e COURSE

Manual on DISASTER Management

http://hau.ernet.in/coa/agromet.htm

Compiled By

Diwan Singh ! Ram Niwas ! Raj Singh ! Surender S Dhankhar ! ML Khichar !

Dept of Agril Meteorology
CCS Haryana Agril University
Hisar – 125 004, India

July, 2010

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Foreword

In present era of financial fragility all around, coupled with the growing challenges of climate change/variability and environmental degradation, we must scale up our prevention activities to the most effective way to save lives and livelihoods and to safeguard development. Looking at the vulnerability of the nation to various hazards like droughts, floods, cyclones and other extreme weather events which can be predicted to the more sudden disasters like earthquakes, landslides and various manmade disasters which cannot be predicted and are very frequent in the present day world, now it is high time for us to have an insight into these disasters and get ourselves prepared to reduce losses. Disaster management deals with and avoiding both natural and manmade disasters and should be used as daily work along with establishment and management of local facilities and resources. There are several principles of disaster management, which include the right use of resources for the day-to-day purposes, coordination between various organizations, efforts of individuals, focus of large scale events, right knowledge of geographical location and nature of the society etc. In India, there are many areas, which are often affected with natural calamity or manmade disasters, management of which are now top priority in universities/institutes of higher education. As a result, the study of disaster management has been included in recently restructured postgraduate programs at CCS HAU Hisar.

The unit I of 'Manual on Disaster Management' discusses various natural disasters; their meaning and nature, their types and effects. The unit II discuss man made Disasters and unit III discuss management of all these disasters at various levels. They focus various precautionary measures that one needs to take to get one prepared from various disasters prevalent in our country and also focus on various structural and non-structural measures that we need to take to combat such disasters. The course on Disaster Management aims at having a practical understanding of managing disasters.

I hope this manual will help the PG students who are the future of the nation and volunteers to be able to cope up with disasters and be better disaster managers and save many precious lives.

I congratulate Dr Diwan Singh, Professor and Head, Dept of Agril Meteorology (Nodal Dept for this e-course) and his colleagues in designing and preparing 'E-Course Manual on Disaster Management' compulsory for all postgraduate programs/disciplines in CCS Haryana Agricultural University, Hisar from academic session of 2010-11 onward.

(**OP Toky**)
Dean
Post Graduate Studies
CCS HAU Hisar

July, 2010

Preface

A disaster refers to an extreme disruption of the functioning of a society that causes widespread human, material, or environmental losses that exceed the ability of the affected society to cope with alone. The events like droughts, floods, cyclones, earthquakes by themselves, are not considered disasters. Rather, they become disasters when they adversely and seriously affect human life, livelihoods and property. Disaster management refers to measures taken to prepare for and reduce the effects of natural as well as man made disasters. Therefore, to predict and—where possible—prevent them, mitigate their effects on vulnerable populations, and respond to and effectively cope with their consequences. Early warning and early action offer concrete ways for doing so, locally and globally. Disaster management is a continuous and integrated process of wide range of activities and resources rather than from a distinct sectoral activity. It requires the contributions of many different areas—ranging from training and logistics, to health care to institutional development.

We are highly thankful to Dr KS Khokhar, worthy Vice Chancellor, CCS HAU Hisar for his keen interest and guidance on framing the present ***e-course*** on **'Disaster Management'** and entrusting the Department of Agricultural Meteorology the responsibility of nodal department for teaching the course to all PG students to be admitted in the university *w.e.f.* current academic session (2010-11).

The authors are also thankful to Dr OP Toky, Dean, Post Graduate Studies, CCS HAU Hisar for his guidance and encouragement in preparation of the manual and writing Foreword. The reference material collected from various public domain portals for compilation of e-manual is also duefully acknowledged.

The authors' earnest hope is that this manual will serve as a useful reference material for our students in managing natural/man made disasters in most effective way to save lives and livelihoods to safeguard the development of the state and the nation.

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Ram Niwas

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Contents

Unit-I

What is disaster?

The term 'Disaster' owes its origin to the French word *desastre*, which is a combination of two words 'des' meaning bad and 'aster' meaning star. Thus, the term 'disaster' refers to 'Bad or Evil Star'. In earlier days disasters were considered to be an outcome or outburst of some unfavorable star.

Disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources.

WHO has defined Disaster as- Any occurrence that causes damage, ecological disruption, loss of human life, deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community.

What are we talking about?

A Disaster is …

- a sudden calamitous event bringing great damage, loss or destruction Webster dictionary)
- some rapid, instantaneous or profound impact of the natural environment upon the socio-economic system" (Alexander, 1993)
- an event, concentrated in time and space, which threatens a society or a relatively self -sufficient subdivision of a society with major unwanted consequences as a result of precautions which had hitherto been culturally accepted as unwanted (Turner, 1976).
- an extreme event as any manifestation of the earth's system (lithosphere, hydrosphere, biosphere or atmosphere) which differs substantially from the mean (Alexander, 1993).
- an event that results in death or injury to humans, and damage or loss of valuable good, such as buildings, communication systems, agricultural land, forest, natural environment etc.



Types of Disaster

Generally, disasters are of two types – **Natural** and **Manmade**. Based on the devastation, these are further classified into major/minor natural disaster and major/minor manmade disasters. Some of the disasters are listed below:

Major natural disasters:
- Flood
- Cyclone
- Drought
- Earthquake

Major man-made disaster:
- Setting of fires
- Epidemic
- Deforestation
- Pollution due to prawn cultivation
- Chemical pollution.
- Wars

Minor natural disasters:
- Cold wave
- Thunderstorms
- Heat waves
- Mud slides
- Storm

Minor man-made disaster:
- Road / train/ air accidents, riots
- Food poisoning
- Industrial disaster/ crisis
- Environmental pollution

Risk:
Risk is a measure of the expected losses due to a hazardous event of a particular magnitude occurring in a given area over a specific time period. Risk is a function of the probability of particular occurrences and the losses each would cause. The level of risk depends on:
- Nature of the Hazard
- Vulnerability of the elements which are affected
- Economic value of those elements

Vulnerability: It is defined as "the extent to which a community, structure, service, and/or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrain or a disaster prone area."

Hazards: Hazards are defined as "Phenomena that pose a threat to people, structures, or economic assets and which may cause a disaster. They could be either manmade or naturally occurring in our environment."

The extent of damage in a disaster depends on:
1) The impact, intensity and characteristics of the phenomenon and
2) How people, environment and infrastructures are affected by that phenomenon

This relationship can be written as an equation:

Disaster Risk = Hazard +Vulnerability

Difference between an emergency and a disaster situation
An emergency and a disaster are two different situations:
- An ***emergency*** is a situation in which the community is capable of coping. It is a situation generated by the real or imminent occurrence of an event that requires immediate attention and that requires immediate attention of emergency resources.
- A ***disaster*** is a situation in which the community is incapable of coping. It is a natural or human-caused event which causes intense negative impacts on people, goods,

services and/or the environment, exceeding the affected community's capability to respond; therefore the community seeks the assistance of government and international agencies.

Natural Disasters

A natural disaster is an event caused by natural forces of nature that often has a significant effect on human populations. Typically the human populations either are displaced (left homeless) or killed. **Natural disasters** are the effect of a natural hazard (e.g. flood, tornado, hurricane, volcanic eruption, earthquake or landslide) that affects the environment, and leads to financial, environmental and/or human losses.

Natural disasters occur due to the activities of nature:

- Weather disasters occur due to changes in atmospheric conditions
- Land disasters are primarily due to changes in the earth's crust. For example volcanoes and earthquakes.
- Water disasters: often are combination of both at above

Tornado

Flood

Volcano Eruption

Man made hazard is a threat having an element of human intent, negligence, or error, or involving a failure of a man-made system. **Man-made disasters** are disasters resulting from the same factors.

Chemical disaster

Fire

1. Flood: The term 'flood' is a general or temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters or from the unusual and rapid accumulation or runoff of surface waters from any source. Flooding and flash flooding are the deadliest of natural disasters. Floodwaters claim thousands of lives every year and render millions homeless. One of the more frightening things about flooding is that it can occur nearly anywhere, at any time. It can result from excess water jams on rivers, even moderate rain, or a single very heavy downpour as it occurred in Himachal Pradesh recently.


Floods

Many states in our country are flood prone due to heavy rain or otherwise. The flood causes loss to human life and wide spread damage to property. Unimaginable damage to agriculture takes place affecting the States planning and upset the financial budgeting there by slowing down the whole economy of the country.

People not affected by the flood tend to ignore the event thinking that it does not affect them so why bother?

Flood is not unique to our country. Floods come in different parts of the world. Floods are the biggest cause of loss of life every year through out globe. Majority of countries do not document or map floods methodically. People are generally taken by surprise by the floods as they may come in the night when every body is asleep, giving very little time for evacuation. Water remains stag anent after the flood recedes, source of drinking water get polluted and the food get spoiled. People are left with no resource to combat the natural calamity that has take place. Floods are ugly part of our system we cannot ignore or wish them away. The only way to fight the floods is to try to predict the flood, prepare for it, train and educate people. Identify those areas, which are flood prone.

2. Flash Flood: Flash flood is a rapid flooding of geomorphic low-lying areas - washes, rivers, dry lakes and basins. Flash flooding occurs when a barrier holding back water fails or when water falls too quickly on saturated soil or dry soil that has poor absorption ability.


Flash Flood

It may be caused by heavy rain associated with a storm, hurricane, or tropical storm or melt water from ice or snow flowing over ice sheets or snowfields. Flash can also occur after the collapse of a natural ice or debris dam, or a human structure such as a man-made dams. Flash floods are distinguished from a regular flood by a timescale less than six hours.

3. A cloudburst is an extreme form of rainfall, sometimes mixed with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. Basically it is an intense and very heavy rain that lasts a relatively short time.


Cloud Burst

The usual reason is that the updraft in the storm initially holds up a lot of the rain and hail, but after a time the updraft weakens, allowing all this rain and sometimes hail to suddenly fall to the ground. Cloud bursts are a result of sudden collisions of two or more clouds it results in a very heavy rain fall (its called so because the rainfall is not expected at that moment).

Cloudbursts descend from very high clouds, sometimes with tops above 15 kilometers. Meteorologists say the rain from a cloudburst is usually of the shower type with a fall rate equal to or greater than 100 mm per hour.

During a cloudburst, more than 2 cm of rain may fall in a few minutes. When there are instances of cloudbursts, the results can be disastrous. Rapid precipitation from cumulonimbus clouds is possible due to so called Langmuir precipitation process in which large droplets can grow rapidly by coagulating with smaller droplets which fall down slowly.

Record Cloudbursts

Duration	**Rainfall (mm)**	**Location**	**Date**
1 minute	38.10	Barst, Guadeloupe	26 November, 1970
5 minutes	61.72	Port Bells, Panama	29 November, 1911
15 minutes	198.12	Plumb Point, Jamaica	12 May, 1916
20 minutes	205.74	Curtea-de-Arges, Romania	7 July, 1947
40 minutes	234.95	Guinea, Virginia, USA	24 August, 1906

Cloudbursts in the Indian subcontinent

In the Indian subcontinent, a cloudburst usually occurs when a pregnant monsoon cloud drifts northwards, from the Bay of Bengal or Arabian Sea across the plains, then onto the Himalaya and bursts, bringing rainfall as high as 75 mm per hour.

An example was the sudden cloud burst over the Indian city of Mumbai and other regions of western India, on 26 July 2005, during the 2005 Maharashtra floods. Approximately 950 mm of rainfall was recorded in Mumbai over a span of eight to ten hours; the deluge completely paralyzed India's largest city and financial centre.

Cloudbursts frequently occur in Himachal Pradesh during the monsoon. The monsoon rains during July and August put a lot of water into the Himalayan soil. On 5th August, 2010, sudden overnight rains due to cloud burst caused flash floods in the town of Leh, the administrative center of the mountainous northern Ladakh region that borders China and Pakistan, killing more than 100 people and leaving hundreds injured. IMD described it as a 'disastrous weather event' in which "rate of rainfall may be of the order of 100 mm per hour.

Many buildings crumbled after sudden rains and flash floods in Ladakh

4. Drought:

Drought Occurs When Human Demand for Water Exceeds the Available Supply

Droughts can be of four kinds:

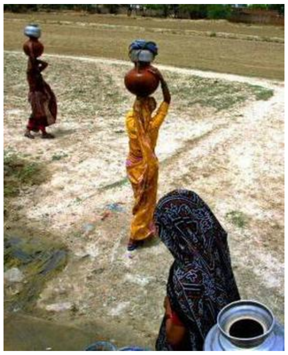
(i) Meteorological drought: This happens when the actual rainfall in an area is significantly less than the climatological mean of that area. The country as a whole may have a normal monsoon, but different meteorological districts and sub-divisions can have below normal rainfall. The rainfall categories for smaller areas are defined by their deviation from a meteorological area's normal rainfall-

- Excess: 20 per cent or more above normal
- Normal: 19 per cent above normal - 19 per cent below normal
- Deficient: 20 per cent below normal - 59 per cent below normal
- Scanty: 60 per cent or more below normal

(ii) Hydrological drought: A marked depletion of surface water causing very low stream flow and drying of lakes, rivers and reservoirs

(iii) Agricultural drought: Inadequate soil moisture resulting in acute crop stress and fall in agricultural productivity

(iv) Economic drought: Type of drought when a period of below-average precipitation of sufficient magnitude to have substantial impacts on the local and regional economy.



Drought consequences

- During the year (2001-02), 19 per cent of India's land area experienced 'moderate drought' ; 10 per cent suffered 'severe drought'
- Rainfall in July (most important for agriculture) was 49 per cent 'deficient'. The last time this figure fell below 45 per cent was in 1911
- When there is more than 10 per cent rainfall deficiency, and more than 20 per cent of the area of the country is under drought, the situation is called "all-India drought"
- In 2002, rainfall deficiency was 19 and 29 per cent of India was under drought.

Meteorological Sub-Division	Rainfall (% below normal)
SEVERE DROUGHT	
West Rajasthan	-71
East Rajasthan	-60
MODERATE DROUGHT	
Haryana	-36
Chandigarh	-36
Delhi	-36
Punjab	-36
Coastal Andhra Pradesh	-26
Rayalseema	-33
North Interior Karnataka	-31
South Interior Karnataka	-44
Coastal Karnataka	-30
Tamil Nadu	-45
Kerala	-35
Lakshadweep	-45

Source: Down to Earth, January 15, 2003

Drought 2000-2001

During the drought of 2000-2001, a total of eight states have fallen foul of the rain gods. These included Gujarat, Madhya Pradesh, Orissa, Rajasthan, Chattisgarh, Himachal Pradesh, Maharashtra and Tehri Garhwal districts in Uttaranchal. Some states were in their second, or third consecutive year of drought.

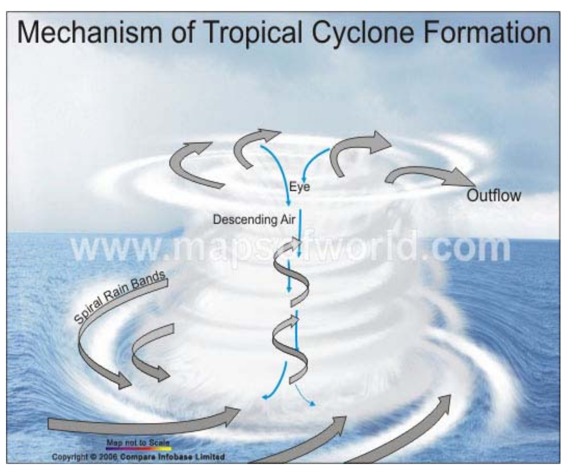
Frightening figures: States hit by drought

- Chhattisgarh: 10,252 villages in 12 of 16 districts, 9,400,000 people affected.
- Gujarat: 12,240 villages in 22 of 25 districts, 29,100,000 people, 107,00,000 cattle.
- Madhya Pradesh: 22,490 villages in 32 of 45 districts, 12,700,000 people, 8,570,000 cattle.
- Orissa: 15,000 villages in 28 of 30 districts, 11900,000 people, 39900,000 cattle.
- Rajasthan: 31,000 villages in 31 of 32 districts, 33,000,000 people, 39,900,000 cattle.
- Himachal Pradesh: All 12 districts affected, 4600,000 people, 88,000 hectare of crop area.
- Maharashtra: 20,000 villages in 26 of 35 districts, 45,500,000 people, 258,000 cattle.
- Uttaranchal: One district affected.

