is managed by FEMA, and disaster aid programs of other participating federal agencies. A presidential major disaster declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, and designed to help disaster victims, businesses and public entities.

An emergency declaration is more limited in scope and without the long-term federal recovery programs of a major disaster declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or to help prevent a major disaster from occurring.

A major disaster declaration in the United States usually follows these steps:

- Local government responds, supplemented by neighbouring communities and volunteer agencies. If overwhelmed, turn to the state for assistance
- The state responds with state resources, such as the National Guard and state agencies
- Damage assessment by local, state, federal, and volunteer organizations determines losses and recovery needs
- A major disaster declaration is requested by the governor, based on the damage assessment, and an agreement to commit state funds and resources to the long-term recovery
- FEMA evaluates the request and recommends action to the White House based on the disaster, the local community and the state's ability to recover
- The President approves the request or FEMA informs the governor it has been denied. This decision process could take a few hours or several weeks depending on the nature of the disaster

4.2.2 Models of Risk Assessment and Disaster Response

The standard mechanism for the assessment of disaster risk and disaster response in the United States is the Hazards U.S. Multi-Hazard (HAZUS-MH) model. A brief discussion of the model that is designed to deal with various disasters follows.

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The Hazards U.S. Multi-Hazard (HAZUS-MH) is a nationally applicable standardized methodology that estimates potential losses from earthquakes, hurricane winds, and floods. HAZUS-MH was developed by FEMA under contract with the National Institute of Building Sciences (NIBS). HAZUS-MH uses state-of-the-art Geographic Information Systems (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of earthquakes, hurricane winds, and floods on populations. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing mitigation plans and policies, emergency preparedness, and response and recovery planning.

Needs and Damage Assessment

The HAZUS-MH model estimates damage and loss to buildings, lifelines and essential facilities from scenario and probabilistic earthquakes, including:

- Ground shaking and ground failure
- Estimate of casualties
- Estimate of displaced households and shelter requirements
- Estimates the damage and loss of use of essential facilities
- Estimates the cost of repairing damaged buildings
- Estimates the quantity of debris
- Estimates the damage to buildings
- Estimates direct costs associated with loss of function (e.g., loss of business revenue)

HAZUS-MH displays the analysis both through GIS maps and tables. This forecasting capability enables users to carry out a wide range of analyses.

- Emergency managers can use HAZUS-MH to develop scenarios to drive exercises and support emergency operations plans
- State hazard mitigation officials can use information on costs and benefits of specific mitigation measures and to use analysis for risk assessments for state and local hazard mitigation plans
- Shelter managers can use estimates of displaced households and shelter requirements to scale mass care mission requirements
- Utility company representatives can use information on the locations and duration of potential utility outages in setting restoration priorities and committing necessary personnel and other resources

HAZUS Application for International Use

Since the early 1990s, when HAZUS development was initiated, there has been considerable interest within the international community in the application of the HAZUS loss estimation methodology and software application for international use. The National Institute for Building Sciences (NIBS) has led efforts on behalf of FEMA to evaluate steps that need to be taken to develop an internationally applicable version of HAZUS.

Recently, the earthquake risk assessment (ERA) of buildings using HAZUS was carried out in Dehradun, India. The HAZUS is one of the ERA tools developed in the United States, which assesses the earthquake loss for the built environment and population in urban areas. The applicability of HAZUS model for the assessment of earthquake risk of buildings in India was analyzed. The HAZUS approach while being and in India faced many shortcomings.

The HAZUS model uses various classifications of civil structures as well as infrastructure for assessing earthquake losses. The up-to-date building inventory is always necessary to assess the loss for pre and post earthquake events. The method of making building inventories is well described in this model. There is a need to study the criteria of building classification and building inventory used in this model for assessing risk for buildings under Indian conditions.

4.2.3 Disaster Response in India

India's size and geographical diversity makes disasters in India almost an annual occurrence. We face all kinds of threats from natural disasters. The effects of global warming and climate change have only exacerbated these threats.

Forecasting climate change is a pre-requisite for taking preparedness measures to respond to the disaster. This is the most important element of disaster management. The Ministry of Environment and Forest (MoEF), Ministry of Earth Sciences (MoES), Ministry of Science and Technology (MST), Ministry of Agriculture (MoA), Ministry of Water Resources (MWR), Ministry of Human Resource Development (MHRD), Ministry of Non-conventional Energy (MNES), Defence Research and Development Organization (DRDO), Ministry of Defence (MoD), Ministry of Health and Family Welfare (MoHFW), Indian Space Research Organization (ISRO) and Indian Meteorological Department (IMD) promote and undertake climate and climate change related research in the country.

The Government of India has designated various agencies as the nodal agencies for early warning of different natural hazards:

- Cyclone - Indian Meteorological Department
- Tsunami - Indian National Centre for Oceanic Information Services
- Floods - Central Water Commission
- Landslides - Geological Survey of India
- Avalanches - Snow and Avalanche Study Establishment
- Heat and Cold Waves - Indian Meteorological Department

Since India is facing natural disasters, especially flooding, on an annual basis, an annual Conference of Relief Commissioners, Secretaries, to the Department of Disaster Management of States and UTs is organized before the onset of south-west monsoon to review the status of preparedness for the ensuing monsoon and to discuss other disaster management related issues. The representatives of various central ministries, organizations rendering emergency support functions besides representatives of central para-military forces also participate in the conference.

Activation of Emergency Preparedness Plan

- **Issue of guidelines:** Necessary guidelines in the form of checklist for taking necessary preparatory measures are issued to the state for their guidance and appropriate action. Instructions are also issued for creating reserves of essential items required during rescue and relief phase. The checklist issued to a state includes:
    - o Vulnerability assessment
    - o Dissemination of warning
    - o Emergency Response activities
    - o Coordination
    - o Rapid Damage Assessment
    - o Maintenance of essential services
    - o Stocking of essential commodities
    - o Medicines
    - o Drinking water
    - o Shelter/camps
    - o Pre-contract
    - o Evacuation plan
    - o Activating Control Rooms
    - o Search and Rescue Team
    - o Communication
    - o Identification of Nodal Officer
    - o Status of SDRF
    - o Preparedness Drill
- **Trigger mechanism:** This mechanism has been developed to activate the disaster response system automatically after receiving warning signals of a disaster that is occurring or is likely to

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occur or on receipt of information about the incident. The responders are required to undertake activities as per the SOPs issued in respect of such disasters. There may be scenario where early warning signals could be available and there may happen a disaster without any early warning.

- **Crisis Management Plan (CMP) and Standard Operating Procedures (SOPs):** In accordance with the National Crisis Management Plan 2003 of the Cabinet Secretariat, the Ministry of Home Affairs formulated its CMP 2004 and circulated it to all states and UTs. The CMP of MHA comprises of two parts; Part-I deals with aspects, which are common to all contingencies situations and Part-II about the individual Standard Operating Procedures (SOPs) for dealing with specific crisis situations. SOPs are preparedness plans that activate the procedure for response on receiving warnings of impending disaster.

The CMP of MHA is reviewed periodically. It was last reviewed in 2009 and was circulated to all Ministries and Departments of Central Government as well as states and UTs. State governments have also been advised to formulate similar kinds of CMPs and SOPs. The MHA has conducted a number of training workshops for states and UTs for assisting them in the formulation of SOPs.

Exhibit 4.1: *Role of the Armed Forces in Disaster Response in India*

June, 2013

The Himalayan tsunami that struck Uttarakhand and parts of Himachal Pradesh again revived the debate over whether it was a natural disaster or a man-made one. Irrespective of what the answer is, one thing that is crystal clear is that neither the Centre nor the state governments were able to respond adequately. Despite the fact that there is an elaborate disaster management structure mentored by the National Disaster Management Authority (NDMA) under the Prime Minister, the level of response of Central and state agencies was far from satisfactory. This can be attributed to the fact that even after eight years of the enactment of the Disaster Management Act, SDMAs are yet to be established all over the country. In certain states, the department for disaster management is the changed name of the department of relief and rehabilitation, home guards and emergency fire services with ad hoc personnel. It is always expected of the ITBP, Indian Army and Air Force, to intervene and take charge of a situation.

The involvement of the armed forces in disaster response and relief operations is crucial in civil-military relations. In the Indian context, their role is mainly in response to the immediate requirement of human resources and technical equipment for rescue and relief operations by the civil authorities of the affected area. Since the disaster management system of the civilian administration is not really operational, the civil authorities rely heavily on the armed forces for disaster response. Therefore, a defined role for the armed forces in disaster management is required.

The government could begin by setting up a centre for excellence in disaster management for the Indian armed forces. Steps should be taken to ensure that military equipment meant for war is not deputed for secondary tasks. Expertise of the armed forces should be used to bolster the capacity of the civil authorities, including disaster response forces and making them self-reliant.

(***Source:*** Based on an article by By Mohan Das Menon, former additional secy, Cabinet Secretariat, in the *New Indian Express*, http://newindianexpress.com/magazine/voices/We-must-define-the-role-of-armed-forces-in-disaster-management/2013/06/30/article1655937.ece, Accessed on 29.11.13)

Role and responsibility of central and state governments

You have already learned about the responsibilities of the state and central governments to prevent a natural calamity and what they do during a natural disaster in the previous unit. A brief discussion on their roles and responsibilities during the response phase is summarized below.

The Ministry of Home Affairs is the nodal Ministry for the management of natural disasters (other than drought, hailstorms and pest attacks, which are handled by Ministry of Agriculture) on behalf of the Government of India. The Disaster Management Division (DM Division) performs the

function in the Ministry of Home Affairs. The Central and state governments are jointly responsible for undertaking relief, rehabilitation, preparedness, mitigation and response measures. The basic responsibility for undertaking these measures in the event of a disaster rests with the concerned state government.

The Central Government supplements the efforts of the state governments by providing logistic and financial support in case of natural calamities of severe nature. The logistic support includes the deployment of aircrafts and boats, specialist teams of Armed Forces, Central Paramilitary Forces and personnel of National Disaster Response Force (NDRF), arrangements for relief materials and essential commodities including medical stores, restoration of critical infrastructure facilities including communication network and such other assistance as may be required by the affected states to meet the situation effectively.

The DM Division of MHA closely monitors the disaster and disaster-like situations to facilitate strategic interventions in the form of logistic and financial support by the Government of India to augment the resources of the affected states and UTs to deal effectively with each disaster situation. For this purpose, a close liaison is made with the affected states on the one side and the concerned Central line Ministries such as the Ministry of Health, Ministry of Defence, Ministry of Civil Aviation, Ministry of Food and Civil Supplies, and so on, on the other.

Logistics Management, Coordination and Participation

Co-ordination at the central and the state level is achieved by way of various committees involving all departments that are working in disaster management.

The Cabinet Committee on Management of Natural Calamities is one of the agencies involved in coordination and communication between various agencies. It was constituted to:

- Oversee all aspects relating to management of natural calamities including assessment of the situation and identification of measures considered necessary to reduce its impact
- Examine and implement programmes for reducing the adverse impact of natural calamities
- Monitor and suggest long-term measures for prevention of such calamities in the future
- Formulate and recommend programmes for public awareness for building up society's resilience to natural calamities

The Committee is serviced by the Ministry of Home Affairs in all cases except in cases relating to Drought Management and Epidemics when it is serviced, as the case may be, by the Department of Agriculture and Cooperation and Department of Health and Family Welfare.

In the context of federal set-up of India, the responsibility to formulate the government's response to a natural calamity is essentially that of the concerned state government. However, the Central Government, with its resources, physical and financial, does provide the needed help and assistance to buttress relief efforts in the wake of major natural disasters.

Most of the states have relief commissioners under the Department of Disaster Management, who are in charge of the relief measures in the wake of natural disasters. In the absence of the relief commissioner, the chief secretary or an officer nominated by him is in overall charge of the relief operations in the concerned state. At the state level, the state relief commissioner supervises and controls relief operations through collectors or deputy commissioners, who are the main functionaries to coordinate the relief operation at district level. The state governments are autonomous in organizing relief operations in the event of natural disasters and in developing the long-term rehabilitation measures. The state government's efforts are supplemented by Central Government based on the recommendations of the Finance Commission.

State Crisis Management Group (SCMG)

States in India also have a State Crisis Management Group (SCMG) under the chairmanship of chief secretary and the relief commissioner. This group comprises senior officers from the Departments of Revenue/relief, Home, Civil Supplies, Power, Irrigation, Water Supply, Panchayat (local self government), Agriculture, Forests, Rural Development, Health, Planning, Public Works and Finance.

The SCMG is required to take into consideration the guidance received, from time to time, from the Government of India and formulate action plans for dealing with different natural disasters. It is also the duty of the relief commissioner of the state to establish an Emergency Operation Center (Control

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Room) at the state headquarters as soon as a disaster situation develops. Besides having all updated information on forecasting and warning of disaster, the EOC would also be the contact point for the various concerned agencies.

Role of District Administration

The district administration is the focal point for field level organizations. It is responsible for implementation of all government contingency plans. Considerable powers have therefore been vested the district collector to carry out operations in the shortest possible time.

The district administration in the country is required to prepare an advance contingency plan depending on the type of disaster that is likely to affect the district. District contingency plans follow a framework that is laid down nationally which comprises type of preparedness, the relief material required to be mobilized and the concerned departments that need to work together and provide an efficient feedback and monitoring system.

The district magistrate exercises coordinating and supervisory powers over functionaries of all the departments at the district level in the event of emergencies. During actual operations for disaster mitigation or relief, the powers of the collector are considerably enhanced, generally, by standing instructions or orders on the subject, or by specific governments orders, if so required. Sometimes, the administrative culture of the state concerned permits, although informally, the collector to exercise higher powers in emergency situations and the decisions are later ratified by the competent authority.

Role of Sub-district Administration

A district is sub-divided into sub-divisions and Tehsils or Talukas. The head of a sub-division is called the Sub-Divisional Officer (SDO) while the head of a Tehsil is generally known as the Tehsildar (Talukdar or Mamlatdar in some states). Contact with the individual villages is through the village officer or patwari who has one or more villages in his charge. When a disaster is apprehended, the entire machinery of the District, including officers of technical and other departments, swings into action and maintains almost continuous contact with each village in the disaster threatened area. In the case of extensive disasters like drought, contact is maintained over a short cycle of a few days. The entire hierarchy right from the Central Government (the Department of Agriculture and Cooperation in the Ministry of Agriculture and irrigation) to the district level is connected by means of a telecommunication system.

Communication

(I) National Emergency Operation Centre (NEOC): The National Emergency Operation Centre (NEOC) in the Ministry of Home Affairs functions 24X7 to monitor a disaster or disaster like situation. Based on the feedback received from National Forecasting Agencies viz Indian Meteorological Department, Central Water Commission, Snow and Avalanche Study Establishment advisories to the concerned states/UTs are issued from time to time for keeping watch on the developing situation and take necessary measures such as evacuation of the vulnerable persons, operation of relief camps, pre-positioning of essential commodities, and so on. During the south-west monsoon, daily situation reports (are prepared based on the feedback received from the affected states and concerned Central Ministries and organizations, and are sent to all concerned. During the calamities of severe nature, special situation reports are also prepared and issued to all concerned. NEOC also issue SMS alerts to the concerned officers in MHA, PMO and Cabinet Secretariat.

(II) State Control Room: There is a State Level control room set up whenever a disaster situation develops. The control room is responsible for:

- Transmitting information about the development of a crisis as a result of natural disaster on continued basis to the central relief commissioner
- Receiving instructions and communicating them to appropriate agencies for immediate action
- Collection and submission of information relating to implementation of relief measures to the Central Relief Commissioner
- Keeping the state level authorities apprised of the developments on a continuing basis

(III) District Control Room: Likewise in the wake of natural disasters, a control room is set up in the district for day-today monitoring of the rescue and relief operations on a continuing basis,

operationalising the contingency plan and keep close liaison with the state Headquarters, NGOs and other agencies dealing with disaster management and relief.

National Disaster Response Force (NDRF)

- **Task and role of NDRF:** The main task of the NDRF is to provide specialist response in case of disasters which broadly covers:
  - o NBC disasters (Decontamination of the area and personnel)
  - o Removal of debris
  - o Extrication of victims- live or dead
  - o First medical response to victims
  - o Extend moral support to victims
  - o Assistance to civil authorities in distribution of relief material
  - o Co-ordination with sister agencies
  - o Capacity building
  - o Providing assistance to foreign countries, if asked
- **Specialized equipment for NDRF Battalions:** The NDRF has been equipped with latest and state of the art equipments required for rescue and relief works. Equipments of around 310 types have been authorized to NDRF which broadly consist of Medical First Responder (MFR) Equipments, Collapsed Structure Search and Rescue (CSSR), water rescue, CBRN equipments, specialist vehicles, and so on.
- **Other activities of NDRF:** NDRF is engaged in the following other activities beside search and rescue operations undertaken during emergency situation:
  - o Conducting familiarization exercise in order to acquaint personnel with vulnerability of their area of responsibility to different disasters
  - o Conducting mock exercises in coordination with other stake holders for well coordinated response during disasters
  - o Conducting community awareness program for capacity building
  - o Organizing demonstrations and exhibitions as part of community awareness
  - o Undergoing different kinds of training in order to increase the skill and expertise of NDRF personnel
  - o Training State Disaster Response Force (SDRF), community and NGO'S in disaster management
- **Major Operational Achievements of NDRF:** In the previous years, NDRF has proved its efficacy with its commendable performance during various disasters including the drowning cases, building collapses, landslides, devastating floods and Cyclones. NDRF has saved 1, 41,257 human lives and retrieved 362 dead bodies of disaster victims in various response operations in the country.

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4.2.4 Managing and Funding Relief and Recovery

In post independent India, financing relief expenditure has largely been arranged through the Finance Commission appointed under Article 280 of the Constitution. In the earlier phases, the role of the Commission was restricted to suggesting the pattern of financial assistance by the centre. Subsequently, the recommendations were enlarged to cover the 'scheme of financing relief expenditure'.

To understand the measures undertaken for relief in India, let us look at the type of relief offered by the Government of India in the event of a drought.