In the 70 important water reservoirs in India, the storage position is officially described as the lowest in a decade. Ground water levels have fallen considerably in the eight drought hit states. In a number of districts, says the nodal agriculture ministry, the fall in water levels is at the rate of over 2 meters a year- this includes eight districts in Chattisgarh, 13 in Gujarat, 30 in Madhya Pradesh, 18 in Orissa and 15 in Rajasthan.

5. Cyclone: In meteorology, a **cyclone** is an area of closed, circular fluid motion rotating

Cyclone Catarina (March 26, 2004)



Cyclone Formation

in the same direction as the Earth. This is usually characterized by inward spiraling winds that rotate counter clockwise/anti clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere of the Earth.

A **tropical cyclone** is a storm system characterized by a low pressure center and numerous thunderstorms that produce strong winds and flooding rain. A tropical cyclone feeds on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air.

The practice of giving storms people's names was introduced by Clement Lindley Wragge, an Anglo-Australian meteorologist at the end of the 19th century. He used female names, the names of politicians who had offended him, and names from history and mythology. During World War II, tropical cyclones were given feminine names, mainly for the convenience of forecasters and in a somewhat adhoc manner. In addition, GR Stewart's 1941 novel *Storm* helped to popularize the concept of giving names to tropical cyclones.

LIST 1	LIST 2	LIST 3	LIST 4
2001	2002	2003	2004
2005	2006	2007	2008
2009	2010	2011	2012
2013	2014	2015	2016

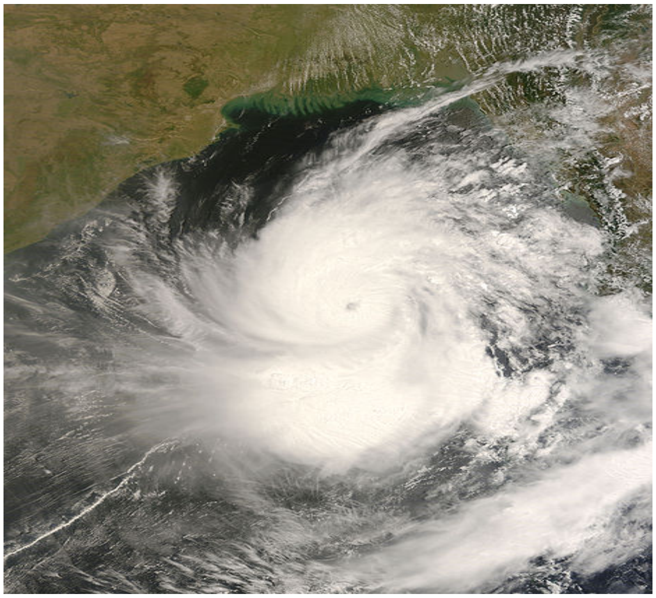
Northern Indian Ocean Names

LIST 1	LIST 2	LIST 3	LIST 4
Onil	Ogni	Nisha	Giri
Agni	Akash	Bijli	Jal
Hibaru	Gonu	Aila	Keila
Pyarr	Yemyin	Phyan	Thane
Baaz	Sidr	Ward	Murjan
Fanoos	Nargis	Laila	Nilam
Mala	Abe	Bandu	Mahasen
Mukda	Khai Muk	Phet	Phailin

Experience shows that the use of short, distinctive given names in written as well as spoken communications is quicker and less subject to error than the older more cumbersome latitude-longitude identification methods. These advantages are especially important in exchanging detailed storm information between hundreds of widely scattered stations, coastal bases, and ships at sea.

http://www.nhc.noaa.gov/aboutnames.shtml

Cyclone Nargis (***01B):*** Also known as **Very Severe Cyclonic Storm Nargis**, was a strong tropical cyclone that caused the worst natural disaster in the recorded history of Burma (Myanmar). The cyclone made landfall in the country on May 2, 2008, causing catastrophic destruction and at least 138,000 fatalities. The Labutta Township *alone* was reported to have 80,000 dead, with about 10,000 more deaths in Bogale. There were around 55,000 people missing and many other deaths were found in other towns and areas, although the Burmese government's official death toll may have been underreported, and there have been allegations that they stopped updating the death-toll after 138,000 to minimize political fallout. The feared 'second wave' of fatalities from disease and lack of relief efforts never materialized. Damage was estimated at over



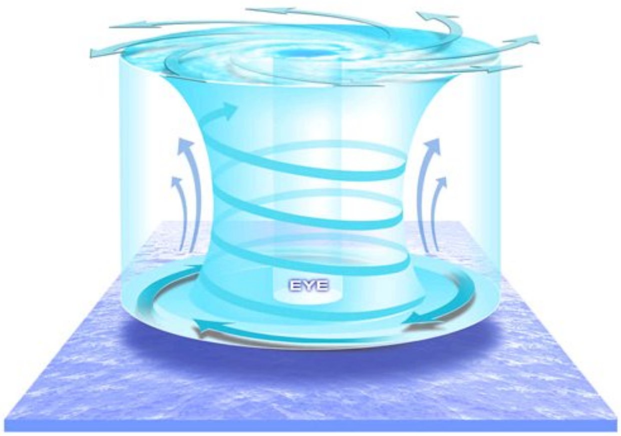
Formed	April 27, 2008
Dissipated	May 3, 2008
Highest winds	165 km/h) 215 km/h)
Lowest pressure	962 mbar (hPa; 28.41 inHg)
Fatalities	138,366 total
Damage	$10 billion USD
Areas affected	Bangladesh, Burma, India, Sri Lanka

Cyclone 'Nargis' on May 1, 2008

$10 billion (USD), which made it the most damaging cyclone ever recorded in this basin.

6. Anticyclone: An **anticyclone** (opposite to a cyclone) is a weather phenomenon defined as 'A large-scale circulation of winds around a central region of high atmospheric pressure, clockwise in the Northern Hemisphere, counterclockwise in the Southern Hemisphere'.

Effects of surface-based anticyclones include clearing skies as well as cooler, drier air. Fog can also form overnight within a region of higher pressure. Surface anticyclones form due to downward motion through the troposphere, the atmospheric layer where weather occurs.



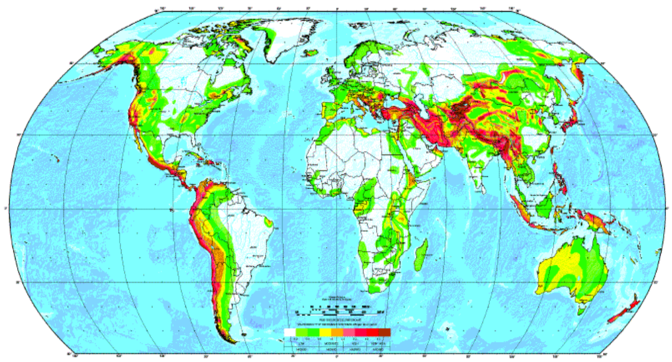
Anti Cyclone

Calm weather

Calm weather and dry conditions are the hallmarks of an anticyclone -- a weather phenomenon which most people probably know better as a "high pressure area." These zones of generally soothing conditions are created by dry air masses. Dry air is heavier than a similar volume of wet air, so it tends to sink and compress, forming an area of high pressure. The fact that that air is sinking means that winds flow outwards from the high pressure area's center at ground level, where the Earth's surface itself prevents the heavy, dry air from sinking any more. These winds spiral outwards in a clockwise direction in the northern hemisphere and in a counterclockwise pattern in the south, due to the effects of the earth's spin.

7. Earthquake: An earthquake makes the ground move or shake. Earthquakes are usually caused when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake. When two blocks of rock or two plates are rubbing against each other, they stick a little. They don't just slide smoothly; the rocks catch on each other. The rocks are still pushing against each other, but not moving. After a while, the rocks break because of all the pressure that's built up. When the rocks break, the earthquake occurs. During the earthquake and afterward, the plates or blocks of rock start moving, and they continue to move until they get stuck again. The spot underground where the rock breaks is called the **focus** of the earthquake.

Earthquake Devastation



Global Seismic Risk Map

The place right above the focus (on top of the ground) is called the **epicenter** of the earthquake. These natural events can cause massive damage and destruction. The study of earthquakes is called seismology. The epicenter is the point on the surface where the earthquake is the strongest. The Richter scale is used to measure the amount of energy released by the earthquake. The severity of an earthquake runs from 0 to 9 on this scale. Small tremors occur constantly, but every few months a major earthquake occurs somewhere in the world. Scientists are researching ways to predict earthquakes, but their predictions are not always accurate.

Main shock, foreshocks and aftershocks

A large earthquake is generally preceded and followed by many smaller shocks. The largest earthquake is called the main shock. The smaller ones that precede the main shock are called foreshocks and the subsequent shocks are called aftershocks.

Earthquake swarms

The earthquake swarms are groups of earthquakes which are concentrated in a certain region, but none of them is significantly larger than the others.

Seismograph

Seismograph is the instrument for recording motions of the earth's surface caused by seismic waves, as a function of time. The simplest earthquake recording system consists of a sensor and an analog or digital recorder. The record is known as a seismogram. Location and magnitude of an earthquake are calculated from seismograms.

Intensity

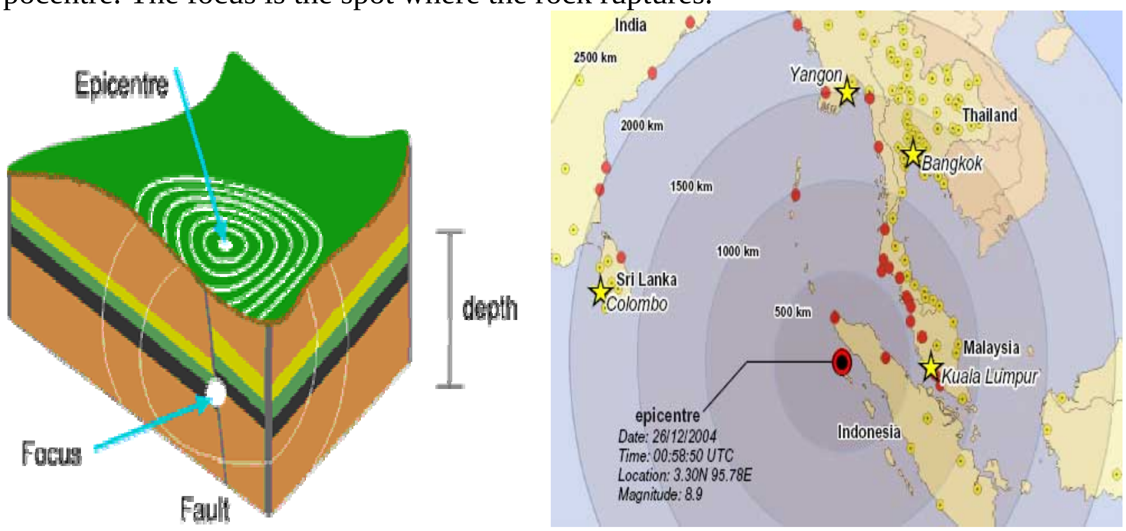
Intensity is description of the effects of an earthquake at a particular place, based on observations of damage, using a descriptive scale like the Modified Mercalli Scale. A map showing intensities at individual locations may be contoured based on isoseismals, which are lines of equal intensity. An isoseismal map provides a representation of broad variations of shaking over the region surrounding the earthquake.

Magnitude

Magnitude is a measure of the size of the earthquake, calculated from the amplitude of the seismic waves and is closely related to the energy released by the earthquake. If the magnitude increases by 1, then the energy is about 30 times larger; if it increases by 2, then the energy is about 900 times. Richter magnitude, surface-wave and body-wave magnitudes are commonly used to indicate this measure. Duration or coda- magnitude based on the duration of the seismic signal is also in use.

Hypocentre and epicenter

The place on the earth's surface vertically above the origin of the earthquake and is identified by geographic coordinates. Where the earthquake began is called the focus of hypocentre. The focus is the spot where the rock ruptures.



Earthquake's Epicenter

The MSK (Medvedev-Sponheuer-Karnik) intensity broadly associated with the various seismic zones is VI (or less), VII, VIII and IX (and above) for Zones 2, 3, 4 and 5, respectively, corresponding to Maximum Considered Earthquake (MCE).

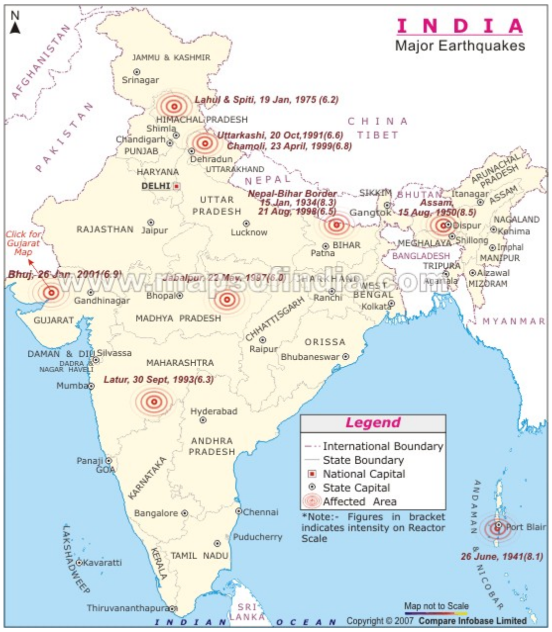
Zone 5: It covers the areas with the highest risk zone that suffers earthquakes of intensity MSK IX or greater. The state of Kashmir, Punjab, the western and central Himalayas, the North-East Indian region and the Rann of Kutch fall in this zone.

Zone 4: This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The Indo-Gangetic basin and the capital of the country (Delhi, Jammu)and Bihar fall in Zone 4.

Delhi prone areas - The areas which are near to Yamuna bank are very much prone to the earthquake. East delhi is the most earthquake prone area. Some areas are- Shahdara, Mayur Vihar - I, II, III, Laxmi Nagar and nearby areas, Gurgaon, Rewari, NOIDA.

Zone 3: The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII.

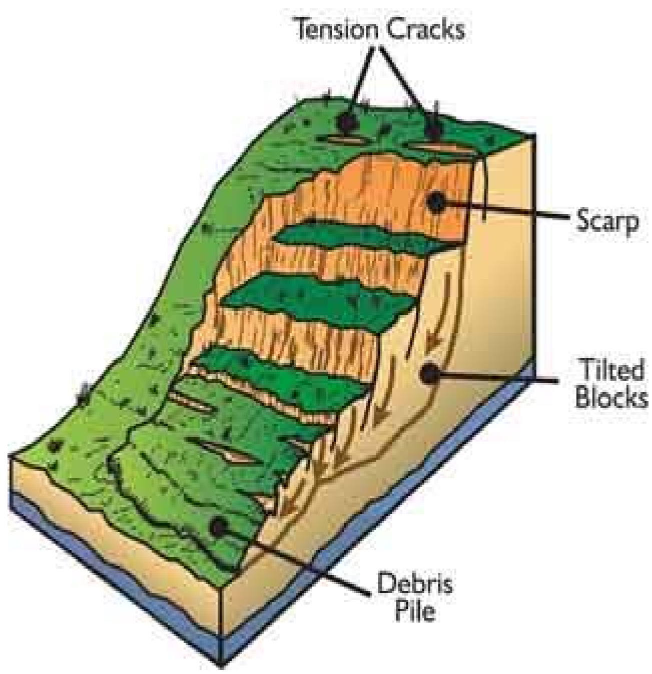
Zone 2: This region is liable to MSK VI or less and is classified as the Low Damage Risk Zone.



India's major Earthquake

Seismic Zonation map of India

8. Landslide: Landslide is defined as the mass movement of rock, debris or earth down a slope and have come to include a broad range of motions whereby falling, sliding and flowing under the influence of gravity remove earth material. They often take place in combination with earthquakes, floods and volcanoes. At times, prolonged rainfall causing heavy blockade of the flow or river for quite some time. The formation of river blocks can cause havoc to the settlements downstream on it's bursting.
In the hilly terrain of India including the Himalayas, landslides have been a major and widely spread natural disaster the often strike life and property and occupy a position of major concern.