- **Relief employment:** The most important relief component is the generation of employment provision during the drought period. As soon as drought is declared, it is therefore, necessary for the state governments to immediately start relief employment programmes and provide work to those who need employment within a radius of five kilometers. Most state governments have their own food for work programme. The Government of India has started the National Rural Employment Guarantee Scheme (NREGS), providing 100 days of employment to one person per

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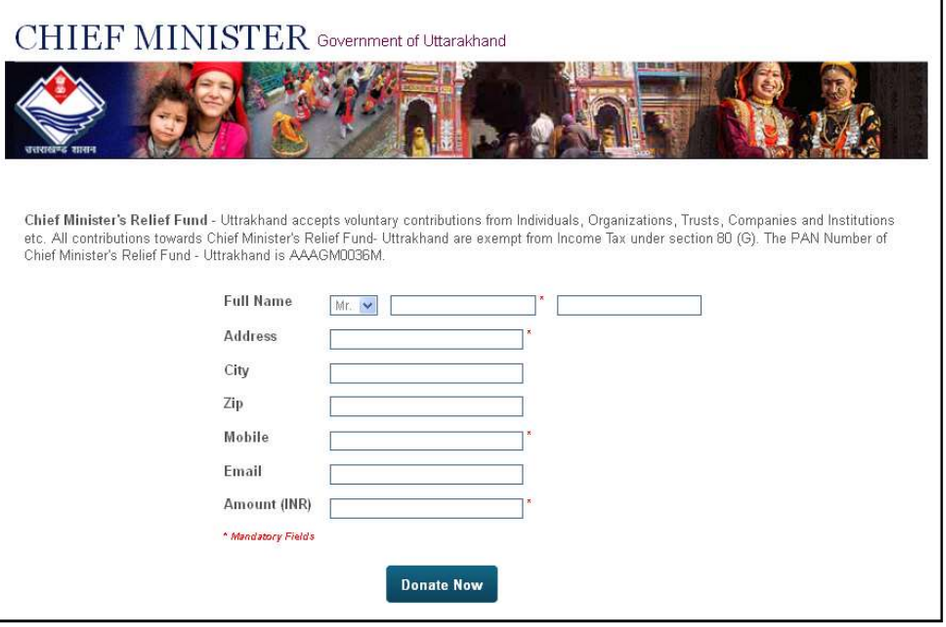
family on demand. The scheme has been extended to the entire country. A large number of public works and watershed programmes could be supported through the NREGS. These programmes together can create substantial employment to tide over the hardship and deprivation caused by drought.

- **Water resource management:** Water resource management in the drought affected areas is one of the most critical tasks of relief operations. It requires diverse measures such as augmentation of water supply, rationing of water use, and efficient utilization and management of water resources, in both urban and rural areas. Shortage of water is one of the earliest indicators of drought, affecting the entire society, rural and urban. Assessing the demand for water and its total availability in a specific region, therefore, is extremely important for meeting the needs of different user groups.
- **Food security:** Food security is one of the most important objectives of drought management. It is provided through food for work programmes, which are started by the state governments to provide relief employment. Wages on these relief employment works are paid in the form of food grains, on a full or partial basis. The National Rural Employment Guarantee Scheme (NREGS), extended to all the districts across the country, guarantees employment opportunities in the rural areas by providing work that taps labour intensive community assets. It assures manual work to one person per family for a maximum of 100 days in a year.
- **Relief through tax waivers and concessions**: The primary objective of tax waivers and concessions would be to help people meet their basic entitlements. The state government can take a conscious decision to provide a number of tax waivers and concessions when a drought is declared. These tax waivers and concessions should be decided on the basis of the entitlement needs of certain segments of the population and the fiscal implications of such a relief to the state government. Each state government may decide on tax waivers and concessions to the people affected by drought, depending on fiscal situation of the state and severity of the drought.

Exhibit 4.2



The preparedness and response phase in the disaster management cycle are critical in reducing the impact of disasters. The involvement of multi-various stakeholders, therefore, needs to ensure efficient inter-departmental coordination and need to constantly review and improve the systems in place. It has to be kept in mind to ensure that the focus on these two areas help in bringing a tangible improvement in handling the disasters.

Check Your Progress

1. Define disaster relief operation.
2. Which is the first body which responds when disaster strikes?
3. When was development of HAZUS initiated?
4. What is the full form of NDRF?

4.3 DISASTER MEDICINE

Disaster medicine is a field of medical specialization that provides health care to disaster survivors and assists in medically related disaster preparation, disaster planning, disaster response and disaster recovery leadership throughout the life cycle of a disaster. Those who specialize in disaster medicine provide the leadership and technical know-how on managing medical relief in disaster areas. During disaster relief operations, those who specialize in disaster medicine become the link between and partner to the medical contingency planner, emergency management professional, incident command system, government and policymakers.

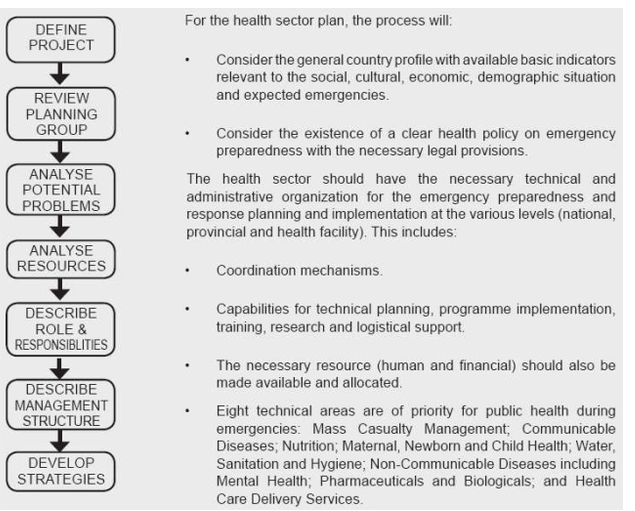
Among all types of medical specialization, disaster medical specialists are unique in the sense that they only operate during emergency situations and not every day. Specialists of disaster management also engage in modifying disaster relief and recovery policies.

Although the usage of the term 'disaster medicine' first began during the Second World War, it was only in the 1980s that the term began to appear in medical journals and the mainstream press. By the 1990s, the term had entered government consciousness. In 2006, Elsevier, the largest publisher of medical textbooks in the world, published the textbook *Disaster Medicine*, further confirming disaster medicine as a genuine area of study with a definable core curriculum.

Medical preparedness plan

A medical preparedness plan is a set of procedures and policies necessary to maximize the ability to prevent, respond to, and recover from major disaster events, including efforts that result in the capability to render an appropriate public health and medical response that will mitigate the effects of illness and injury, limit morbidity and mortality to the maximum extent possible, and sustain societal, economic, and political infrastructure. Effective response to a disaster requires a clear understanding of the medical preparedness plan by the medical personnel responsible for medical relief. Such an understanding can only be inculcated through effective training. Training includes drills and exercises for hospital personnel and emergency response teams with their respective equipment. Medical preparedness plans must be periodically updated and refined keeping in mind the new techniques and strategies of disaster management that appear in the medical literature.

The flowchart below provides the steps that need to be undertaken to prepare a medical preparedness plan.



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Role of information and communication technology in health response

The importance of information technology (IT) in support of disaster medical response and provides a framework for the use of IT in response to natural disasters or terrorist activities cannot be overemphasized. Effective use of technology can literally mean the difference between life and death for the victims of a disaster.

The appropriate use of information technology enhances the effectiveness of the disaster response system, thereby safeguarding the population and the community infrastructure. In India, this entails connecting all state and district capitals with satellite communications that remain unharmed in the event of a disaster and connecting hospitals that have some disaster medical response capabilities with wireless local area networks (LANs). Along with the use of wireless LAN, other important disaster medical response capabilities include personal digital assistants, tablets and handheld personal computers. All of these are extremely handy technological tools that increase the effectiveness of a disaster medical response team.

4.3.1 Disaster Site Management

Disasters bring with them great devastation, ruining not only lives and property but also all patterns of social interactions and consistency. Recovering from a disaster is not an easy task as it involves more than burying the dead, taking care of those who have suffered injuries and again engage in the building of new structures. One has also to recover from a disaster in every aspect; mentally, physically, emotionally and socially.

After a disaster event, consultation teams need to activate at the earliest, frequently without former caution. Often, they should bring their own resources to the disaster site. Even before starting the consultation, the psychiatric consultant sent into a disaster area must create his or her team. The composition of the team depends on several factors including the type of disaster, availability of trained personnel, and the resources available. Ideally, the team should be composed of people from different areas of expertise, i.e, psychologists, psychiatric nurses, mental health professionals, social workers, psychiatrists and so on. If the team is composed of people who are not locals, it is critical for specialists from the disaster area to be also included since it allows the entry into the community as well as continuity of care.

Disaster sites can appear to be considerably calm shortly after the incident, despite the circumstances when destruction and loss have been intense. Individuals feel chaos around them and can experience a feeling of being cut off and a pervasive sense of unreality immediately after being hit by a disaster. During this time, rest and respite can act as relief factors. The initial disaster medicine interventions following a disaster must focus on the establishment of safety, provision of food and water, and protection from the environment. Fears of loss and separation should be addressed by establishing reliable communications and casualty identification and notification procedures.

The opening task of the team is to get an understanding of the nature and scope of disaster and establish for collaboration. Any integration into the disaster area must be done smoothly since victims of the disaster may view the team as outsiders who are interfering. One way to integrate is to liaise with local medical practitioners. Liaison with primary care providers and disaster workers is critical for effective intervention. The team itself should be knowledgeable about the area, its resources, culture and customs. Coordination with government mental health agencies is also a must.

The people who are part of the team may also go through stress, since they are working in an extremely difficult environment. The leader of the team should be aware of the pitfalls of the members of the team falling victim to stress. It may cause impediments to the functioning of the team. Therefore, the leader of the team must ensure that all team members get proper rest and respite from their activities. Although one must be committed to the job at hand, extremely long working hours should be avoided since it may result in exposing oneself to psychological and physical trauma. The type of behaviour that suggests over dedication at a disaster site includes skipping meals, working well beyond the end of the shift, ignoring physical and emotional limits, and so on. The leader of the team must ensure that the well being of the team remains intact; he or she must not hesitate in asking a member to take rest, but it should be done in a way that does not make the member feel devalued.

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Disaster site management in India

The institutional and policy mechanisms in India for carrying out response, relief and rehabilitation in disaster hit areas have been well-established. These mechanisms have proved to be robust and effective as far as response, relief and rehabilitation are concerned. The changed policy/approach, however, mandates a priority to pre-disaster aspects of mitigation, prevention and preparedness. Thus, new institutional mechanisms have recently been put in place to address the policy change. The new institutional mechanisms include the creation of disaster management authorities, both at the national and the state level, which are responsible for disaster site management. These institutions are full of representatives from relevant ministries/departments to bring about a coordinated and multi-disciplinary response with experts covering a large number of branches. The National Emergency Management Authority is one such institution. The authority is headed by an officer of the rank of Secretary/ Special Secretary to the Government in the Ministry of Home Affairs with representatives from the Ministries/ Departments of Health, Water Resources, Environment and Forest, Agriculture, Railways, Atomic Energy, Defence, Chemicals, Science and Technology, Telecommunication, Urban Employment and Poverty alleviation, Rural Development and Indian Meteorological Department as members.

When a disaster strikes, the Authority coordinates disaster management activities. These include:

- Providing necessary support and assistance to state governments by way of resource data, macro-management of emergency response, specialized emergency response teams, sharing of disaster related data base
- Coordinating/mandating government's policies for disaster reduction/mitigation
- Ensuring adequate preparedness at all levels
- Coordinating response to a disaster when it strikes
- Assisting the provincial government in coordinating post-disaster relief and rehabilitation
- Coordinating resources of all national government department/agencies involved
- Monitor and introduce a culture of building requisite features of disaster mitigation in all development plans and programmes
- Any other issues of work, which may be entrusted to it by the government

Logistics management

The increase in the intensity and magnitude of disasters in recent times has forced disaster management policy makers to think of ways to improve the logistics during a relief and rehabilitation response. The logistical response to the Asian tsunami in December 2004 revealed the fragility and inadequacy of the logistics processes in disaster management. The disaster that earthquake and tsunami left in its path spanned 14 countries and millions of victims required coordination among the hundreds of government agencies, NGOs, military forces, and international relief organizations in rescue operations and moving relief materials. The complexity of the situation increased because of insufficient capacity of organizations to provide relief and aid. All these factors led to an inadequate response to the disaster, at least for the first few weeks. The failures of the relief operations during the tsunami forced the international community to review its priorities such as strengthening professional staffing and supporting strategic partnerships and local available expertise and also clarify at the outset who is to coordinate disaster response and recovery. It also required a re-look at the management of logistics during a relief operation.

Logistics management means prioritization, transport planning, reception and distribution of emergency supplies by the agency responsible for coordinating a relief effort during a disaster response. Logistics is a bridge that allows the transition between emergency and development programmes, and links the entire supply chain. This link cannot be ignored by the actors of this particular supply chain because by establishing a long-term process logistics will ensure local development and sustainability.

Logistics management is a key component of any disaster reduction effort. Planning for disasters is both necessary and practical, since it is generally possible to foresee the types of disasters that may affect a given location and the needs that such disasters will be likely to engender. Logistics preparedness must be based on the vulnerability and resource assessment. The assessment of needs during a disaster allows relief organizations to stockpile provisions in advance. The logistics stock preparedness is essential in covering the initial needs in the immediate aftermath of any disaster. The improvement of logistics management in disaster management in India was seen during the evacuation efforts for Cyclone

Phailin in 2013. Not only were the state agencies and the NDMA able to evacuate over a million people from the coastlines to cyclone shelters, but these shelters were extremely well-stocked, with adequate food, water and medical supplies. The efforts of the agencies were praised by all, including international agencies, and were largely responsible for the low casualty during the storm.

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4.3.2 Medical and Health Response to Different Disasters

Hurricane Katrina in August of 2005 swept through the southern and eastern coasts of the United States, leaving 1,833 dead and causing more than $100 billion worth of damage across multiple American states. In Japan in 2011, a massive 9.0 earthquake and resulting tsunami killed over 16,000 people and caused over $235 billion worth of damage. In 1985, a volcano near the town of Armero, Colombia, erupted. The ensuing mudslides result in the deaths of over 25,000 people. Such types of natural disasters, whether they be tsunamis, floods, earthquakes, kill hundreds of thousands of people every decade. Studies have shown that over 15 to 20 per cent of people who have been victims of natural disasters suffer from post-traumatic stress disorder. However, it has only been in the last decade or so that mental health professionals have become actively involved in the relief and recovery operations after a disaster event. Prior to that, recovery and relief only meant reconstruction and providing emergency medical relief.

The area of rehabilitation is still grappling with issues related to people having chronic disorders after trauma. Almost the entire body of literature related to disaster related trauma comes from the field of social work and psychology. However, it is of vital importance for the field of post-disaster rehabilitation to be aware of chronic PTSD. This is because disabilities and mental health issues among the victims of natural disasters have become very common. Moreover, heart attacks and other physical injuries arising out of disasters can lead to permanent disability which requires assistance in order for the victim to recover.

Stress after trauma often has a detrimental effect on a person's social life as well as his vocation. The most significant deficit that is associated with post traumatic stress is dealing with stressors that remind one of the disaster event. Victims of PTSD must be referred to government or private health services so that they get proper treatment.

The reason why victims of natural disasters fall victim to post traumatic stress is because natural disasters represent a crisis that causes significant and sudden change in an individual. That sudden change can be anything, from losing one's home to losing a loved one, and so on. According to the authors Murphy and Laube, such sudden changes lead to feeling of insecurity and vulnerability in the loss of privacy and treasured possessions. Individuals are suddenly thrown into situations where they have to find temporary shelter, food and must reside in very poor conditions. This can cause a sense of dislocation and shock. The loss of home can extend to loss of community and employment, with concomitant loss of support and income.

Death and injury and often follows natural disasters make an impression upon the minds of victims. This often results in guilt for not doing enough to save other. Victims of natural disaster often also go through phases of denial and anger. Denial is associated with those victims who have lost loved ones in a tragedy. Their sudden loss leads to disorientation and victims not being able to cope with loss. Anger of the victims is generally directed towards officials who could not prevent the tragedy, or with relief and recovery personnel who may not arrive fast enough to save people. Anger could also be directed against insurance companies for not paying a claim. Studies by specialists have shown that those who are exposed to a natural disaster face anxiety reactions within five hours from the natural disaster event. This anxiety manifests itself in anxiety related sleep disturbances, fear, startle reactions, and so on. Some victims also abuse substances to cope with the situation. Studies from around the world have shown that drug abuse among victims of disasters is common.

One expected outcome for victims as a result of natural disasters is depression. Grieving is only natural, whether it is grieving for a loved one, for the loss of the home, for the destruction of the community, and so on. This grieving often leads to depression. According to the authors Cohen and Ahearn (1980), bereavement syndrome has five forms. These are:

- The first is inhibited grief, in which intense denial is the main characteristic.
- The second form is anger that leads to victims lashing out.
- The third form is the feeling of extreme guilt which leads to self-blame.

- The fourth form is chronic grief, in which the suffering continues unchanged for years.
- The fifth form is depressive illness, in which the person has social isolation, loss of energy, hopelessness, and even suicidal tendencies.

Significant symptomatology of victims of natural disasters is shown as defense and specific signs. They are shown in the table below:

Table 4.1 *Defense and Specific Signs*

Defense	Specific Signs
Shock	Confusion and psychological numbing
Fear and Anxiety	• Sleep disturbance (e.g. nightmares, insomnia) • Substance abuse • Uncontrollable and distressing images of event • Increased absenteeism at work • Loss of ability for intimacy • Loss of interest in interpersonal relations • Hyperalertness, scanning, hypervigilance, ticks • Desire not to be left alone • Hyperreeactivity to particular cues, (e.g. storms) • Physical changes: increased blood pressure, arthritis, ulcers, chest pains, headaches. • Problems in performance at school, home, or work • Loss of sense of security
Denial	• Containment of feelings • Unwillingness to talk about event • Cheerful or audacious reaction to trauma
Mourning and Depression	• Frequent and endless gravesite visits • Crying at the reminder of loved ones • Social isolation • Loss of energy • Hopelessness • Suicidal ideation • Memory or concentration problems
Guilt and Shame	• Depressed moods • Extreme guilty preoccupation
Retaliation	• Lawsuits and other acting out episodes • Temper tantrums and argumentative style

Clinical casualty management

More and more people are affected by disasters, whether natural or man-made, every single day. Such situations put a strain on existing health infrastructure and also slow the process of sustainable human development. Many lives can be saved if communities are better prepared to deal with emergency situations and states are capable enough to respond to situations. Post-disaster, many victims also suffer from mental and physical disabilities straining the already over burdened health system and diverting resources from other essential programmes. Much of these effects can be divided if one is properly prepared. Studies have shown that preparedness at the community level is essential for mitigating the adverse effects of disasters. For this reason, clinical casualty management stresses capacity building at the level of the community. Empowering communities to develop plans requires strong involvement of the health sector, both locally and nationally.