Land slide

One of the worst tragedies took place at Malpa Uttarkhand on 11th and 17th August 1998 when nearly 380 people were killed when massive landslides washed away the entire village. This included 60 pilgrims going to Lake Mansarovar in Tibet. Consequently various land reform measures have been initiated as mitigation measures. The two regions most vulnerable to landslides are the Himalayas and the Western Ghats. The Himalayas mountain belt comprise of tectonically unstable younger geological formations subjected to severe seismic activity. The Western Ghats and nilgiris are geologically stable but have uplifted plateau margins influenced by neo- tectonic activity. Compared to Western Ghats region, the slides in the Himalayas region are huge and massive and in most cases the overburden along with the underlying litho logy is displaced during sliding particularly due to the seismic factor.

Causes of Landslides

Landslides can be caused by poor ground conditions, geomorphic phenomena, and natural physical forces and quite often due to heavy spells of rainfall coupled with impeded drainage.

Ground Causes: May be due to Weak, sensitivity, or weathered materials, adverse ground structure (joints, fissures etc.), physical property variation (permeability, plasticity etc)

Morphological Causes: Ground uplift (volcanic, tectonic etc), Erosion (wind, water) etc, Vegetation removal (by forest fire, drought etc)

Physical Causes: Prolonged precipitation, Rapid draw- down, Earthquake, Volcanic eruption, Thawing, Shrink and swell, Artesian pressure (mud slides, Leh, Palampur

9. Mudslide: A **mudslide** is the most rapid (up to 80 km/h, or 50 mph) and fluid type of downhill mass wasting. It is a rapid movement of a large mass ofmud formed from loose soil and water. Similar terms are **mudflow**, **mud stream**, **debris flow.** Heavy rainfall, snowmelt, or high levels of ground water flowing through cracked bedrock may trigger a movement of soil or sediments. Floods, debris- and mud flows may also occur when strong rains on hill or mountain slopes cause extensive erosion.

Avalanches,

10. Avalanche: An **avalanche** is a rapid flow of snow down a slope, from either natural

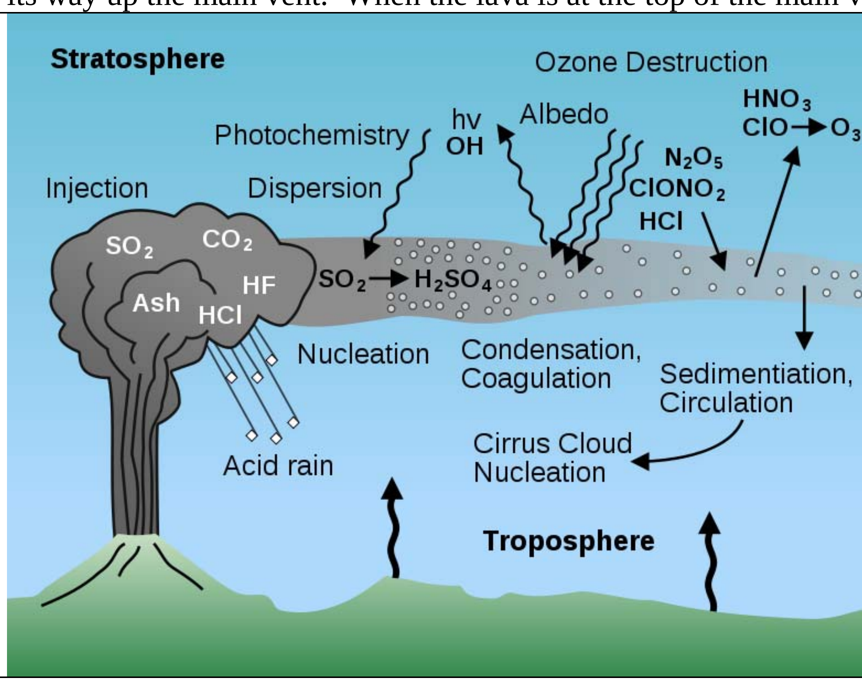
Avalanche in the Himalayas near Mount Everest

triggers or human activity. Typically occurring in mountainous terrain, an avalanche can mix air and water with the descending snow. Powerful avalanches have the capability to entrain ice, rocks, trees, and other material on the slope. Avalanches are primarily composed of flowing snow, and are distinct from mudslides, rock slides etc and collapses on an icefall. In mountainous terrain avalanches are among the most serious objective hazards to life and property, with their destructive capability resulting from their potential to carry an enormous mass of snow rapidly over large distances.

11. Volcanic eruptions: A **volcano** is an opening, or rupture, in a planet's surface or crust, which allows hot magma, ash and gases to escape from below the surface. Volcanoes are generally found where tectonic plates are diverging or converging.

An eruption begins when pressure on a magma chamber forces magma up through the conduit and out the volcano's vents. When the magma chamber has been completely filled, the type of eruption partly depends on the amount of gases and silica in the magma. The amount of silica determines how **sticky** (level of viscosity) the magma is and **water** provides the explosive potential of **steam**.

The way volcanoes erupt usually takes a long time. First a volcano makes something called magma from melted rock. The magma goes through a circulation. It has to form at the bottom of the volcano and then start its way up the main vent. The main vent is a hole that is in the volcano and when the volcano is ready to erupt the lava is at the top of the main vent. The magma goes up the main vent slowly while it is still getting hotter. When the magma is about half way up the main vent it turns into lava. Lava is a very hot liquid which burns the remaining rocks from the magma. The lava slowly continues up the main vent. While going up the lava continues to get hotter and hotter. Ash and rocks are collected and the lava is getting hotter and hotter while the lava is continuing its way up the main vent. When the lava is at the top of the main vent the



Volcanic Injection

volcano erupts. The lava blasts out of the volcano along with ash, rocks, and a cloud of dust that is very thick. The ash and rock crumble to the ground, but the lava is either moving down the volcano side very slowly or at a high speed. The lava burns down almost everything in its way, and it sometimes leaves bits of things burning. The lava from the volcano can cool fast, or sometimes the lava will slowly cool down from its intense heat. Lava that cools slowly forms igneous rocks. There are many types of igneous rocks. Volcanoes can damage themselves in the explosion. A volcano literally blows its top off. One of the volcanoes that has blown its top from an explosion is Mt. St. Helens. Mt. St. Helens has erupted more than once. Volcanoes can be under water or on land. Volcanoes that are under water take a longer time than if they are on land because they are under water the water slows down the magma and lava but if the volcano is on land the lava and magma can move quicker up the main vent. It just depends on the environment how fast the volcano can make the magma the magma makes lava and the volcano makes an explosion. If the volcano is under water the cooled lava will probably make an island. The Hawaiian Islands is an example of island made by a chain of volcanoes. Now go back to the front page of our site and go to a different page on our site and of course be prepared to learn more about volcanoes.

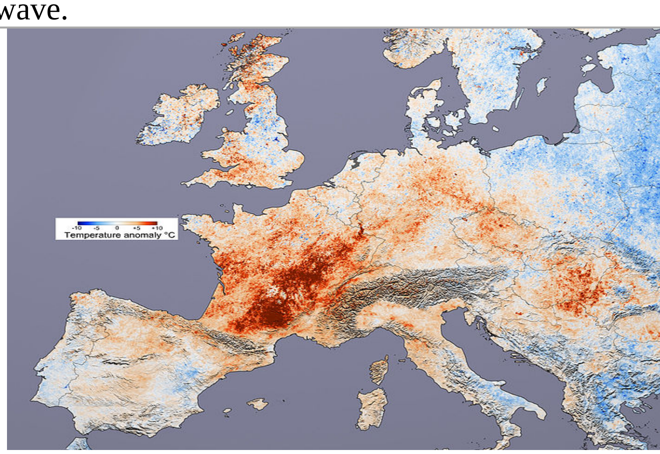
There are active, dormant, and extinct volcanoes in India viz., Barren Island (erupted in 2009), Baratang (erupted in 2005) and Narcondam in Andaman Islands.

12 Heat 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 a heat wave in a cooler area if they are outside the normal climate pattern for that area.

The definition recommended by the World Meteorological Organization (WMO) is when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5^0C, the normal period being 1961–1990.

In the Netherlands, a heat wave is defined as period of at least 5 consecutive days in which the maximum temperature in De Bilt exceeds 25°C, provided that on at least 3 days in this period the maximum temperature in De Bilt exceeds 30°C. Same criteria of heat wave are also used in Belgium and Luxembourg.

In the summer in warm climates, 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.



European Heat Wave 2003

In India, a scorching heat wave swept most parts of North India around **20th June 2010** with high humidity posing problems for citizens as Phalodi in Rajasthan baked at 46.5 °C. In the desert State of Rajasthan, the temperature crossed the 45°C mark at many places. Phalodi was the hottest place at 46.5°C followed by Kota at 46.3°C. Sriganganagar, Barmer and Churu recorded a maximum of 46.2, 46 and 45.9°C, respectively while the high in Jaisalmer and Jodhpur settled at 45°C each. The heat wave also gripped Haryana, Punjab and the Union Territory of Chandigarh as Hisar was hottest in the region at 45.8°C, 5°C above normal.

Climate change promises to bring with it longer, hotter summers to many places on the planet. The June, 2010 turned out to be the fourth-hottest month ever recorded globally. With more heat waves on the horizon, the risk of heat-related health problems increased many fold. These heat waves may cause exhaustion, a relatively common reaction to severe heat and can include symptoms such as dizziness, headache and fainting. Heat stroke is more severe and requires medical attention—it is often accompanied by dry skin, a body temperature above 103°F, confusion and sometimes unconsciousness and may prove fatal.

13. Cold wave: A **cold wave** is a weather phenomenon that is distinguished by a cooling of the air. A cold wave is a rapid fall in temperature within a 24 hour period requiring substantially increased protection to agriculture, industry, commerce, and social activities. The precise criterion for a cold wave is determined by the rate at which the temperature falls, and the minimum to which it falls. This minimum temperature is dependent on the geographical region and time of year.

Effects: A cold wave can cause death and injury to livestock and wildlife. Exposure to cold mandates greater caloric intake for all animals, including humans, and if a cold wave is accompanied by heavy and persistent snow, grazing animals may be unable to reach needed food and die of hypothermia or starvation. They often necessitate the purchase of foodstuffs at considerable cost to farmers to feed livestock.

Extreme winter cold often causes poorly insulated water pipelines and mains to freeze. Even some poorly-protected indoor plumbing ruptures as water expands within them, causing much damage to property and costly insurance claims. Demand for electrical power and fuels rises dramatically during such times, even though the generation of electrical power may fail due to the freezing of water necessary for the generation of hydroelectricity. Some metals may become fragile at low temperatures. Motor vehicles may fail as antifreeze fails and motor oil gels, resulting even in the failure of the transportation system.

14. Climatic Change: Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole Earth.

The term sometimes is used to refer specifically to climate change caused by human activity; for example, the United Nations Framework Convention on Climate Change (UNFCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." In the latter sense climate change is synonymous with global warming.

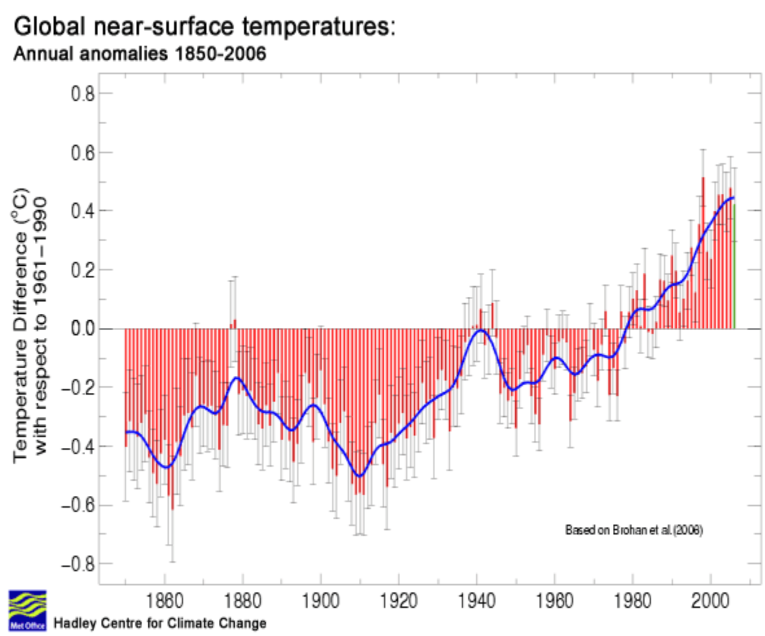
Human influences

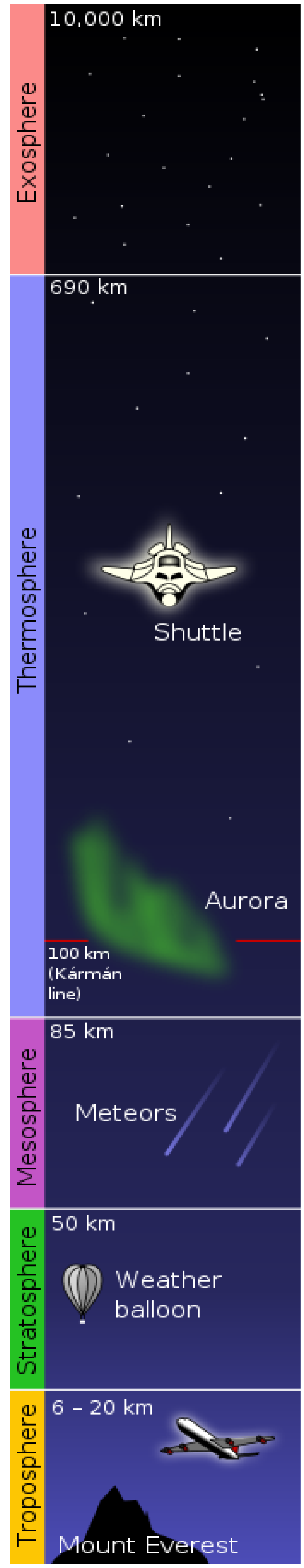
Anthropogenic factors are human activities that change the environment. Various hypotheses for human-induced climate change have been argued for many years. Presently the scientific consensus on climate change is that human activity is very likely the cause for the rapid increase in global average temperatures over the past several decades. Consequently, the debate has largely shifted onto ways to reduce further human impact and to find ways to adapt to change that has already occurred.

Of most concern in these anthropogenic factors is the increase in CO_2 levels due to emissions from fossil fuel combustion, followed by aerosols (particulate matter in the atmosphere) and cement manufacture. Other factors, including land use, ozone depletion, animal agriculture and deforestation, are also of concern in the roles they play - both separately and in conjunction with other factors - in affecting climate, microclimate, and measures of climate variables.

15. Global warming: Global warming is the increase in the average temperature of Earth's near-surface air and oceans since the mid 20th century and its projected continuation. According to the 2007 Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), global surface temperature increased 0.74 ± 0.18 °C during the 20th century. Most of the observed temperature increase since the middle of the 20th century was caused by increasing concentrations of greenhouse gases, which results from human activity such as the burning of fossil fuel and deforestation. Global dimming, a result of increasing concentrations of atmospheric aerosols that block sunlight from reaching the surface, has partially countered the effects of greenhouse gas induced warming.

Climate model projections summarized in the latest IPCC report indicate that the global surface temperature is likely to rise a further 1.1 to 6.4°C during the 21st century. The uncertainty in this estimate arises from the use of models with differing sensitivity to greenhouse gas concentrations and the use of differing estimates of future greenhouse gas emissions. An increase in global temperature will cause sea levels to rise and will change





Earth's atmosphere can be divided into five main layers. These layers are mainly determined by whether temperature increases or decreases with altitude. From highest to lowest, these layers are:

Exosphere: The outermost layer of Earth's atmosphere extends from the exobase upward. Here the particles are so far apart that they can travel hundreds of kilometres without colliding with one another. The exosphere is mainly composed of hydrogen and helium.