Although the shortfalls faced during emergency situations are understood by everyone, most countries of the world still have not addressed the issue in a comprehensive way. Many nations do not have a Mass Casualty Management Plans which forces local communities to initially fend for themselves while facing a disaster.

Guidelines for mass casualty management

The World Health Organization (WHO) has framed some guidelines for the formulation of mass casualty management plans. These are as follows:

- **Clear lines of responsibility**: Roles must be clearly defined in the plans and policies so that there is no confusion about who is in charge during the different stages of the response.

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- **Scalability**: Although some activities would be common for all types of mass casualty incidents, preparations for emergency events must look into issues related to scalability and upsurge in demands for health services.
- **Whole-of-health**: Along with preparing for mass scale injury and death, other health services like providing clean drinking water and sanitation must also be planned.
- **Knowledge-based:** Since pretty much every single mass casualty event that can be imagined has already taken place, it would be useful to use the body of knowledge and data available to prepare plans.
- **Coordination:** Any response to a mass casualty incident can only succeed if there is proper coordination between the different agencies at the local, state and national level.

Any mass casualty management plan should be based on a tiered approach based on the above WHO approved guidelines. Such an approach recognizes that although a national approach to policy and management of mass casualty incidents is necessary, the preparedness of local health services will be the decisive element in the success or failure of the plan.

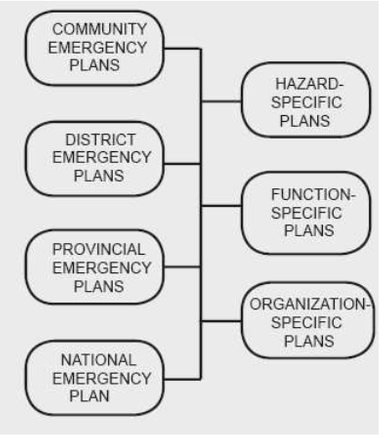

Fig. 4.1 *Context of Emergency Plans (Source: WHO)*

A tier based approach suggests that the first response to any disaster must be at the local level with local health care personnel and relief agencies working to provide relief. When it seems that the situation is overwhelming, the next tier may be activated. This tier consists of activating plans of the state government and utilizing its resources. If the state is not capable of handling the disaster on its own, the third tier, the resources of the national government must be activated. Therefore, any management plan of mass casualty events must provide clear criteria regarding the 'triggers' for these escalations. The triggers should be agreed by all stakeholders, and tested in training drills and simulation exercises.

Epidemiological study of disasters

Epidemiology is that branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health. The use of epidemiology in disaster situations, whether natural or man-made, is known as disaster epidemiology. Disaster epidemiology is one of the newer fields of disaster management. It entails studying the characteristics of disasters from an epidemiologic perspective. Such a perspective can be used to measure and describe the negative effects of natural and human-caused disasters.

There are two approaches that can be utilized in epidemiologic investigation of a disaster. They are:

- **Understanding the causes of a disaster**: This approach focusses on the disaster event. Learning as much as possible about the reasons for disasters is important for developing prevention activities in the future.
- **Understanding ways of controlling a disaster**: This approach focusses on mechanisms that can be developed to relieve the burden associated with a disaster once it has occurred. Such an approach can be applied during the phase of disaster preparation or at the stage of disaster relief and rehabilitation. The most direct application of epidemiology in this situation is the establishment of surveillance systems to identify injuries and the possible emergence of communicable diseases.

The types of studies that come under disaster epidemiology include:

- Surveillance
- Public health impact evaluation
- Natural history evaluation
- Analytic studies of risk factors
- Clinical investigation
- Population based study
- Studies of psychological effects of disasters

Before a disaster, epidemiologic methods can be applied in hazard and vulnerability analysis. During a disaster, they can be applied in damage assessment, collection of information and public health surveillance. Post disaster, epidemiologic methods can be applied in analysing the frequency of deaths, injuries, illnesses and other negative health related factors related to a disaster. They can also be applied in analysing the risk factors that cause death and injury so as to formulate evidence-based prevention strategies.

Clearly, the application of epidemiology can offer much needed information on which a rational, effective, and flexible disaster management policy can be based. Epidemiology in particular offers the tools for swift and efficient problem solving during public health emergencies such as natural and technological disasters.

Remote Area Planning

One of the factors that lead to an effective disaster relief response is the time it takes for disaster management agencies to spring into action. While it is relatively easier to respond to disasters in well-connected areas, responding to disasters in remote areas requires advance planning.

During the recent floods in Uttarakhand, communication links were destroyed in the upper regions of the Himalaya. Flood and debris washed away roads, bridges and cut off entire districts from the country. The situation was such that government agencies were not able to figure out the extent of the disaster for a few days after the event. Moreover, bad weather made it impossible to fly in relief materials to upper regions of the Himalaya, or to rescue pilgrims who were stranded in temple towns. Although, the Indian armed forces came to the rescue of those stranded, flying in dangerous weather and sometimes even climbing mountains to reach those who were stranded, a lot of victims could have been saved if the civilian agencies had responded in time. Such a response would have been only possible if the state government or the disaster management agencies had taken steps towards remote area planning.

Any remote area plan entails giving planners in the regions better access to valuable knowledge for disaster mitigation, preparedness and response. It entails creating local level response teams, making local communities aware of risks and preparing them for all eventualities, as well as putting in place policies of relief and response that would take into account the adverse local conditions of the area.

Check Your Progress

5. What is disaster medicine?
6. Define medical preparedness plan.
7. What is meant by logistics management?
8. Define disaster epidemiology.

4.4 REHABILITATION, RECONSTRUCTION AND RECOVERY

Counter disaster planning means the planning, organization, co-ordination and implementation of measures that are necessary or desirable to prevent, minimize or overcome the effects of an emergency or disaster upon members of the public or any property and includes the conduct of or participation in training for those purposes and for civil defence measures. The four phases of a counter disaster cycle are prevention, preparedness, response and recovery. In this section, we shall focus on recovery and rehabilitation.

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The damage caused by floods, earthquakes and cyclones is on a much larger scale than other disasters and recovery after these disasters poses a challenge. In disasters like drought, the relief phase is prolonged and since there is no damage to the infrastructure and property, the rehabilitation is confined to restoration of livelihoods which can get subsumed in normal development programmes.

Recovery in case of epidemics is more in the form of sanitising the locality against any future recurrence and may also involve counseling of the victims. Industrial disasters being quite varied in nature, the rehabilitation in major ones like the 'Bhopal Gas Tragedy' could involve rehabilitation efforts spanning over a generation of victims apart from restoring livelihoods and providing social and psychological assistance. Rehabilitation following disasters such as landslides and avalanches is localised and is of a similar nature as in earthquakes but on a smaller scale. Finding safer sites near such locations often poses challenges and resistance.

Guiding Principles for Post-Recovery

The following points are the guiding principles generally applied during the recovery phase and are based on international practices:

- Mainstreaming disaster risk reduction in recovery and development process
- Improving coordination
- Promoting participatory approaches and decentralising planning and programming for recovery
- Enhancing safety standards and integrating risk reduction in reconstruction and development
- Improving the living conditions of the affected communities and sectors
- Building local and national capacities for increased resilience, risk management and sustainable development
- Taking advantage of ongoing initiatives
- Gender sensibility
- Demonstrative effects
- Monitoring, evaluation and learning

Assessment

The first step after stabilizing the situation in a disaster hit region by providing sufficient relief is to assess the damage caused by the disaster. A meticulously executed assessment exercise would provide an ideal base for the rehabilitation efforts. This exercise is best carried out through multi-disciplinary teams which go into all aspects of damage (social, economical, psychological) in participation with the local community. Based on the assessment of the damage and the needs, a recovery strategy has to be formulated. The strategy should include all interventions - economic, social, political and psychological. The resources should be identified and the roles and responsibilities of all concerned should be defined.

Coordination

Following any major disaster, a number of players arrive on the scene and as already stated, ensuring proper coordination amongst them becomes very important. Recovery activities are taken up by government agencies, local bodies, international agencies, voluntary organizations and others, through separate, overlapping and uncoordinated interventions. This leads to imbalances in the scale of operations, duplication of efforts in some areas, gaps in others and leakage and misuse of resources. Therefore, establishing a framework for coordination is extremely important for effective recovery. The role of voluntary organizations including international ones like the Red Cross is extremely useful for mitigating the impact of disaster.

The administration is also required to set up a voluntary organizations' coordination centre to coordinate the relief and rehabilitation activities of the multiple organizations so that they are not concentrated in a few pockets. It is often observed that post-disaster recovery efforts tend to focus on rapid and visible solutions to restore normalcy at the cost of sustainable development. The post-disaster recovery phase provides a 'window of opportunity' for disaster risk reduction. Risk reduction aspects should therefore be built into the re-development process.

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Recovery

Recovery is not only about the restoration of structures, systems and services in a disaster hit region; a successful recovery is also about individuals and families being able to bounce back from their losses, and sustain their physical, social, economic and spiritual well-being. The goal of recovery is to bring a community back to a new normal after it has been devastated by a disaster.

There are two phases of recovery:

- Short-term recovery
  - o Many emergency and relief programs complete their work
  - o Restoration of infrastructure and vital life support systems happen in this phase
  - o The community identifies local resources to form a long term recovery group (LTRG), and initiation of plans for permanent housing begins
- Long-term recovery
  - o Transition occurs between the presence of national organizations and the local community
  - o Implementation begins for disaster case management and recovery initiatives administered by the local community
  - o Construction activities to include repairing, rebuilding and/or relocation of homes proceeds during this phase
  - o Resumption of the routines of daily life characterizes this phase

Disaster Resistant House Construction

Shelter is one of the most visible and immediate needs in a post-crisis setting. Relief efforts are often focused on providing shelter quickly, without taking into account the impact of short-term shelter strategies. Long-term shelter strategies help not only to focus on determination and implementation of realistic and permanent reconstruction plans for the affected communities, but are also concerned with rebuilding community confidence and support structure for civic responsibility and urban governance through participatory planning of reconstruction. The development of disaster resistant housing is a major factor in reducing vulnerability to disasters. However, shelter issues in mitigation go beyond the structural aspects. Rights to ownership and security of tenure make an enormous difference to the maintenance, management and development of shelter, particularly in urban areas.

Construction of a Disaster Resistant House in Tamil Nadu after the 2004 Indian Ocean Tsunami

Creation of long-term livelihood options

Normally, it is seen that the recovery efforts have a tendency of tapering off with the passage of time. The Bureau for Crisis Prevention and Recovery of the UNDP has also observed 'the general experience

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is that once the initial flurry of activities of providing rescue and relief is over, the attention received by the recovery efforts goes on declining steadily over a period of time and "business as usual" sets in'.

Most of the time it is seen that post disaster relief and rehabilitation by the state or NGOs are usually haphazard measures that are not linked to the overall development goals of the disaster hit country. This tends to exacerbate the already fragile situation which results in people being dependent on aid to survive. Short-sighted relief operations are also a waste of resources. Relief and rehabilitation of disaster areas by government and non-governmental services can no longer exist in isolation; they must be linked to overall objectives of development for the community and require the participation of development agencies. The real test lies in broadening the portfolios of humanitarian and developmental actors and in bringing them together in shared realization of recovery processes for sustainable development.

The sustainability component in recovery process therefore is important. This could be achieved by capability building of the community and awareness generation and preparing local crisis management plans.

4.4.1 Monitoring and Evaluation of Rehabilitation Work

A system of accountability needs to be evolved during the relief and rehabilitation phase. This system should ensure that the relief material reaches the target groups and that the funds are being utilized efficiently and optimally. A grievance redressal mechanism should also be put in place.

After the recovery phase, it is necessary to conduct a detailed evaluation of all aspects of crisis management. This should bring out the strengths and weaknesses of the disaster management machinery and also provide the basis for future improvements. Such an evaluation should be carried out by an independent professional agency like the NIDM, in all major disasters. This assessment should also include a quick audit of the expenditure incurred.

Assessing nature of damage to houses and infrastructure

Any post-disaster response is based on an assessment of damages to understand the nature and extent of impact on various aspects of human life and living conditions. From the past experiences, it has been learnt that damages are measurable, but without getting in to the subjective dimensions, the human sufferings cannot be fully understood.

Damage to Housing

Good housing conditions are a prerequisite for the well-being of a family. Housing is not only a shelter for a family to live in, but also in many cases, a setting for an economic enterprise. A natural disaster can cause varying degrees of damage to houses depending on various factors. The quality of construction, materials used, construction technology, type of dwelling, location, and so on add to the vulnerability of built structures and affect the extent of damage. The restoration of respectable habitat for the affected families is usually one of the primary objectives of humanitarian response. To ensure reduction of vulnerable constructions in the post-disaster period, an assessment of the extent and type of housing damage is required.

The geographic location of the settlement is the first information needed to understand the impact of the disaster. The location describes its setting with respect to land forms and proximity to natural features such as lakes, rivers or sea. The assessment should further elaborate, in terms of urban or rural, size, typology on the basis of design and structural system, types of ownership and functional usage. Additionally, information about the average dwelling size, average number of inhabitants per dwelling unit and average area should also be collected. The number of dwellings in the affected area needs to be determined, specifying in each case whether they are single- or multi-family, owned by men or women, as freehold, state conferred or customary title, rented or without title. The issues like land title and tenancy are important to understand for planning for housing.

The houses need to be categorized based on the extent of damage. This helps in formulating a suitable response. Participation of the affected people in the process of enumeration is essential, as recovery policies and responses are based on this database.

The number of houses affected and the extent of damage may be categorized as:

- Completely destroyed houses or the buildings which are beyond repair
- Partially damaged houses which are repairable

- Houses with minor damage
- Undamaged houses

The indicators for such categorisation may require inputs from housing professionals. This assessment should also identify the various prevalent construction materials and techniques. Information on quality of existing dwellings, disaggregated by its conditions or the type of construction materials (mud, bamboo, wood, brick, reinforced concrete) can help us in estimating financial, material and skill resources required for reconstruction. Damage depends on both the types of disaster and the type of construction. Poorly built dwellings sometimes, even with seemingly so-called strong materials like RCC, tend to be the hardest hit. These comparisons, therefore, provide important clues and relation between types of disaster and vulnerability of shelter for post-disaster reconstruction and help in developing safety guidelines.

Housing Damage after the 2001 Gujarat Earthquake

Damage to infrastructure

The infrastructure required for various goods and services that are essential for well being of people is frequently damaged due to disasters. This affects people's lives adversely. Basic services like drinking water, access roads, sewage disposal, electricity, and so on, if affected can pose, not only difficulties for the community but also challenges for the humanitarian workers in undertaking rescue and relief operations.

Infrastructure damage includes not only the damage to basic services, but also to public buildings essential for providing education, health care or those serving other social functions. In addition to these, there are many community owned infrastructural facilities like religious places, community halls, animal shelters, fodder lands or forests, old monuments, tanks and wells, check dams and minor dams. Damage to community infrastructure adversely affects or restricts important functions of the community. Typically, the community infrastructure involves high capital and social process costs. Given the nature and importance of such community infrastructure, it is imperative to design it with all appropriate safety considerations.

The assessment of infrastructural damage should cover all the components of public delivery systems of goods and services located in the affected community. These goods and services may be provided by the public institutions, local community collectives-formal or informal and other civil society institutions.

The three categories that need to be included in the assessment are:

- **Public buildings**: These include *anganwadis*, schools, health centres, community halls, panchayat building, PDS shop, vocational training centres or any other government structures. The disaster may damage these buildings and affect the services being provided through them. Usually, the public buildings also serve as rescue centres, after the disaster; and if they are damaged, the affected community may face difficulties in coping.

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- **Basic services**: The basic services such as drinking water supply, access roads, sewage disposal, drainage, electricity and communication are very important for the community's well-being. If these services are disrupted, many lives may be threatened due to the possible outbreak of diseases or other such problems. Therefore, damage assessment must try understand how these services have been affected, the extent of damage in terms of quantum and the people it serves. Sometimes, damage to these services may be qualitative. For example contamination of the drinking water supply of the community. Thus, it is essential to understand such impacts in the damage assessment. Another critical aspect to be included in damage assessment is to determine the worst affected in the community due to disruption, so that appropriate priority and targeting may be assigned during the recovery process.
- **Community owned infrastructure**: Much of the infrastructure may be community-owned in many settlements affected by the disaster. Community owned infrastructure is the outcome of various collective social processes, formal or informal, at the community level. The infrastructure may belong to different social groups within the community or to the entire village. It is essential to understand the damage to such infrastructure in terms of its spread, quantum, type and extent. The examples of such infrastructure are tanks, wells, community hall, animal shelters, religious buildings and spaces, cooperative buildings and so on. The extent and type of damage to the community-owned infrastructure should be assessed. Here, it is essential to identify the worst affected within the community.

Development of physical and economic infrastructure

When a natural or a man-made disaster occurs, people, houses and property are always the most affected. Thus, any relief measure, in addition to immediate human needs, must also consider the problems that may arise in settling humans in large numbers temporary and providing them adequate infrastructure. In most post disaster situations it has been seen that interventions are most effective when they are designed to begin concurrently; consideration of long term impacts of short term interventions can add value to the latter, and depth to the former. Thus, any planning for long term recovery must be concurrent even while short term relief measures are underway.

The first challenge for any sustainable recovery is to provide security and protection of the displaced population. To do this, it is extremely important to restore the institutions of the state, the law and order machinery backed by an impartial judiciary.

A natural or a man-made disaster also wreaks the livelihood of the victims of the disaster. Poverty lack of resources increases vulnerability, weakens coping strategies and delays the recovery process. One of the most vital components of recovery is a vibrant economy, yet most disaster rehabilitation experts feel the economic recovery of a disaster area is the most difficult aspect of rehabilitation. Despite disasters, many communities have resources that can be tapped such as the availability of local building materials, existence of a labour force, and most importantly eagerness of local communities and the private sector to participate in the recovery process. Restoring employment opportunities in a disaster area and reinforcing the local building sectors all are contributing to sustainable recovery.

4.4.2 Managing Relief Camps

A refugee camp is a temporary camp built to receive refugees. Hundreds of thousands or even millions of people may live in any one single camp. Usually, they are built and run by a government, the United Nations, or international organizations, (such as the Red Cross) or NGOs. Refugee camps are generally set up in an impromptu fashion and designed to meet basic human needs for only a short time. Some refugee camps are dirty and unhygienic. If because of any reason, whether a civil war or government incompetence, the return of refugees is prevented, it may result in a humanitarian crisis. Some refugee camps grew into permanent settlements, such as the Palestinian refugee camp in Lebanon called Ein el-Hilweh, and have existed for decades, which has major implications for human rights.