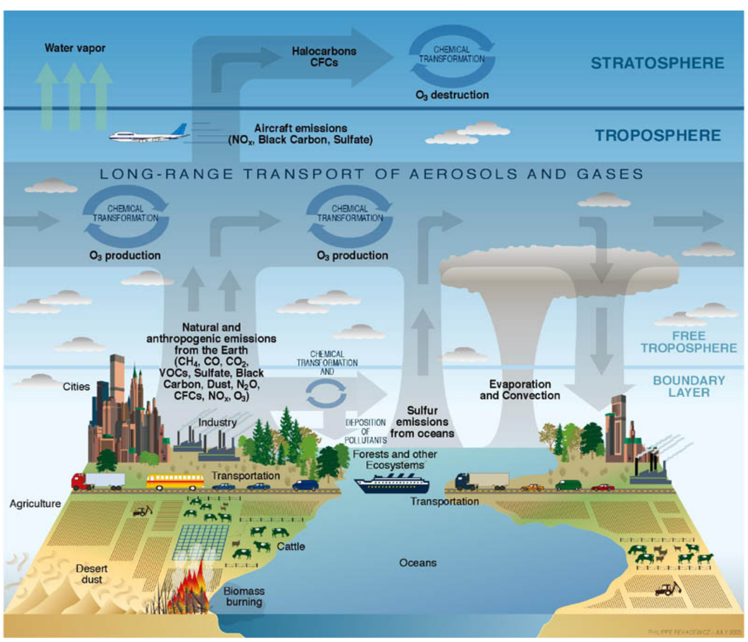
Thermosphere: Temperature increases with height in the thermosphere from the mesopause up to the thermopause, then is constant with height. The temperature of this layer can rise to 1500°C, though the gas molecules are so far apart that temperature in the usual sense is not well defined.

Mesosphere: The mesosphere extends from the stratopause to 80–85 km. It is the layer where most meteors burn up upon entering the atmosphere. Temperature decreases with height in the mesosphere. The mesopause, the temperature minimum that marks the top of the mesosphere, is the coldest place on Earth and has an average temperature around −85°C.

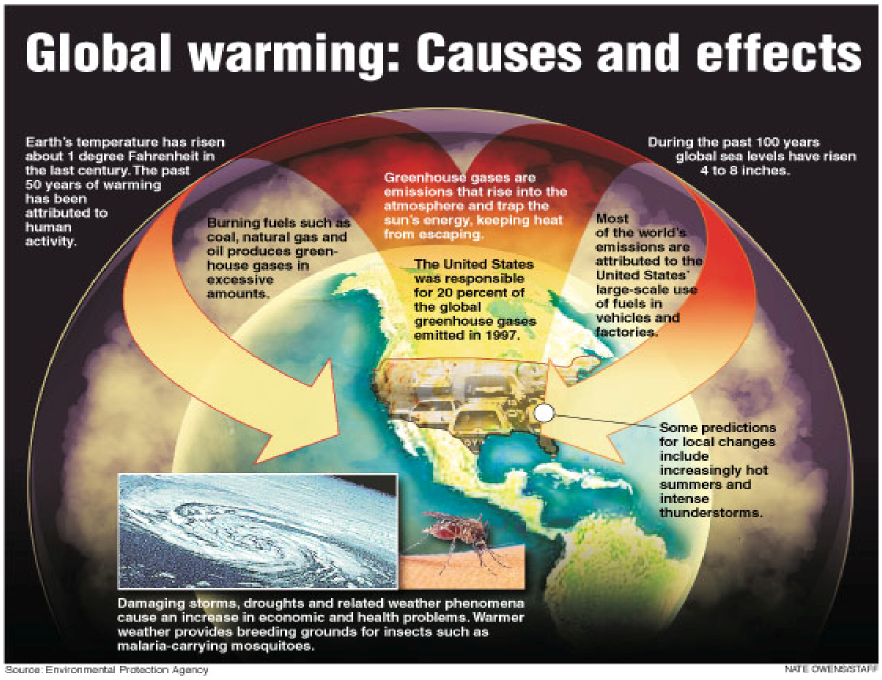
Stratosphere: The stratosphere extends from the tropopause to about 51 km. Temperature increases with height, which restricts turbulence and mixing. The stratopause, which is the boundary between the stratosphere and mesosphere, typically is at 50-55 km.

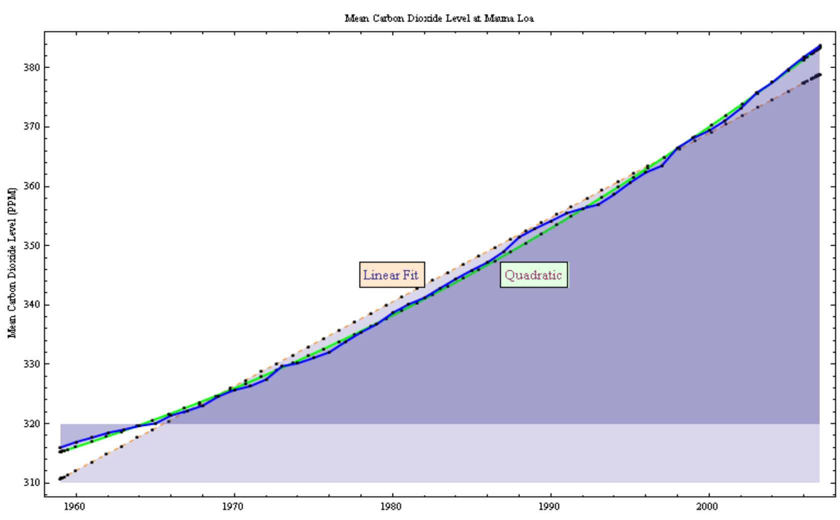
Troposphere: The troposphere begins at the surface and extends to between 7 km at poles and 17 km at equator. The troposphere is mostly heated by transfer of energy from the surface, so on average the lowest part of the troposphere is warmest and temperature decreases with altitude.

Dry air contains roughly (by volume) 78.09% Nitrogen, 20.95% Oxygen, 0.93% Argon, 0.039% Carbon dioxide, and small amounts of other gases. Air also contains a variable amount of Water vapor, on average around 1%.



Atmosphere structure

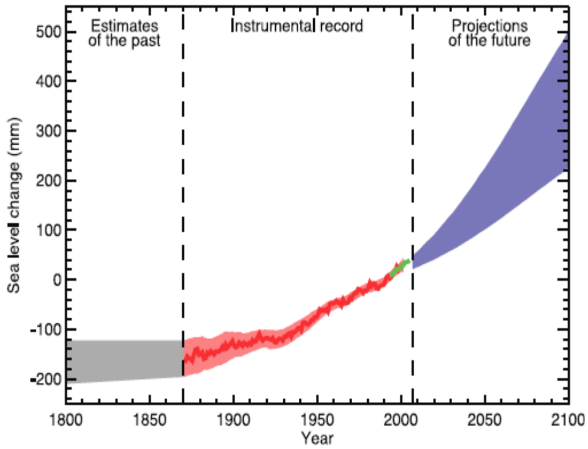




Mean CO_2 level at Mauna Loa

the amount and pattern of precipitation, probably including expansion of subtropical deserts. Warming is expected to be strongest in the Arctic and would be associated with continuing retreat of glaciers, permafrost and sea ice. Other likely effects include changes in the frequency and intensity of extreme weather events, species extinction , and changes in agricultural yields. Warming and related changes will vary from region to region around the globe, though the nature of these regional variations is uncertain. Another major worldwide concomitant of global warming, and one which is presently happening as well as being predicted to continue, is ocean acidification, which is likewise a result of contemporary increases in atmospheric carbon dioxide.

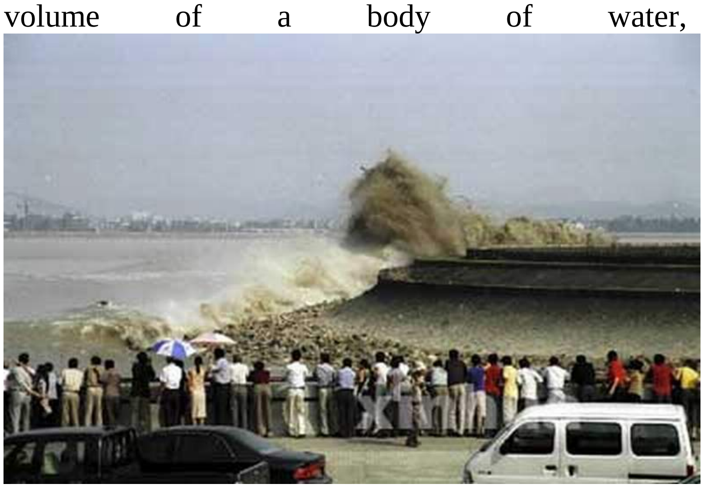
16. Sea Level rise: Current sea level rise has occurred at a mean rate of 1.8 mm per year for the past century, and more recently, during the satellite era of sea level measurement, at rates estimated near 2.8 ± 0.4 to 3.1 ± 0.7 mm per year (1993–2003). Current sea level

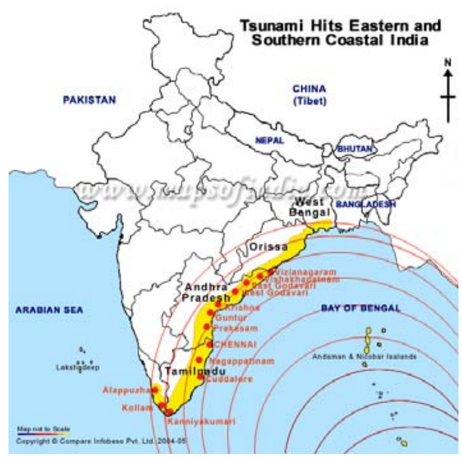


Sea level projections

rise is due significantly to global warming which will increase sea level over the coming century and longer periods. Increasing temperatures result in sea level rise by the thermal expansion of water and through the addition of water to the oceans from the melting of mountain glaciers, ice caps and ice sheets. At the end of the 20th century, thermal expansion and melting of land ice contributed roughly equally to sea level rise, while thermal expansion is expected to contribute more than half of the rise in the upcoming century. Values for predicted sea level rise over the course of this century typically range from 90 to 880 mm, with a central value of 480 mm. Models of glacier mass balance (the difference between melting and accumulation of snow and ice on a glacier) give a theoretical maximum value for sea level rise in the current century of 2 meters based on limitations on how quickly glaciers can melt.

17. Tsunami: A tsunami (Japanese word) tidal wave is a series of water waves (called a tsunami wave train caused by the displacement of a large volume of a body of water,





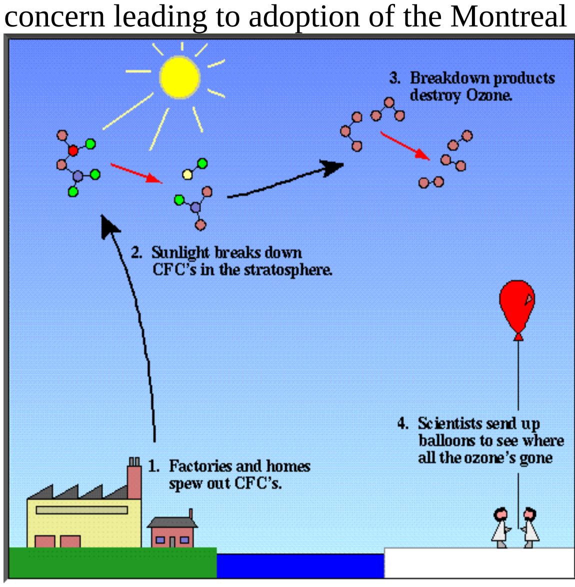
Tsunami waves

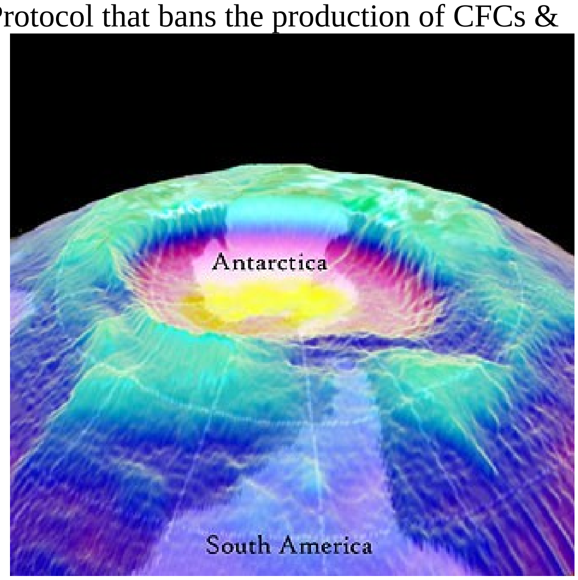
usually an ocean, but can occur in large lakes. Tsunamis are a frequent occurrence in Japan. Due to the immense volumes of water and energy involved, tsunamis can devastate coastal regions. Earthquakes, volcanic eruptions and other underwater explosions (including detonations of underwater nuclear devices), landslides and other mass movements meteorite ocean impacts or similar impact events, and other disturbances above or below water all have the potential to generate a tsunami.

18. Ozone Depletion: Ozone depletion describes two distinct, but related observations: a slow, steady decline of about 4%/decade in the total volume of ozone in Earth's stratosphere (the ozone layer) since the late 1970s, and a much larger, but seasonal, decrease in stratospheric ozone over Earth's polar regions during the same period. The latter phenomenon is commonly referred to as the **ozone hole**. In addition to this well-known stratospheric ozone depletion, there are also tropospheric ozone depletion events, which occur near the surface in polar regions during spring.

The detailed mechanism by which the polar ozone holes form is different from that for the mid-latitude thinning, but the most important process in both trends is catalytic destruction of ozone by atomic chlorine and bromine. The main source of these halogen atoms in the stratosphere is photodissociation of chlorofluorocarbon (CFC) compounds, commonly called freons, and of bromofluorocarbon compounds known as halons. These compounds are transported into the stratosphere after being emitted at the surface. Both ozone depletion mechanisms strengthened as emissions of CFCs and halons increased.

CFCs and other contributory substances are commonly referred as **ozone-depleting substances** (**ODS**). Since the ozone layer prevents most harmful UVB wavelengths (270–315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone have generated worldwide concern leading to adoption of the Montreal Protocol that bans the production of CFCs &





Ozone depletion

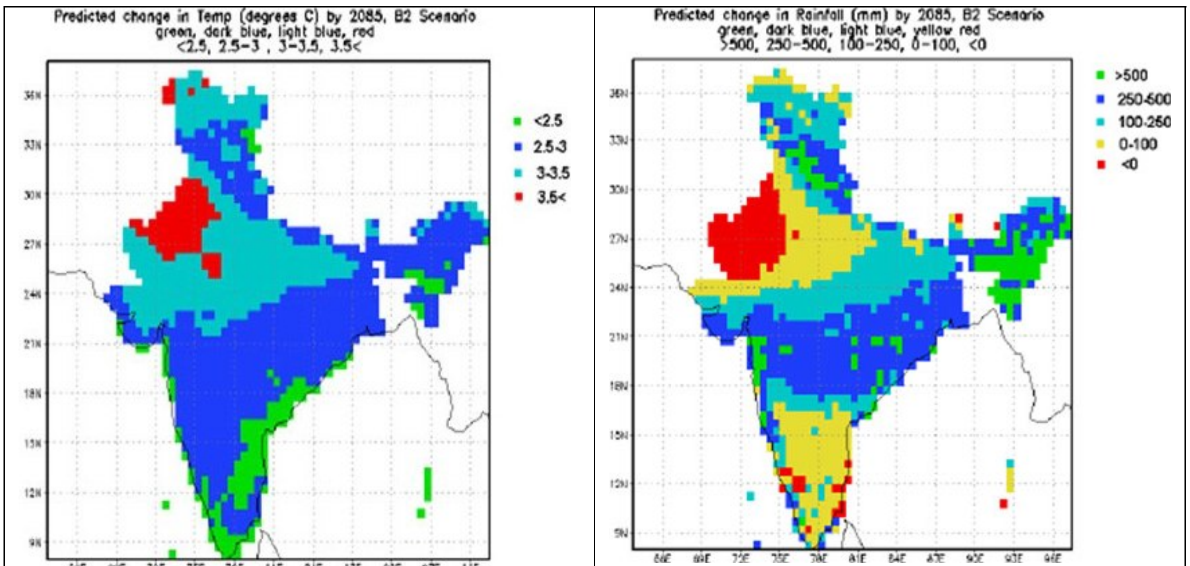
halons as well as related ozone depleting chemicals such as carbon tetrachloride and trichloroethane. It is suspected that a variety of biological consequences such as increases in skin cancer, cataracts damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

19. Climate change and India

Precisely at a time when India is confronted with development imperatives, we will also be severely impacted by climate change. Like other developing countries, several sections of the Indian populace will not be able to buffer themselves from impacts of global warming. With close economic ties to natural resources and climate-sensitive sectors such as agriculture, water and forestry, India may face a major threat and require serious adaptive capacity to combat climate change. As a developing country, India can little afford the risks and economic backlashes that industrialized nations can. With 27.5% of the population still below the poverty line, reducing vulnerability to the impacts of climate change is essential.