Facilities

Facilities in a refugee camp can include the following:

- Sleeping accommodations (tents)
- Hygiene facilities (cleaning and toilets)

- Medical supplies
- Communication equipment (like radio)
- Protection from bandits (like barriers, checkpoints, peacekeeping troops)

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Duration

People may stay in these camps, receiving emergency food and medical aid, until it is safe to return to their homes. In some cases, often after several years, it is decided that it will never be safe to return these people and they are resettled in 'third countries' away from the border they crossed.

Exportation

Globally, about 17 countries (Australia, Benin, Brazil, Burkina Faso, Canada, Chile, Denmark, Finland, Iceland, Ireland, Mexico, Netherlands, New Zealand, Norway, Sweden, United Kingdom and United States) regularly accept 'quota refugees' from refugee camps. Refugee camps are typically used to describe settlements of people who have escaped war. In recent years, most quota refugees have come from Iran, Afghanistan, Iraq, Liberia, Somalia and Sudan, which have been in various wars and revolutions and the former Yugoslavia, due to the Yugoslav wars.

Some examples of refugee camps around the world are as follows:

- Camps in the east of Chad, such as Breidjing Camp, hosting approximately 250,000 refugees from the Darfur region in Sudan (starting 2002)
- Camps in the south of Chad, hosting approximately 50,000 refugees from Central African Republic
- Bududuram refugee camp, home to more than 12,000 Liberians (opened 1990)
- Camps for Sri Lanka Tamils, 110,000 in India in 1998, and more than 560,000 internally displaced (starting 1983)
- Four camps near Tindouf (opened in 1977)

Camp management

Refugees and internally displaced persons (IDPs) are given shelter and safety in the camps. They are, however, not very helpful in the long run due to various reasons. If they are run and managed well, they can provide short-term solutions by serving primary protection functions for these people displaced by armed conflict or natural disasters. The operations and types of camps and its settings, vary to a large extent based on the preceding disaster and the coping strategies in place.

Coordinating the activities on the campsite needs proper management by the relief workers. The relief workers are responsible to motivate and coordinate the various service providers to make their services available in a comprehensive manner where the primary motive that is to be kept in mind is the interest of camp residents.

Camp management is inclusive of the following activities:

- Securing and upholding the protection of the rights of refugees under international law (which includes an adequate standard of living in accordance with international minimum standards at all levels of planning, practice and participation)
- Forming camp committees
- Establishing community participation and mobilization mechanisms
- Promoting self-management, protection monitoring, data collection and sharing
- Providing defined services
- Monitoring the service delivery of other providers based on the set standards in order to avoid the duplication of activities and emergence of protection and assistance gaps
- Ensuring the maintenance of camp infrastructure

In order to ensure that the camps function smoothly, training is provided to individuals who will work as the camp managers. In providing camp management training, the following activities are ensured:

- Follow-up sessions, advising and coaching

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- Contextualized training modules will be provided to make the training more effective and local case studies will also be used to aid comprehension, if possible
- Training all stakeholders who are directly or indirectly related to the management of the camp
- Roles and responsibilities are clearly defined and the best practices for each of the positions are also highlighted
- Each relief worker involved with camp management, also participates in the training

Any camp that aims to function in accordance with the interests of the refugees and internally displaced persons (IDPs) needs to:

- Work with camp residents, humanitarian agencies, authorities and the local populations to provide security for all, especially the most vulnerable
- Make sure that coordination plans between all relevant camp authorities have been established and maintained to internationally accepted standards
- Manage providers so that they provide services efficiently, including monitoring, plugging gaps and avoiding duplication
- To act like an advocate for those who are staying in the camp and act as the intermediary between the residents and the authorities, security forces, implementing agencies and the local community leaders
- Use and develop local capacity where possible
- Make sure to apply based approaches communities for all sorts of activities
- Notify the agencies coordinating activities in the camp, so that they allow intervention by national and international agencies

However, the activities and functioning of the camp need to be constantly monitored, in order to plug any loopholes present. Camp monitoring includes keeping a check on:

- Provision of defined services
- Standard of the services provided
- Duplication of activities
- Emergence of protection and assistance gaps
- Maintenance of the infrastructure of the camp
- Collecting and sharing data

4.4.3 Disaster Management in India

Disaster management in India has evolved from an activity-based reactive setup to a proactive institutionalized structure; from single faculty domain to a multi-stakeholder setup; and from a relief-based approach to a 'multi-dimensional pro-active holistic approach for reducing risk'. The beginnings of an institutional structure for disaster management can be traced to the British period following the series of disasters such as famines of 1900, 1905, 1907 and 1943, and the Bihar-Nepal earthquake of 1937. Over the past century, the disaster management in India has undergone substantive changes in its composition, nature and policy.

Emergence of institutional arrangement in India

A permanent and institutionalised setup of disaster management began in the decade of 1990s with set up of a disaster management cell under the Ministry of Agriculture, following the declaration of the decade of 1990 as the 'International Decade for Natural Disaster Reduction' (IDNDR) by the UN General Assembly. Following a series of disasters such as Latur Earthquake (1993), Malpa Landslide (1994), Orissa Super Cyclone (1999) and Bhuj Earthquake (2001), a high powered Committee under the Chairmanship of Mr. J.C. Pant, Secretary, Ministry of Agriculture was constituted for drawing up a systematic, comprehensive and holistic approach towards disasters. There was a shift in policy from an approach of relief through financial aid to a holistic one for addressing disaster management. Consequently, the disaster management division was shifted under the Ministry of Home Affairs in 2002.

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Disaster Management Framework

Shifting from relief and response mode, disaster management in India started to address the issues of early warning systems, forecasting and monitoring setup for various weather related hazards. A structure for flow of information, in the form of warnings, alerts and updates about the oncoming hazard, also emerged within this framework. A multi-stakeholder high powered group was set up by involving representatives from different ministries and departments. Some of these ministries were also designated as the nodal authorities for specific disasters. Following a High Powered Committee Report on Disaster Management for establishment of a separate institutional structure for addressing disasters and enactment of a suitable law for institutionalizing disaster management in the country, a multi-level links between these ministries and the disaster management framework have emerged.

Present structure for disaster management in India

The institutional structure for disaster management in India is in a state of transition. The new setup, following the implementation of the Act, is evolving; while the previous structure also continues. Thus, the two structures co-exist at present. The National Disaster Management Authority has been established at the centre, and the SDMA at state and district authorities at district level are gradually being formalized. In addition to this, the National Crisis Management Committee, part of the earlier setup, also functions at the Centre. The nodal ministries, as identified for different disaster types of function under the overall guidance of the Ministry of Home Affairs (nodal ministry for disaster management). This makes the stakeholders interact at different levels within the disaster management framework.

Within this transitional and evolving setup, two distinct features of the institutional structure for disaster management may be noticed. Firstly, the structure is hierarchical and functions at four levels – centre, state, district and local. In both the setups – one that existed prior to the implementation of the Act, and other that is being formalized post-implementation of the Act, there have existed institutionalized structures at the centre, state, district and local levels. Each preceding level guides the activities and decision making at the next level in hierarchy. Secondly, it is a multi-stakeholder setup, i.e., the structure draws involvement of various relevant ministries, government departments and administrative bodies.

Disaster Management Act, 2005

The Disaster Management Act provides for the effective management of disaster and for matters connected therewith or incidental thereto. It provides institutional mechanisms for drawing up and monitoring the implementation of the disaster management. The Act also ensures measures by the various wings of the government for prevention and mitigation of disasters and prompt response to any disaster situation.

The Act provides for setting up of a National Disaster Management Authority (NDMA) under the Chairmanship of the Prime Minister, State Disaster Management Authorities (SDMAs) under the Chairmanship of the Chief Ministers, District Disaster Management Authorities (DDMAs) under the Chairmanship of Collectors/District Magistrates/Deputy Commissioners. The Act further provides for the constitution of different Executive Committee at national and state levels. Under its aegis, the National Institute of Disaster Management (NIDM) for capacity building and National Disaster Response Force (NDRF) for response purpose have been set up. It also mandates the concerned Ministries and Departments to draw up their own plans in accordance with the National Plan. The Act further contains the provisions for financial mechanisms such as creation of funds for response, National Disaster Mitigation Fund and similar funds at the state and district levels for the purpose of disaster management. The DM Act, 2005 also envisages specific roles to be played by the local bodies in disaster management.

National Disaster Management Authority (NDMA)

The NDMA has been mandated with laying down policies on disaster management and guidelines which would be followed by different ministries, departments of the Government of India and state government in taking measures for disaster risk reduction. It has also to laid down guidelines to be followed by the state authorities in drawing up the state plans and to take such measures for the management of disasters.