It is in India's interest to ensure that the world moves towards a low carbon future. Many studies have underscored the nation's vulnerability to climate change. With changes in key climate variables, namely temperature, precipitation and humidity, crucial sectors like agriculture and rural development are likely to be affected in a major way.

Impacts are already being seen in unprecedented heat waves, cyclones, floods, salinisation of the coastline and effects on agriculture, fisheries and health8. India is home to a third of the world's poor, and climate change will hit this section of society the hardest. Set to be the most populous nation in the world by 2045, the economic, social and ecological price of climate change will be massive.



Climate Change Projections in India

The future impacts of climate change, identified by the Government of India's National Communications (NATCOM) in 2004 include:

- Decreased snow cover, affecting snow-fed and glacial systems such as the Ganges and Bramhaputra. 70% of the summer flow of the Ganges comes from meltwater
- Erratic monsoon with serious effects on rain-fed agriculture, peninsular rivers, water and power supply
- Drop in wheat production by 4-5 million tones, with even a 1ºC rise in temperature

- Rising sea levels causing displacement along one of the most densely populated coastlines in the world, threatened freshwater sources and mangrove ecosystems
- Increased frequency and intensity of floods. Increased vulnerability of people in coastal, arid and semi-arid zones of the country
- Studies indicate that over 50% of India's forests are likely to experience shift in forest types, adversely impacting associated biodiversity, regional climate dynamics as well as livelihoods based on forest products.

Unit-II

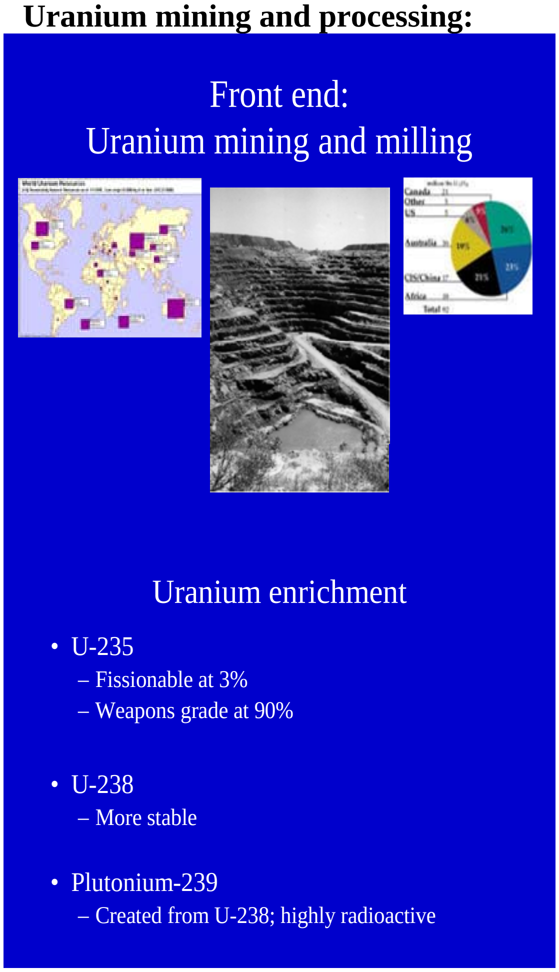
Man-made Disasters

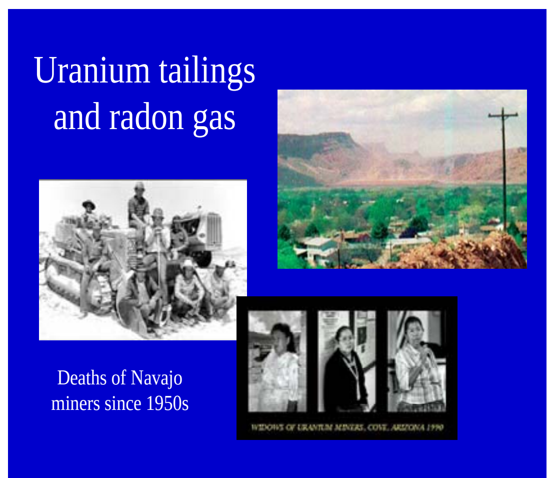
Disastrous event caused directly and principally by one or more identifiable deliberate or negligent human actions, also called human-made disaster. Man made disasters cover a wide range of events created largely due to accidents, negligence or sometimes even by human design, which result in huge loss of lives and property every year in South Asia. These include road, rail, river, marine and aviation accidents, oil spill, building and bridge collapse, bomb blast, industrial and chemical accidents etc. These also include the threats of nuclear, biological and chemical disasters.

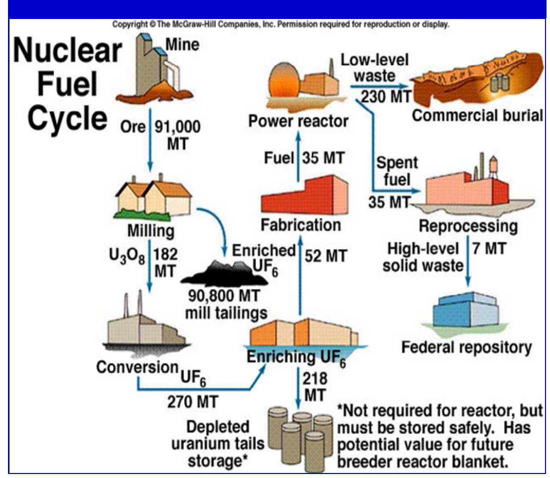
Nuclear disasters

Nuclear Threat: Nuclear threats are differentiated between military (caused by belligerent actions or civil war) and non- military causes.

Uranium mining and processing:







Radioactivity of plutonium

Life span of least
240,000 years

Last Ice Age glaciation
was 10,000 years ago

Neanderthal Man died out
30,000 years ago

Risks of enrichment and fuel fabrication

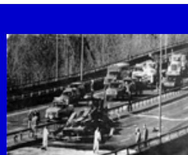
- Largest industrial users of water, electricity
  - Paducah, KY, Oak Ridge, TN, Portsmouth, OH
- Cancers and leukemia among workers
  - Fires and mass exposure.
  - Karen Silkwood at Oklahoma fabrication plant.
- Risk of theft of bomb material.

Risk of terrorism
(new challenge to industry)

9/11 jet
passed near
Indian Point

Back end: Radioactive wastes

- Low-level wastes in commercial facilities
- Spent fuel in pools or “dry casks” by plants
- Nuclear lab wastes
  - Hanford wastes leaked radiation into Columbia River
- High-level underground repository
  - Yucca Mountain in Nevada to 2037
  - Wolf River Batholith in Wisconsin after 2037?
  - Risks of cracks in bedrock, water seepage



Transportation risks

- Uranium oxide spills
- Fuel rod spills (WI 1981)
- Radioactive waste risks

Radioactive Waste Recycling

- Disposal of radioactive waste from nuclear power plants and weapons facilities by recycling it into household products.
- In 1996, 15,000 tons of metal were received by the Association of Radioactive Metal Recyclers . Much was recycled into products without consumer knowledge.
- Depleted Uranium munitions for military.

Summary

- Nuclear energy has no typical pollutants or greenhouse gasses
- Nuclear waste contains high levels of radioactive waste, which are active for hundreds of thousands of years.
- The controversy around nuclear energy stems from all parts of the nuclear chain.

Non-military causes

- accidents due to negligent handling or transportation of radioactive material
- accidents due to technical failure in industrial, scientific or medical facilities
- breakdown and crash of orbital satellites with nuclear inventory
- accidents in nuclear power stations, nuclear reconditioning plants and reconditioning points for nuclear fuel assembly
- of radioactive substances due to terrorism
- nuclear power station accidents due to natural hazards (earthquake) or aeroplane-crash
- improper storage of nuclear waste material

Military causes

- nuclear power station disasters caused by military operations
- liberation of radioactive material after accidents with nuclear weapon-systems
- detonation of nuclear strategic and tactical weapons

The implications of nuclear disasters are varied depending on the actual event and kind of liberated radioactive isotopes. Comparing explosions of nuclear weapons with atomic-reactor accidents one identifies different fall-out characteristics and therefore different assault-potential. Decontamination measures must be tailored accordingly.

Possible effects:

- contamination/death of large parts of the population and long term effects due to incorporation of radioactive material (fall-out)
- contamination of land, especially densely populated and agricultural regions
- contamination of food and drinking water
- necessary evacuations or population movements
- devastation and contamination of infrastructure
- area conflagration

Effects of Nuclear Weapons

The effects of nuclear weapons are classified as either initial or residual. Initial effects occur in the immediate area of the explosion and are hazardous in the first minute after the explosion. Residual effects can last for days or years and cause death. The principal initial effects are blast and radiation.

Blast

Defined as the brief and rapid movement of air away from the explosion's center and the pressure accompanying this movement. Strong winds accompany the blast. Blast hurls debris and personnel, collapses lungs, ruptures eardrums, collapses structures and positions, and causes immediate death or injury with its crushing effect.

Thermal Radiation

The heat and light radiation a nuclear explosion's fireball emits. Light radiation consists of both visible light and ultraviolet and infrared light. Thermal radiation produces extensive fires, skin burns, and flash blindness.

Nuclear Radiation

Nuclear radiation breaks down into two categories-initial radiation and residual radiation.

Initial nuclear radiation consists of intense gamma rays and neutrons produced during the first minute after the explosion. This radiation causes extensive damage to cells throughout the body. Radiation damage may cause headaches, nausea, vomiting, diarrhea, and even death, depending on the radiation dose received. The major problem in protecting yourself against the initial radiation's effects is that you may have received a lethal or incapacitating dose before taking any protective action. Personnel exposed to lethal amounts of initial radiation may well have been killed or fatally injured by blast or thermal radiation.

Residual radiation consists of all radiation produced after one minute from the explosion. It has more effect on you than initial radiation. A discussion of residual radiation takes place in a subsequent paragraph.

Types of Nuclear Bursts

There are three types of nuclear bursts—airburst, surface burst, and subsurface burst. The type of burst directly affects your chances of survival. A subsurface burst occurs completely underground or underwater. Its effects remain beneath the surface or in the immediate area where the surface collapses into a crater over the burst's location. Subsurface bursts cause you little or no radioactive hazard unless you enter the immediate area of the crater. No further discussion of this type of burst will take place.

An airburst occurs in the air above its intended target. The airburst provides the maximum radiation effect on the target and is, therefore, most dangerous to you in terms of *immediate* nuclear effects.

A surface burst occurs on the ground or water surface. Large amounts of fallout result, with serious long-term effects for you. This type of burst is your *greatest* nuclear hazard.

Nuclear Injuries

Most injuries in the nuclear environment result from the initial nuclear effects of the detonation. These injuries are classed as blast, thermal, or radiation injuries. Further radiation injuries may occur if you do not take proper precautions against fallout. Individuals in the area near a nuclear explosion will probably suffer a combination of all three types of injuries.

Blast Injuries

Blast injuries produced by nuclear weapons are similar to those caused by conventional high-explosive weapons. Blast overpressure can produce collapsed lungs and ruptured internal organs. Projectile wounds occur as the explosion's force hurls debris at you. Large pieces of debris striking you will cause fractured limbs or massive internal injuries. Blast over-pressure may throw you long distances, and you will suffer severe injury upon impact with the ground or other objects. Substantial cover and distance from the explosion are the best protection against blast injury. Cover blast injury wounds as soon as possible to prevent the entry of radioactive dust particles.

Thermal Injuries

The heat and light the nuclear fireball emits causes thermal injuries. First-, second-, or third-degree burns may result. Flash blindness also occurs. This blindness may be permanent or temporary depending on the degree of exposure of the eyes. Substantial cover and distance from the explosion can prevent thermal injuries. Clothing will provide significant protection against thermal injuries. Cover as much exposed skin as possible before a nuclear explosion. First aid for thermal injuries is the same as first aid for burns. Cover open burns (second-or third-degree) to prevent the entry of radioactive particles. Wash all burns before covering.

Radiation Injuries

Neutrons, gamma radiation, alpha radiation, and beta radiation cause radiation injuries. Neutrons are high-speed, extremely penetrating particles that actually smash cells within your body. Gamma radiation is similar to X rays and is also a highly penetrating radiation. During the initial fireball stage of a nuclear detonation, initial gamma radiation and neutrons are the most serious threat. Beta and alpha radiation are radioactive particles normally associated with radioactive dust from fallout. They are short-range particles and you can easily protect yourself against them if you take precautions.

Residual Radiation

Residual radiation is all radiation emitted after 1 minute from the instant of the nuclear explosion. Residual radiation consists of induced radiation and fallout.

Induced Radiation

It describes a relatively small, intensely radioactive area directly underneath the nuclear weapon's fireball. The irradiated earth in this area will remain highly radioactive for an extremely long time. You should not travel into an area of induced radiation.

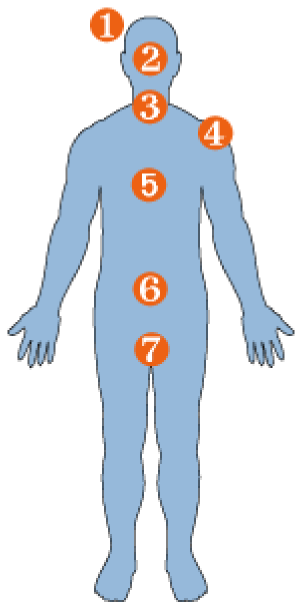
Fallout

Fallout consists of radioactive soil and water particles, as well as weapon fragments. During a surface detonation, or if an airburst's nuclear fireball touches the ground, large amounts of soil and water are vaporized along with the bomb's fragments, and forced upward to altitudes of 25,000 meters or more. When these vaporized contents cool, they can form more than 200 different radioactive products. The vaporized bomb contents condense into tiny radioactive particles that the wind carries and they fall back to earth as radioactive dust. Fallout particles emit alpha, beta, and gamma radiation. Alpha and beta radiation are relatively easy to counteract, and residual gamma radiation is much less intense than the gamma radiation emitted during the first minute after the explosion. Fallout is your most significant radiation hazard, provided you have not received a lethal radiation dose from the initial radiation.

Bodily Reactions to Radiation

The effects of radiation on the human body can be broadly classed as either chronic or acute. Chronic effects are those that occur some years after exposure to radiation. Examples are cancer and genetic defects. Chronic effects are of minor concern insofar as they affect your immediate survival in a radioactive environment. On the other hand, acute effects are of primary importance to your survival. Some acute effects occur within hours after exposure to radiation. These effects result from the radiation's direct physical damage to tissue. Radiation sickness and beta burns are examples of acute effects. Radiation sickness symptoms include nausea, diarrhea, vomiting, fatigue, weakness, and loss of hair. Penetrating beta rays cause radiation burns; the wounds are similar to fire burns.

Effects of Radiation on the Human Body:



Effects of radiation on the body

(1) **Hair**- The losing of hair quickly and in clumps occurs with radiation exposure at 200 rems or higher.

(2) **Brain**- Since brain cells do not reproduce, they won't be damaged directly unless the exposure is 5,000 rems or greater. Like the heart, radiation kills nerve cells and small blood vessels, and can cause seizures and immediate death.

(3) **Thyroid**- The certain body parts are more specifically affected by exposure to different types of radiation sources. The thyroid gland is susceptible to radioactive iodine. In sufficient amounts, radioactive iodine can destroy all or part of the thyroid. By taking potassium iodide, one can reduce the effects of exposure.

(4) **Blood System**- When a person is exposed to around 100 rems, the blood's lymphocyte cell count will be reduced, leaving the victim more susceptible to infection. This is often refered to as mild radiation sickness. Early symptoms of radiation sickness mimic those of flu and may go unnoticed unless a blood count is done. According to data from Hiroshima and Nagaski, show that symptoms may persist for up to 10 years and may also have an increased long-term risk for leukemia and lymphoma.

(5) **Heart**- Intense exposure to radioactive material at 1,000 to 5,000 rems would do immediate damage to small blood vessels and probably cause heart failure and death directly.
(6) **Gastrointestinal Tract**- Radiation damage to the intestinal tract lining will cause nausea, bloody vomiting and diarrhea. This is occurs when the victim's exposure is 200 rems or more. The radiation will begin to destroy the cells in the body that divide rapidly. These including blood, GI tract, reproductive and hair cells, and harms their DNA and RNA of surviving cells.
(7) **Reproductive Tract**- Because reproductive tract cells divide rapidly, these areas of the body can be damaged at rem levels as low as 200. Long-term, some radiation sickness victims will become sterile.

Recovery Capability

The extent of body damage depends mainly on the part of the body exposed to radiation and how long it was exposed, as well as its ability to recover. The brain and kidneys have little recovery capability. Other parts (skin and bone marrow) have a great ability to recover from damage. Usually, a dose of 600 centigrams (cgys) to the entire body will result in almost certain death. If only your hands received this same dose, your overall health would not suffer much, although your hands would suffer severe damage.

External and Internal Hazards

An external or an internal hazard can cause body damage. Highly penetrating gamma radiation or the less penetrating beta radiation that causes burns can cause external damage. The entry of alpha or beta radiation-emitting particles into the body can cause internal damage. The external hazard produces overall irradiation and beta burns. The internal hazard results in irradiation of critical organs such as the gastrointestinal tract, thyroid gland, and bone. A very small amount of radioactive material can cause extreme damage to these and other internal organs. The internal hazard can enter the body either through consumption of contaminated water or food or by absorption through cuts or abrasions. Material that enters the body through breathing presents only a minor hazard. You can greatly reduce the internal radiation hazard by using good personal hygiene and carefully decontaminating your food and water.

Symptoms

The symptoms of radiation injuries include nausea, diarrhea, and vomiting. The severity of these symptoms is due to the extreme sensitivity of the gastrointestinal tract to radiation. The severity of the symptoms and the speed of onset after exposure are good indicators of the degree of radiation damage. The gastrointestinal damage can come from either the external or the internal radiation hazard.

Countermeasures against Penetrating External Radiation

Knowledge of the radiation hazards discussed earlier is extremely important in surviving in a fallout area. It is also critical to know how to protect yourself from the most dangerous form of residual radiation—penetrating external radiation.

The means you can use to protect yourself from penetrating external radiation are time, distance, and shielding. You can reduce the level of radiation and help increase your chance of survival by controlling the duration of exposure. You can also get as far away from the radiation source as possible. Finally you can place some radiation-absorbing or shielding material between you and the radiation.

Time: Time is important to you, as the survivor, in two ways. First, radiation dosages are cumulative. The longer you are exposed to a radioactive source, the greater the dose you will receive. Obviously, spend as little time in a radioactive area as possible. Second, radioactivity decreases or decays over time. This concept is known as radioactive *half-life.* Thus, a radioactive element decays or loses half of its radioactivity within a certain time. The rule of thumb for radioactivity decay is that it decreases in intensity by a factor of ten for every sevenfold increase in time following the peak radiation level. For example, if a nuclear fallout area had a maximum radiation rate of 200 cgys per hour when fallout is complete, this rate would fall to 20 cgys per hour after 7 hours; it would fall still further to 2 cgys per hour after 49 hours. Even an untrained observer can see that the greatest hazard from fallout occurs immediately after detonation, and that the hazard decreases quickly over a relatively short time. As a survivor, try to avoid fallout areas until the radioactivity decays to safe levels. If you can avoid fallout areas long enough for most of the radioactivity to decay, you enhance your chance of survival.

Distance: Distance provides very effective protection against penetrating gamma radiation because radiation intensity decreases by the square of the distance from the source. For example, if exposed to 1,000 cgys of radiation standing 30 centimeters from the source, at 60 centimeters, you would only receive 250 cgys. Thus, when you double the distance, radiation decreases to $(0.5)^2$ or 0.25 the amount. While this formula is valid for concentrated sources of radiation in small areas, it becomes more complicated for large areas of radiation such as fallout areas.

Shielding: Shielding is the most important method of protection from penetrating radiation. Of the three countermeasures against penetrating radiation, shielding provides the greatest protection and is the easiest to use under survival conditions. Therefore, it is the most desirable method.

If shielding is not possible, use the other two methods to the maximum extent practical.

Shielding actually works by absorbing or weakening the penetrating radiation, thereby reducing the amount of radiation reaching your body. The denser the material, the better the shielding effect. Lead, iron, concrete, and water are good examples of shielding materials.

Special Medical Aspects: The presence of fallout material in your area requires slight changes in first aid procedures. You must cover all wounds to prevent contamination and the entry of radioactive particles. You must first wash burns of beta radiation, then treat them as ordinary burns. Take extra measures to prevent infection. Your body will be extremely sensitive to infections due to changes in your blood chemistry. Pay close attention to the prevention of colds or respiratory infections. Rigorously practice personal hygiene to prevent infections. Cover your eyes with improvised goggles to prevent the entry of particles.

Shelter

As stated earlier, the shielding material's effectiveness depends on its thickness and density. An ample thickness of shielding material will reduce the level of radiation to negligible amounts.

The primary reason for finding and building a shelter is to get protection against the high-intensity radiation levels of early gamma fallout as fast as possible. Five minutes to locate the shelter is a good guide. Speed in finding shelter is absolutely essential. Without shelter, the dosage received in the first few hours will exceed that received during the rest of a week in a contaminated area. The dosage received in this first week will exceed the dosage accumulated during the rest of a lifetime spent in the same contaminated area.

Shielding Materials: The thickness required to weaken gamma radiation from fallout is far less than that needed to shield against initial gamma radiation. Fallout radiation has less energy than a nuclear detonation's initial radiation. For fallout radiation, a relatively small amount of shielding material can provide adequate protection. Figure 23-1 gives an idea of the thickness of various materials needed to reduce residual gamma radiation transmission by 50 percent.

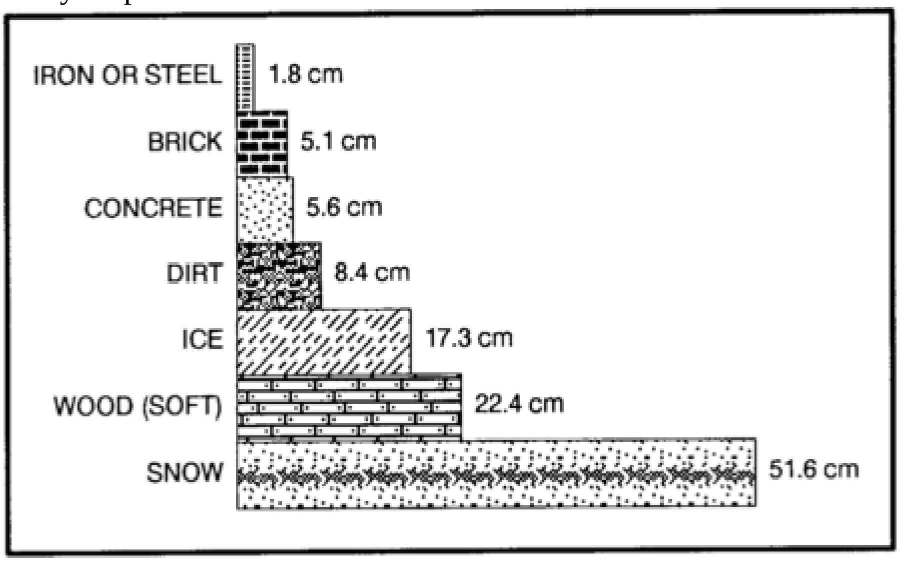


Figure 23-1. Thickness of materials to reduce gamma radiation.

The principle of *half-value layer thickness* is useful in understanding the absorption of gamma radiation by various materials. According to this principle, if 5 centimeters of brick reduce the gamma radiation level by one-half, adding another 5 centimeters of brick (another half-value layer) will reduce the intensity by another half, namely, to one-fourth the original amount. Fifteen centimeters will reduce gamma radiation fallout levels to one-eighth its original amount, 20 centimeters to one-sixteenth, and so on. Thus, a shelter protected by 1 meter of dirt would reduce a radiation intensity of 1,000 cgys per hour on the outside to about 0.5 cgy per hour inside the shelter.

Natural Shelters: Terrain that provides natural shielding and easy shelter construction is the ideal location for an emergency shelter. Good examples are ditches, ravines, rocky outcropping, hills, and river banks. In level areas without natural protection, dig a fighting position or slit trench.

Trenches: When digging a trench, work from inside the trench as soon as it is large enough to cover part of your body thereby not exposing all your body to radiation. In open country, try to dig the trench from a prone position, stacking the dirt carefully and evenly around the trench. On level ground, pile the dirt around your body for additional shielding. Depending upon soil conditions, shelter construction time will vary from a few minutes to a few hours. If you dig as quickly as possible, you will reduce the dosage you receive.

Other Shelters: While an underground shelter covered by 1 meter or more of earth provides the best protection against fallout radiation, the following unoccupied structures (in order listed) offer the next best protection:

- Caves and tunnels covered by more than 1 meter of earth.
- Storm or storage cellars.
- Culverts.
- Basements or cellars of abandoned buildings.
- Abandoned buildings made of stone or mud.

Roofs: It is not mandatory that you build a roof on your shelter. Build one only if the materials are readily available with only a brief exposure to outside contamination. If building a roof would require extended exposure to penetrating radiation, it would be wiser to leave the shelter roofless. A roof's sole function is to reduce radiation from the fallout source to your body. Unless you use a thick roof, a roof provides very little shielding.

You can construct a simple roof from a poncho anchored down with dirt, rocks, or other refuse from your shelter. You can remove large particles of dirt and debris from the top of the poncho by beating it off from the inside at frequent intervals. This cover will not offer shielding from the radioactive particles deposited on the surface, but it will increase the distance from the fallout source and keep the shelter area from further contamination.

Shelter Site Selection and Preparation: To reduce your exposure time and thereby reduce the dosage received, remember the following factors when selecting and setting up a shelter:

- Where possible, seek a crude, existing shelter that you can improve. If none is available, dig a trench.
- Dig the shelter deep enough to get good protection, then enlarge it as required for comfort.
- Cover the top of the fighting position or trench with any readily available material and a thick layer of earth, if you can do so without leaving the shelter. While a roof and camouflage are both desirable, it is probably safer to do without them than to expose yourself to radiation outside your fighting position.
- While building your shelter, keep all parts of your body covered with clothing to protect it against beta burns.
- Clean the shelter site of any surface deposit using a branch or other object that you can discard. Do this cleaning to remove contaminated materials from the area you will occupy. The cleaned area should extend at least 1.5 meters beyond your shelter's area.
- Decontaminate any materials you bring into the shelter. These materials include grass or foliage that you use as insulation or bedding, and your outer clothing (especially footgear). If the weather permits and you have heavily contaminated outer clothing, you may want to remove it and bury it under a foot of earth at the end of your shelter. You may retrieve it later (after the radioactivity decays) when leaving the shelter. If the clothing is dry, you may decontaminate it by beating or shaking it outside the shelter's entrance to remove the radioactive dust. You may use any body of water, even though contaminated, to rid materials of excess fallout particles. Simply dip the material into the water and shake it to get rid of the excess water. Do not wring it out, this action will trap the particles.
- If at all possible and without leaving the shelter, wash your body thoroughly with soap and water, even if the water on hand may be contaminated. This washing will remove most of the harmful radioactive particles that are likely to cause beta

burns or other damage. If water is not available, wipe your face and any other exposed skin surface to remove contaminated dust and dirt. You may wipe your face with a clean piece of cloth or a handful of uncontaminated dirt. You get this uncontaminated dirt by scraping off the top few inches of soil and using the "clean" dirt.

- Upon completing the shelter, lie down, keep warm, and sleep and rest as much as possible while in the shelter.
- When not resting, keep busy by planning future actions, studying your maps, or making the shelter more comfortable and effective.
- Don't panic if you experience nausea and symptoms of radiation sickness. Your main danger from radiation sickness is infection. There is no first aid for this sickness. Resting, drinking fluids, taking any medicine that prevents vomiting, maintaining your food intake, and preventing additional exposure will help avoid infection and aid recovery. Even small doses of radiation can cause these symptoms which may disappear in a short time.

Exposure Timetable: The following timetable provides you with the information needed to avoid receiving serious dosage and still let you cope with survival problems:

- Complete isolation from 4 to 6 days following delivery of the last weapon.
- A very brief exposure to procure water on the third day is permissible, but exposure should not exceed 30 minutes.
- One exposure of not more than 30 minutes on the seventh day.
- One exposure of not more than 1 hour on the eighth day.
- Exposure of 2 to 4 hours from the ninth day through the twelfth day.
- Normal operation, followed by rest in a protected shelter, from the thirteenth day on.
- In all instances, make your exposures as brief as possible. Consider only mandatory requirements as valid reasons for exposure. Decontaminate at every stop.

The **times** given above are conservative. If forced to move after the first or second day, you may do so, Make sure that the exposure is no longer than absolutely necessary.

Water Procurement

In a fallout-contaminated area, available water sources may be contaminated. If you wait at least 48 hours before drinking any water to allow for radioactive decay to take place and select the safest possible water source, you will greatly reduce the danger of ingesting harmful amounts of radioactivity.

Although many factors (wind direction, rainfall, sediment) will influence your choice in selecting water sources, consider the following guidelines.

Safest Water Sources: Water from springs, wells, or other underground sources that undergo natural filtration will be your safest source. Any water found in the pipes or containers of abandoned houses or stores will also be free from radioactive particles. This water will be safe to drink, although you will have to take precautions against bacteria in the water. Snow taken from 15 or more centimeters below the surface during the fallout is also a safe source of water.

Streams and Rivers: Water from streams and rivers will be relatively free from fallout within several days after the last nuclear explosion because of dilution. If at all possible, filter such water before drinking to get rid of radioactive particles. The best filtration method is to dig sediment holes or seepage basins along the side of a water source. The water will seep laterally into the hole through the intervening soil that acts as a filtering agent and removes the contaminated fallout particles that settled on the original body of water. This method can remove up to 99 percent of the radioactivity in water. You must cover the hole in some way in order to prevent further contamination.

Standing Water: Water from lakes, pools, ponds, and other standing sources is likely to be heavily contaminated, though most of the heavier, long-lived radioactive isotopes will settle to the bottom. Use the settling technique to purify this water. First, fill a bucket or other deep container three-fourths full with contaminated water. Then take dirt from a depth of 10 or more centimeters below the ground surface and stir it into the water. Use about 2.5 centimeters of dirt for every 10 centimeters of water. Stir the water until you see most dirt particles suspended in the water. Let the mixture settle for at least 6 hours. The settling dirt particles will carry most of suspended fallout particles to the bottom and cover them. You can then dip out the clear water. Purify this water using a filtration device.

Additional Precautions: As an additional precaution against disease, treat all water with water purification tablets from your survival kit or boil it.

Food Procurement

Although it is a serious problem to obtain edible food in a radiation-contaminated area, it is not impossible to solve. You need to follow a few special procedures in selecting and preparing rations and local foods for use. Since secure packaging protects your combat rations, they will be perfectly safe for use. Supplement your rations with any food you can find on trips outside your shelter. Most processed foods you may find in abandoned buildings are safe for use after decontaminating them. These include canned and packaged foods after removing the containers or wrappers or washing them free of fallout particles. These processed foods also include food stored in any closed container and food stored in protected areas (such as cellars), if you wash them before eating. Wash all food containers or wrappers before handling them to prevent further contamination.

If little or no processed food is available in your area, you may have to supplement your diet with local food sources. Local food sources are animals and plants.

Animals as a Food Source: Assume that all animals, regardless of their habitat or living conditions, were exposed to radiation. The effects of radiation on animals are similar to those on humans. Thus, most of the wild animals living in a fallout area are likely to become sick or die from radiation during the first month after the nuclear explosion. Even though animals may not be free from harmful radioactive materials, you can and must use them in survival conditions as a food source if other foods are not available. With careful preparation and by following several important principles, animals can be safe food sources.

First, do not eat an animal that appears to be sick. It may have developed a bacterial infection as a result of radiation poisoning. Contaminated meat, even if thoroughly cooked, could cause severe illness or death if eaten.

Carefully skin all animals to prevent any radioactive particles on the skin or fur from entering the body. Do not eat meat close to the bones and joints as an animal's skeleton contains over 90 percent of the radioactivity. The remaining animal muscle tissue, however, will be safe to eat. Before cooking it, cut the meat away from the bone, leaving at least a 3-millimeter thickness of meat on the bone. Discard all internal organs (heart, liver, and kidneys) since they tend to concentrate beta and gamma radioactivity.

Cook all meat until it is very well done. To be sure the meat is well done, cut it into less than 13-millimeter-thick pieces before cooking. Such cuts will also reduce cooking time and save fuel.