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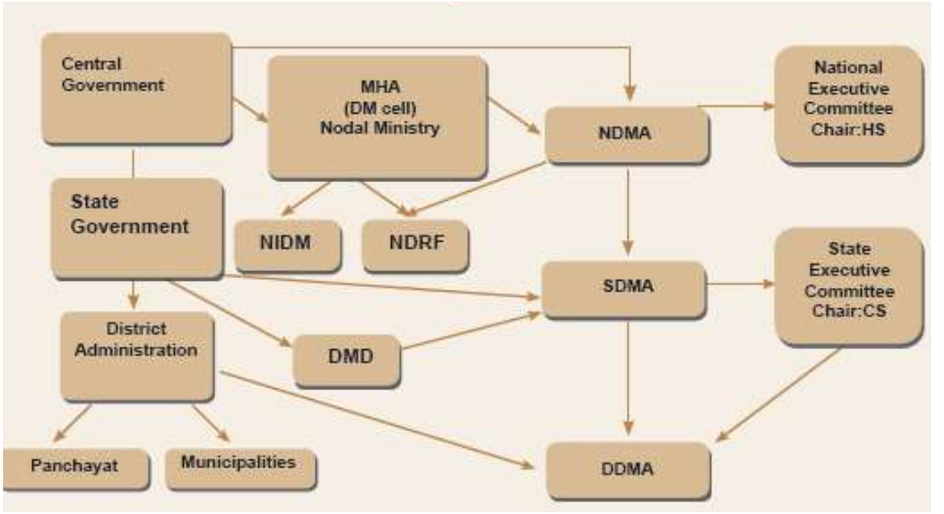
The details of these responsibilities are given as under:-

- Lay down policies on disaster management;



Legal Institutional Framework, DM Act 2005

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

National Policy on Disaster Management (NPDM)

The National Policy on Disaster Management (NPDM) was approved by the Central Government in 2009. The policy envisages a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response. The policy covers all aspects of disaster management including institutional and legal arrangements, financial arrangements, disaster prevention, mitigation and preparedness, techno-legal regime, response, relief and rehabilitation, reconstruction and recovery, capacity development, knowledge management, research and development. It focuses on the areas where action is needed and the institutional mechanism through which such action can be channelised.

The NPDM addresses the concerns of all the sections of the society including differently-abled persons, women, children and other disadvantaged groups in terms of granting relief and formulating measures for rehabilitation of the persons affected by disasters. The issue of equity and inclusiveness has been accorded due consideration. It aims to bring in transparency and accountability in all aspects of disaster management through involvement of community, community based organizations, Panchayati Raj Institutions (PRIs), local bodies and civil society.

Funding arrangements for reconstruction

Financial assistance in the wake of natural calamities is provided in accordance with the schemes of relief funds. These schemes are based on the recommendations of the successive Finance Commissions. While the budgetary provision of these relief funds is dealt with by Ministry of Finance, the processing of request of the state government for these funds is done by the Ministry of Home Affairs (DM Division). The present scheme of State Disaster Response Fund (SDRF) and National Disaster Response Fund (NDRF) are based on the recommendations of the 13th Finance Commission, operative from 1st April 2010 to 31st March 2015.

State Disaster Response Fund: Section 48 (1) of Disaster Management Act 2005 provides for constitution of State Disaster Response Fund (SDRF) by the state governments. The Ministry of Home Affairs has issued the guidelines to the state for operation of SDRF. Allocations to the State Relief Funds have been made based on the recommendations of the successive Finance Commissions. While allocating the funds to various states for a period of five years the factors considered include the expenditure incurred by the state government on relief operations during the last about 10 years, vulnerability of the state to natural disasters and economic status of the state. Currently, as per the recommendations of the 13th Finance Commission, the GoI has approved an allocation of ₹ 33580.93 crore in the State Disaster Relief Fund to all the states, comprising of ₹ 25847.93 crore as central share and ₹ 7733.00 crore as state share. The scheme of SDRF provides for release of the central share SDRF in two equal installments in the months of June and December.

National Disaster Response Fund (NDRF): Section 46(1) of DM Act 2005 provides for constitution of NDRF for meeting any threatening disaster management situation or disaster. The Government of India raised this Fund by levying the 'National Calamity Contingency Duty' on imported petrol and products, crude oil, motor cars, imported multi utility vehicles, two wheelers, mobile phones, pan masala and certain specific tobacco products. The collection for year 2009-10 was ₹ 3160.00 crore and was expected to be around ₹ 3900.00 crore in the financial year 2010-2011. For the year 2011-12, the estimate is ₹ 4525.00 crores.

Additional financial assistance: Over and above the provisions of the SDRF, funding is provided from the NDRF in the wake of calamities of severe nature. On receipt of the memorandum from the affected states, an Inter Ministerial Central Team comprising of representatives of the central ministries/ departments is constituted and its report after examination by the Inter Ministerial Group (IMG) headed by Home Secretary is placed before the High Level Committee (HLC) for their consideration and approval of funds from NDRF. The composition of HLC is given in the Policy and Guideline, Chapter-2, which at present are headed by Finance Minister with Home Minister, Minister for Agriculture and Vice Chairman of Planning Commission as its member on the committee.

Monitoring of expenditure from relief funds

The Ministry of Home Affairs oversees the operations of SDRF and monitors its compliance with these guidelines. A format for monitoring the relief expenditure in accordance with the extant items and norms of assistance has been prescribed. A web based computerized tracking system has also been developed for monitoring the relief expenditure. The Accountant General of the State maintains the accounts of the SDRF. The Comptroller and Auditor General of India audits SDRF every year.

Check Your Progress

9. What is meant by counter-disaster planning?
10. State the goal of recovery.
11. Define a refugee camp.
12. State the aim of the National Policy on Disaster Management.

4.5 SUMMARY

- The response phase of disaster management encompasses the mobilization of necessary emergency services and first responders to the disaster site. This entails mobilize the first responders, i.e., firefighters, police and medical crews. When such a response if conducted with military precision, it is termed Disaster Relief Operation (DRO).

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- Institutional arrangements for disaster response constitute the heart of any disaster management system.
- The standard mechanism for the assessment of disaster risk and disaster response in the United States is the Hazards U.S. Multi-Hazard (HAZUS-MH) model.
- The HAZUS model uses the various classifications of civil structures as well as infrastructure for assessing earthquake losses.
- Disaster medicine is a field of medical specialization that provides health care to disaster survivors and provides medically related disaster preparation, disaster planning, disaster response and disaster recovery leadership throughout the life cycle of a disaster.
- A medical preparedness plan are a set of procedures and policies, necessary to maximize the ability to prevent, respond to, and recover from major disaster events, including efforts that result in the capability to render an appropriate public health and medical response that will mitigate the effects of illness and injury, limit morbidity and mortality to the maximum extent possible, and sustain societal, economic, and political infrastructure.
- Logistics management means the prioritization, transport planning, reception and distribution of emergency supplies by the agency responsible for coordinating a relief effort during a disaster response.
- Counter disaster planning means the planning, organization, co-ordination and implementation of measures that are necessary or desirable to prevent, minimize or overcome the effects of an emergency or disaster upon members of the public or any property and includes the conduct of or participation in training for those purposes and for civil defence measures.
- The first step after stabilizing the situation in a disaster hit region by providing sufficient relief is to assess the damage caused by the disaster.
- The goal of recovery is to bring a community back to a new normal after it has been devastated by a disaster.
- A refugee camp is a temporary camp built to receive refugees.
- The NDMA has been mandated with laying down policies on disaster management and guidelines which would be followed by different ministries, departments of the Government of India and state Government in taking measures for disaster risk reduction.

4.6 KEY TERMS

- **Epidemiology**: Epidemiology is that branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health.
- **Refugee camp**: A refugee camp is a temporary camp built to receive refugees.

4.7 ANSWERS TO 'CHECK YOUR PROGRESS'

1. The response phase of disaster management encompasses the mobilization of necessary emergency services and first responders to the disaster site. This entails mobilizing the first responders, i.e., firefighters, police and medical crews. When such a response if conducted with military precision, it is termed Disaster Relief Operation (DRO).
2. Usually, the first response to a disaster comes from the local government body.
3. HAZUS development was initiated since early 1990s.
4. The full form of NDRF is National Disaster Response Force.
5. Disaster medicine is a field of medical specialization that provides health care to disaster survivors and provides medically related disaster preparation, disaster planning, disaster response and disaster recovery leadership throughout the life cycle of a disaster.
6. A medical preparedness plan is a set of procedures and policies necessary to maximize the ability to prevent, respond to, and recover from major disaster events, including efforts that result in the

capability to render an appropriate public health and medical response that will mitigate the effects of illness and injury, limit morbidity and mortality to the maximum extent possible, and sustain societal, economic, and political infrastructure.

7. Logistics management means the prioritization, transport planning, reception and distribution of emergency supplies by the agency responsible for coordinating a relief effort during a disaster response.
8. The use of epidemiology in disaster situations, whether natural or manmade, is known as disaster epidemiology.
9. Counter disaster planning means the planning, organization, co-ordination and implementation of measures that are necessary or desirable to prevent, minimize or overcome the effects of an emergency or disaster upon members of the public or any property and includes the conduct of or participation in training for those purposes and for civil defense measures.
10. The goal of recovery is to bring a community back to a new normal after it has been devastated by a disaster.
11. A refugee camp is a temporary camp built to receive refugees.
12. The National Policy on Disaster Management (NPDM) envisages a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response.

4.8 QUESTIONS AND EXERCISES

Short-Answer Questions

1. Write a short note on HAZUS-MH model.
2. Write a short note on State Crisis Management Group (SCMG).
3. What are the two approaches that can be utilized in epidemiologic investigation of a disaster?
4. What is remote area planning?
5. What are the two phases of recovery?

Long-Answer Questions

1. Write an essay on disaster response in India.
2. Discuss disaster site management in India.
3. Describe the management of relief camps.
4. Discuss the disaster management Act, 2005 in detail.

4.9 FURTHER READING

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