The extent of contamination in fish and aquatic animals will be much greater than that of land animals. This is also true for water plants, especially in coastal areas. Use aquatic food sources only in conditions of extreme emergency.

All eggs, even if laid during the period of fallout, will be safe to eat. Completely avoid milk from any animals in a fallout area because animals absorb large amounts of radioactivity from the plants they eat.

Plants as a Food Source: Plant contamination occurs by the accumulation of fallout on their outer surfaces or by absorption of radioactive elements through their roots. Your first choice of plant food should be vegetables such as potatoes, turnips, carrots, and other plants whose edible portion grows underground. These are the safest to eat once you scrub them and remove their skins.

Second in order of preference are those plants with edible parts that you can decontaminate by washing and peeling their outer surfaces. Examples are bananas, apples, tomatoes, prickly pears, and other such fruits and vegetables.

Any smooth-skinned vegetable, fruit, or plant that you cannot easily peel or effectively decontaminate by washing will be your third choice of emergency food.

The effectiveness of decontamination by scrubbing is inversely proportional to the roughness of the fruit's surface. Smooth-surfaced fruits have lost 90 percent of their contamination after washing, while washing rough-surfaced plants removes only about 50 percent of the contamination.

You eat rough-surfaced plants (such as lettuce) only as a last resort because you cannot effectively decontaminate them by peeling or washing. Other difficult foods to decontaminate by washing with water include dried fruits (figs, prunes, peaches, apricots, pears) and soya beans.

In general, you can use any plant food that is ready for harvest if you can effectively decontaminate it. Growing plants, however, can absorb some radioactive materials through their leaves as well as from the soil, especially if rains have occurred during or after the fallout period. Avoid using these plants for food except in an emergency.

Chemical Disasters

The terms "**chemical accident**" or "**chemical incident**" refer to an event resulting in the release of a substance or substances hazardous to human health and/or the environment in the short or long term. Such events include fires, explosions, leakages or releases of toxic or hazardous materials that can cause people illness, injury, disability or death.

The extent of chemical disaster scenarios are, influenced by the military - non-military circumstance. In many peacetime scenarios industrial man-made chemical accidents are more probable. Natural disasters where volcanic activities occur highlight the dynamics of the natural environment in contributing to the chemical hazards leading to disaster.

Many if not most products we use in everyday life are made from chemicals and thousands of chemicals are used by manufacturing industries to make these products. The source of many of these chemicals is petroleum, which is refined into two main fractions: fuels and the chemical feedstocks that are the building blocks of plastics, paints, dyes, inks, polyester, and many of the products we buy and use every day. Fuels and chemical feedstocks made from petroleum are called organic chemicals. The other important class of chemicals is inorganics, which include acids, caustics, cyanide, and metals. Commercial products made from inorganics range from car bodies to computer circuit boards. Of the more than 400000 chemicals in commercial use, most are subject to accidental spills or releases. Chemical spills and accidents range from small to large and can occur anywhere chemicals are found, from oil drilling rigs to factories, tanker trucks to fifty-five-gallon drums and all the way to the local dry cleaner or your garden tool shed.

Sources of Chemical Disasters: Chemical accidents may originate in:

1. Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal.
2. Material handling and storage in manufacturing facilities, and isolated storages; warehouses and godowns including tank farms in ports and docks and fuel depots.
3. Transportation (road, rail, air, water, and pipelines).

Causative Factors Leading to Chemical Disasters

Chemical disasters, in general, may result from:

- **i)** Fire.
- **ii)** Explosion.
- **iii)** Toxic release.
- **iv)** Poisoning.
- **v)** Combinations of the above.

Initiators of Chemical Accidents

A number of factors including human errors could spark off chemical accidents with the potential to become chemical disasters. These are:

a. Process and Safety System Failures:

- i. Technical errors: design defects fatigue, metal failure, corrosion etc.
- ii. Human errors: neglecting safety instructions, deviating from specified procedures etc.
- iii. Lack of information: absence of emergency warning procedures, nondisclosure of line of treatment etc.
- iv. Organizational errors: poor emergency planning and coordination, poor communication with public, noncompliance with mock drills/exercises etc., which are required for ensuring a state of quick response and preparedness.

b. Natural Calamities:

The Indian subcontinent is highly prone to natural disasters, which can also trigger chemical disasters. Damage to phosphoric acid sludge containment during the Orissa super cyclone in 1999 and the release of acrylonitrile at Kandla Port, during an earthquake in 2001, are some of the recent examples.

Impact of Chemical Disasters

In addition to loss of life, the major consequences of chemical disasters include impact on livestock, flora/fauna, the environment (air, soil, water) and losses to industry as shown in Figure below. Chemical accidents may be categorised as a major accident or a disaster depending upon the number of casualties, injuries, damage to the property or environment.

A major accident is defined in the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989, issued under the Environment (Protection) Act, 1986, whereas 'disaster' is defined in the DM Act, 2005. The Major Chemical Accidents in India following the Bhopal Gas Disaster in 1984, major incidences of chemical disasters

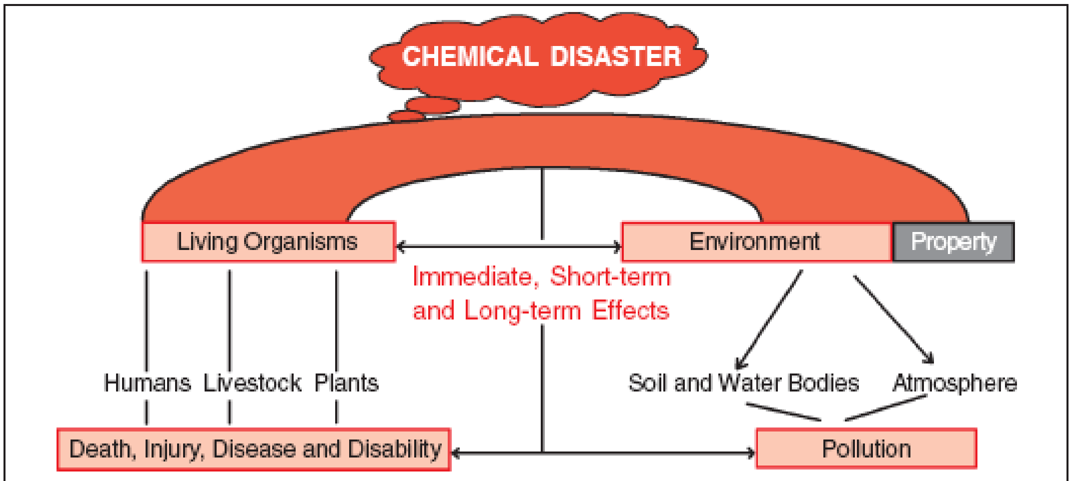


Figure -1: Impact of a Chemical Disaster

in India include A fire in an oil well in Andhra Pradesh (2003); a vapour cloud explosion in the Hindustan Petroleum Corporation Limited Refinery (HPCL), Vishakhapatnam (1997); and an explosion in the Indian Petrochemicals Corporation Limited (IPCL) Gas Cracker Complex, Nagothane, Maharashtra (1990).

Non-military causes:

- accidents due to negligent handling or transportation of dangerous chemical substances
- accidents due to technical failure in industrial, scientific or medical facilities
- liberation of hazardous chemical agents due to terrorism
- liberation of hazardous chemical agents due to natural hazards (earthquakes, floods, volcanoes)
- accidents related to disposal measures of chemical waste

Military causes:

- military-strikes on facilities containing dangerous chemical compounds
- liberation of hazardous material after accidents with chemical weapon-systems
- employment of chemical weapons as a military action during combat
- accidents related to production or disposal processes

The effects of chemical disasters are dependent on the actual event, possible chemical reactions, the kind of liberated dangerous compounds and the kind of occurrence (solid, liquid, gaseous). Influences of meteorological conditions, especially temperature and winds, are of importance to estimate the dimensions of a disaster. According to its hazardous potential, each scenario and analysed carefully for possible effects on the environment. Decontamination measures will have to be applied accordingly. Examples of possible effects include:

- contamination/death of large parts of the population, long time effects due to incorporation of poisonous substances
- contamination of land, especially densely populated regions and agricultural acreage
- contamination of food and drinking water
- necessary evacuations or refugee movements
- over-strainment of medical personnel and supply systems
- contamination of basic infrastructure (e.g. roads, bridges,...)

Based on these causes and resulting effects the employment of military and civil defence forces is probable. The types of forces include:

- C-specialists (reconnaissance, detection, decontamination)
- C-labs for detailed identification of dangerous substances
- Fire-brigades (fire fighting, water supply)
- SAR-specialists (SAR operations, evacuations)
- Basic logistic and support forces (communication, transport)
- Helicopters and aircraft forces (air lift, air-drop evacuation)
- Naval forces (reconnaissance, transport)
- Medical forces (medical on-site support)
- Personnel for hedging and characterising of contaminated areas
- Personnel for disposal of cadavers and dangerous substances

Disaster is a rarity in the chemical industry, but negligence or misfortune can so easily result in devastating consequences.

Considering the potentially dangerous materials and processes employed in the chemical sector, most producers can be justifiably proud of their health and safety records. Occasionally, however, things do go wrong.

Aside from the immediate implications surrounding a major incident, such as loss of life, a threat to the environment or the destruction of plants and surrounding buildings, the damage to the industry's reputation is almost irrevocable.

"If you measure the fears of the population about chemicals all over Europe, then air pollution, water pollution and the risk of plant catastrophes are still the most important to them," says Daniel Verbist, executive director responsible for communications at the European Chemical Industry council (Cefic). But from each disaster, lessons can be learned, he says - and these can often lead to the introduction of more stringent health, safety and environment legislation. Here is a selection of some of the industry's worst moments.

Oppau, Germany - September 21, 1921

Workers at BASF's Oppau site, in Germany, decided that the best course of action to loosen a 4,500 tonne mound of ammonium nitrate (AN) and ammonium sulfate that had solidified was to detonate several dynamite charges.

Unfortunately, the use of this tried-and-true method was not suited to the explosive nature of AN, resulting in a massive 125m (410ft)-long and 19m-deep crater and the deaths of more than 500 people.

The accident destroyed around 80% of the homes in Oppau and ripped the roofs off houses as far as 25km (10 miles) away.

AN has since been responsible for numerous explosions in the chemical sector globally, as well as many acts of terrorism. Strict measures have been imposed to ensure the safe handling and storage of the fertilizer.

Texas City, Texas, US - April 16, 1947

On the morning of April 16, 1947, a French ship - The Grandcamp - was being loaded with ammonium nitrate (AN) fertilizer. With over 2,000 tonnes of AN onboard, a fire started in the hold. Not wanting to damage the cargo, the captain refused to use water on the flames and opted instead to control the fire using the steam system.

The heat intensified and the ship exploded, killing crewmembers and showering onlookers with shrapnel. The blast was heard over 150 miles (240km) away.

A 15ft (4.6m) wave swept a barge ashore, buildings were destroyed - including a Monsanto chemical plant nearby - and the ship's anchor was found more than a mile away. There were around 3,500 injuries and 576 people were killed.

Texas City, Texas, US - March 23, 2005

The 2005 disaster at UK oil major BP's Texas City refinery, in Texas, US, was considered the nation's worst industrial disaster in 15 years.

A series of explosions occurred when a hydrocarbon isomerization unit was restarted and a distillation tower flooded with hydrocarbons. As a result, 15 were killed and another 180 were injured. BP admitted to charges and accepted fines last year, with BP America chairman Bob Malone conceding that the company was guilty of a felony "for failing to have adequate written procedures for maintaining the ongoing mechanical integrity of process equipment at the Texas City refinery.

"If our approach to process safety and risk management had been more disciplined and comprehensive, this tragedy could have been prevented," he said.

Jilin City, China - November 13, 2005

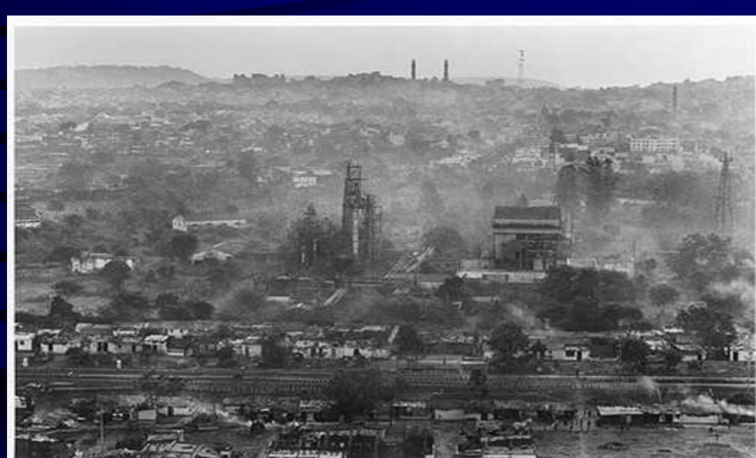
A series of explosions rocked China-based Jilin Petrochemical's 70,000 tonne/year aniline complex in Northeast China, killing five and injuring 70. Benzene also leaked into the Songhua river and caused millions of people to go without drinking water, with many fleeing their homes.

Initial investigations suggested the explosion occurred after operators attempted to unblock a nitrobenzene rectification tower. Jilin's Bureau of Production Safety Supervision and Administration concluded that a valve was left open, causing temperatures to rise rapidly.

Nearby equipment and storage tanks containing nitrobenzene, benzene and nitric acid feedstocks also caught fire and exploded. Water and electricity supplies had to be cut off as local residents reported tap water turning red or yellow. There were also concerns that water supplies to some Russian towns could be affected by the contamination of the river.

Bhopal, India - December 3, 1984

A gas leak at US-based Union Carbide's pesticide plant in Bhopal, India, is cited as one of the chemical industry's greatest tragedies.



On the night of Dec. 2nd and 3rd, 1984, a Union Carbide plant in Bhopal, India, began leaking.

On December 3, 1984, methyl isocyanate gas leaked from the facility during the early hours of the morning while local residents slept. Around 2,000 people died immediately, with another 8,000 dying later.

The initial investigation suggested that large volumes of water had entered the chemical tank, which caused a chemical reaction and led to the leak. The incident highlighted the problem of urbanization and having a plant located near a densely populated area. In 2001, Union Carbide became a wholly owned subsidiary of US giant Dow Chemical.

Flixborough, UK - June 1, 1974

In 1974, cyclohexane vapor leaked from ruptured pipework at the Nypro (UK) site at Flixborough. This resulted in an explosion that killed 28 people and injured 36.

Offsite, 53 injuries were reported. Property in the surrounding area was also severely damaged.

The disaster led to the Health and Safety at Work Act, introduced the same year, when the Health and Safety Executive was also established.

Seveso, Italy - July 10, 1976

On July 10, 1976, in a small Italian town north of Milan, a reactor at the ICMESA chemical plant overheated, resulting in an explosion and the first, and highest known exposure, to dioxins in a residential area. A toxic cloud containing 2,4,5-Trichlorophenol - used to make pesticides and antiseptics - spread to the densely populated city of Seveso.

This became the catalyst for the Seveso Directive, in 1982, which has since undergone numerous amendments. It was replaced by the Seveso II directive in 1996.

Toulouse, France - September 21, 2001

Some seven years later, there is still no official ruling on the cause of the 2001explosion at Atofina's Grande Paroisse fertilizer plant in Toulouse, France. A report is now expected toward the end of this year or the beginning of 2009.

Around 300 tonnes of ammonium nitrate (AN) exploded, destroying the site and wrecking buildings 3km (1 mile) away in the city center.

The blast left a crater 50m (164 feet) wide and 10m deep. It was responsible for the death of 30 people, and 10,000 injuries.

Schweizerhalle, Switzerland - November 1, 1986

Water used to extinguish a major fire at the Sandoz chemical factory in 1986 washed chemicals into the river Rhine, one of Europe's busiest waterways. The spill caused severe pollution, which took years to eradicate, and killed an estimated 500,000 fish.

The incident highlighted the need for antipollution legislation in Europe. Soil was excavated from the area and decontaminated to ensure there was no risk to the groundwater.

The German chemical company also developed a new framework for warehouse safety, including segregated storage for different risk categories of chemicals, and fire measures such as retention basins for run-off water.

Emergency Planning: After the incident of Bhopal gas disaster, the Factories Act has been amended and a new chapter i.e. Chapter IVA – provision relating to hazardous processes has been added to the Factories Act with addition of new provisions sec 41A, 41B, 41C, 41D, 41E, 41G & 41H covering all hazardous process industries. Under the provision of Sec 41B(4) every occupier shall with the approval of the Chief Inspector of Factories draw up an On-site Emergency Plan and detailed disaster control measures for his factory and make known to the workers employed therein and to the general public living in the vicinity of the factory the safety measures required to be taken in the event of an accident taking place. This is the statutory provision laid down in the act for preparation of On-site Emergency Plan to control disaster in the factories. Major accidents may cause emergency and it may lead to disaster, which may cause heavy damage to plant, property, harm to person and create adverse affects on production. Many disasters like Bhopal gas tragedy, Chernobyl nuclear disaster etc. have occurred at many places in the world causing heavy loss of life and property. Emergency situation arises all on a sudden and creates havoc and damage to person, property, production and environment. Therefore such situations and risks should be thought in advance and it should be planned before hand to tackle them immediately and control them within the shortest time.

What is emergency? A major emergency can be defined as an accident/ incident that has potential to cause serious injuries or loss of life. It may cause extensive damage of property, serious disruption both in production and working of factory and may adversely effect the environment. The following factors may cause major emergency.

- (i) Plant failure.
- (ii) Human error.
- (iii) Vehicle crash.
- (iv) Sabotage.
- (v) Earthquake.
- (vi) Natural Calamities.

On-site Emergency:- If an accident/ incident takes place in a factory, its effects are confined to the factory premises, involving only the persons working in the factory and the property inside the factory it is called as On-site Emergency.

Off-site Emergency:- If the accident is such that it affects inside the factory are uncontrollable and it may spread outside the factory premises, it is called as Off-site Emergency.

Each major hazardous factory should prepare an emergency plan incorporating details of action to be taken in case of any major accident/ disaster occurring inside the factory. The plan should cover all types of major accident/ occurrences and identify the risk involved in the plant. Mock drills on the plan should be carried out periodically to make the plan foolproof and persons are made fully prepared to fight against any incident in the plant. The plan will vary according to the type of industry and emergency.

Statutory Provision:- After the Bhopal gas tragedy (1984) and supreme court direction in case of M/S Sriram Foods and Fertilizers, the Govt. of India has made some important amendments to the Factories Act 1948 in the year 1987 with incorporation of special provisions relating to hazardous process. Under Section 41(B)(4) every occupier is to prepare On-site Emergency Plan and detailed disaster control measures for his factory. Again under provision of Rule 13 of the Manufacture, Storage and Import of Hazardous Chemicals Rules 1989, the occupier shall prepare and keep up to date On-site Emergency plan containing details how major accidents will be dealt with on the site on which the industrial activity is carried on and that plan shall include the name of the person who is responsible for safety on the site and names of those who are authorized to take action in accordance with the plan in case of emergency.

Main elements of On-site Emergency plans:-

- Leadership and Administration.
- Role and Responsibilities of Key Personnel.
- Emergency action.
- Light and Power.
- Source of energy control.
- Protective and rescue equipment.
- Communication.
- Medical care.
- Mutual Aid.
- Public relation.
- Protection of vital records.
- Training.
- Periodical revision of plan.

Emergency Action Plan:- The Action Plan should consist

- ❖ Designated Emergency Control Centre/Room.
- ❖ Key Personnel.

Emergency Control Centre:- This is the main center from where the operations to handle the emergency are directed and coordinated.

Maximum facilities to be made available in the emergency control are –

i. Internal and external communication.
ii. Computer and other essential records.
iii. Daily attendance of workmen employed in factory.
iv. Storage of hazardous material records and manufacturing records.
v. Pollution records.
vi. Walky-talky.
vii. Plan of the plant showing-
    a. Storage area of hazardous materials.
    b. Storage of safety equipments.
    c. Fire fighting system and additional source of water.
    d. Site entrance, roadway and emergency exist.
    e. Assembly points.
    f. Truck parking area.
    g. Surrounding location.
viii. Note Book, Pad and Pencil.
ix. List of Key Personnel with addresses, telephone number etc.

Assembly Points:- A safe place far away from the plant should be pre determined as assembly point where in case of emergency personnel evacuated from the affected areas are to be assembled. The plant workers, contract workers and visitors should assemble in assembly point in case of emergency and the time office clerk should take their attendance so as to assess the missing person during emergency.

The Key Personnel for onsite emergency:-

1. Works main controller.
2. Works incident controller.
    a. Communication Officer.
    b. Security and Fire Officer.

c. Telephone Operators.
d. Medical Officer.
e. Personnel/Administrative Officer.
f. Essential work team leaders.

(1) Works Main Controller:- The General Manager of the Plant should act as main controller. His duties are to -

1. Assess the magnitude of the situation and decide whether the evacuation of staff from the plant is needed.
2. Exercise and direct operational control over areas other than those affected.
3. Maintain a continuous review of possible development and assess in consultation with work incident controller and other Key Personnel.
4. Liaison with Police, Fire Service, Medical Services, Factory Inspectorate and other Govt. agencies.
5. Direct and control rehabilitation of affected area after emergency.
6. Intimate Off-site Emergency controller if the emergency spreads beyond the factory premises and likely to affect the surrounding area.
7. Ensure that evidence is preserved for enquiries to be conducted by statutory authorities.

The Works Main Controller will declare the emergency and he will instruct gate office to operate the emergency siren after assessing the gravity of the situation.

(2) Work Incident Controller (WIC):- He is the next responsible officer after the Works Main Controller. Generally the plant manager is designated as Work Incident Controller. In case of emergency he will rush to the place of occurrence and take overall charge and report to the Works Main Controller by personal communication system like cell phones or walky talky and inform about the magnitude of emergency. He will assess the situation and considering the magnitude of emergency he will take decision and inform Communication Officer to communicate the news of emergency to different agencies. He will give direction to stop all operations within the affected area. He will take the charge of Main Controller till the Main Controller arrives. He will order for shutdown and evacuation of workers and staffs from affected area. He will inform all Key Personnel and all outside agency for help. He will inform security and fire officers and State Fire Services. He will ensure that all non-essential workers/staff are evacuated to assembly point and areas searched for casualties. He will report all significant development to Communication Officer. Moreover he will advise to preserve evidence of emergency into the cause of emergency.

Other Key Personnel and their duties:

Communication Officer: On hearing the emergency siren/alarm he will proceed to the control center and communicate to work incident controller. He will collect information from the emergency affected area and send correct message to work main controller for declaration of emergency. He will maintain a log book of incident. He will contact all essential departments. He will take stock of the meteorological condition from local meteorological Department. He will communicate all information as directed by Works Main Controller.

Security and Fire Officer: The Security or Fire officer will be responsible for the fire fighting. On hearing the emergency alarm/siren, he will reach the incident area with fire and security staff. Immediately after arrival to the emergency area, he will inform through telephone or walky-talky to the communication officer. He will inform to the Work Incident Controller about the situation and requirement of outside help like State Fire Service and other mutual aid members.

At the site, the entire fire squad member will respond to the advice and information given by the works incident controller.

The security will control the visitors and the vehicle entry.

Telephone Operator : In case of fire is discovered but no emergency siren is operated, he shall ensure the information about the location of the fire/emergency incident from the person discovered/ notices the above and communicate to different Key Personnel immediately with clear message.

Medical Officer: Medical Officer with his team will report to the Works Incident Controller on hearing the fire/ emergency siren immediately. The ambulance will be parked nearest to the site of incident. Name of injured and other casualties carried to the Hospital will be recorded and handed over to Works Incident Controller. The ambulance will carry the injured to the nearest hospital for treatment.

Personnel/ Administrative Officer: He should work as a liaison officer liaisoning with works main controller and other essential departments such as Police, Press and Statutory authorities. His responsibilities shall include-

- To ensure that casualties receive adequate attention to arrange additional help if required and inform relatives.
- To control traffic movement into the factory and ensure that alternative transport is available when needed.
- When emergency is prolonged, arrange for the relief of personnel and organize refreshment and catering facilities.
- Arrange for finance for the expenditure to handle the emergency.

Essential Works and Team Leaders: During emergency the plants immediately affected or likely to be affected, as determined by the Works Main Controller, need to be shut down for safety. In the area immediately affected, it may be possible to isolate equipment from which flammable or toxic material is leaking. This work must be immediately carried out by plant supervisors and essential operators.

Workers/ staffs need to be nominated to carry out the following essential works at the time of emergency-

- Extra first aid personnel to deal with casualties.
- Emergency engineering works, provision of extra or replacement of light, isolation of equipment, temporary by pass electrical lines etc.
- Moving tankers or other vehicles from area of risk.
- To carry out tests on ambient air quality.
- To act as runner in case of communication system fails.
- The Works Main Controller will require a task force of suitable trained people for the following works-
    i. Manning of assembly points to record the arrival of evacuated people.
    ii. Assistance of casualty arrival areas to record details of casualties.
    iii. Manning the factory entrance in liaison with security to direct emergency vehicle containing the gate e.g. ambulance, fire tenders etc.

For these essential jobs designated teams should be made available. The responsibilities of the team and the leader should be given.

The essential work teams are-

1. Task Force and repair team.
2. Fire fighting team.
3. Communication team.
4. Security Team.
5. Transport Team.
6. First aid and medical team.
7. Safety team.

Alarm System: Alarm system varies and will depend on the size of the works area. Simple fire bell, hand operated siren – break open type, fire alarm etc. Automatic alarm may be needed for highly hazardous nature of plant.

Communication System:

Communication is a key component to control an emergency.

The following communication system may be provided in the plant-

- Walky-Talky.
- Telephone (internal & external).
- Cell phone.
- Intercom/paging.
- Runners (verbal or written messages).

Siren for Emergency: Siren for emergency should be different from the normal siren. The emergency siren should be audible to a distance of 5 KM radius. The emergency siren should be used only in case of emergency.

Escape Route: The escape route from each and every plant should be clearly marked. The escape route is the shortest route to reach out of the plant area to open area, which leads to assembly point. This route should be indicated on the layout plan attached to the On-site Emergency Plan.

Evacuation: All non-essential staff should be evacuated from the emergency site. As soon as the emergency siren rings the workers have to shut down the plant and move to the assembly point. The plant shut down procedure in case of emergency should be prepared and kept ready and responsible person should be nominated for the purpose.

Counting of Personnel: All personnel working in the plant should be counted. Time office person should collect the details of personnel arriving at the assembly point. These should be checked with the attendances of regular workers, contract workers present in the site on the day of emergency. The accident control should be informed and arrangement should be made for searching missing person in the emergency affected area. The employees' address, contact number of next to kin should be maintained in the time office so that during emergency relatives of those affected due to emergency may be informed accordingly.

Information in respect of emergency should be given to the media and other agency.

All Clear Signal: After control of emergency the Work Incident Controller will communicate to the works main controller about the cessation of emergency. The main controller can declare all clear by instructing the time office to sound "All Clear Sirens".

Mutual Aid System: Mutual aid scheme should be introduced among industries so that in case of emergency necessary help from mutual aid partner may be extended.

Essential elements of this scheme are –

Mutual aid must be a written document signed by the Chief Executive of the industries concerned.

- Specify key personnel who are authorized to give requisition of materials from other industries.
- Specify the available quantity of material/equipment that can be spared.
- Mode of requisition during emergency.
- Mode of payment/ replacement of material given during an emergency.
- May be updated from time to time based on experience gained.

Mock drills on emergency planning should be conducted once in 6 months and sequence of events should be recorded for improvement of the exercise. Exercises on On-site Emergency Planning should be monitored by Factory Inspectorate and the high officials of the organization and the plan is reviewed every year.

Emergency facilities: The following facilities should be provided in any factory to tackle any emergency at any time.

1. Fire protection and fire fighting facilities.
2. Emergency lighting and standby power.
3. Emergency equipment and rescue equipment –
   i. Breathing apparatus with compressed air cylinder.
   ii. Fire proximity suit.
   iii. Resuscitator.
   iv. Water gel Blanket.
   v. Low temperature suit.
   vi. First aid kit.
   vii. Stretchers.
   viii. Torches.
   ix. Ladders.
4. Safety Equipment –
   i. Respirators.
   ii. Gum boots.
   iii. Safety helmets.
   iv. Asbestos Rubber hand gloves.
   v. Goggles and face shield.
   vi. Toxic gas measuring instruments.
   vii. Explosive meter.
   viii. Oxygen measuring instruments.
   ix. Toxic gas measuring instrument.
   x. Wind direction indicator.

On-site Emergency Plan should contain -

1. Site plan and topographic plan.
2. Plan showing the fire fighting facilities.
3. Plan showing hazardous material storage area.
4. Material safety data sheets for hazardous chemicals.
5. Facilities available in main control center.
6. List of emergency equipment.
7. List of Safety Equipment.
8. List of important telephone numbers and addresses.

i. Nearest hospitals and ambulance service center.
ii. Nearest fire station.
iii. Govt. Officials.
iv. Transport provider.

9. Names and address & contact telephone number of Key Personnel.

The on site emergency plan so prepared shall be documented in a printed form in sufficient copies to give all concerned for knowledge, study and easy follow up. The emergency plan shall be rehearsed and practised at regular intervals to test efficiency of personnel, equipments coordinated efforts and to increase confidence and experience to operate such plan.

Off-site Emergency Plan: The main objective of the plan are:

i. To save lives and injuries.
ii. To prevent or reduce property losses and
iii. To provide for quick resumption of normal situation or operation.

Risk Assessment: Risk assessment is most essential before preparing any off site emergency plan. Hazardous factories and their hazard identification, other hazard prone areas, specific risks, transportation risk, storage risks, pollution risks by air and water pollution, catastrophic risks such as disasters, natural calamities, acts of god, earthquake, landslide, storm, high wind, cyclone, flood, scarcity, heavy rain, lightening, massive infection, heavy fire, heavy explosion, volcano, heavy spill, toxic exposure, environmental deterioration etc., risks from social disturbances, risks from the past accidents must be considered while carrying out risk assessment for a particular area(district) from which the offsite emergency plan is to be prepared.

Central Control Committee: As the offsite plan is to be prepared by the Government, a Central Control Committee shall be formed under the Chairmanship of the District Collector. Other officers from Police, Fire Service, Factory Inspectorate, Medical Department shall be incorporated as members of the Central Control Committee. Under the Central Control Committee the following committees shall be constituted under the control of the District Collector.

i. Incident and Environment Control Committee.
ii. Fire Control Committee.
iii. Traffic control, Law and order, Evacuation and Rehabilitation Committee.
iv. Medical help, Ambulance and Hospital Committee.
v. Welfare, Restoration and Resumption Committee.
vi. Utility and Engineering Services Committee.
vii. Press, Publicity and Public Relations Committee.

The Off-site Emergency Plan shall be prepared by the District Collector in consultation with the factory management and Govt. agencies. The plan contains up to date details of outside emergency services and resources such as Fire Services, Hospitals, Police etc. with telephone number. The district authorities are to be included in the plan area.

a. Police Department.
b. Revenue Department.
c. Fire Brigade.
d. Medical Department.
e. Municipality.
f. Gram/Village Panchayat.

g. Railway Department.
h. Telephone Department.
i. Factory Department.
j. Electricity Department.
k. Pollution Control Department.
l. Explosive Department.
m. Press and Media.

Mock exercises on Off-site plan should be carried out at least once in a year to train the employees, up to date the plan, observe and rectify deficiencies.

Hazop Study: Before making on site and off site plan hazop study has to be carried out to identify the potential hazardous situations and to find out possible control measures. Hazop study is to be carried out by a team of experts. The team should consist of –

(a) Mechanical Engineer.
(b) Chemical Engineer.
(c) R & D Chemist.
(d) Works Manager.
(e) Project Manager.
(f) Outside experts.
(g) Safety Officer/ Manager.

Biological Disasters

Apart from the natural transnational movement of the pathogenic organisms, their potential use as weapons of biological warfare and bio-terrorism has become far more important now than ever before. Utilization of organisms causing smallpox and anthrax by such terrorist groups can cause greater harm and panic.

Biological agents are living organisms or their toxic products that can kill or incapacitate people, livestock, and plants. **Bio-terrorism** can be defined as the use of biological agents to cause death, disability or damage mainly to human beings. Thus, bio-terrorism is a method of terrorist activity to prevail mass panic and slow mass casualties. The **three basic groups of biological agents,** which could be used as weapons, are bacteria, viruses, and toxins. Most biological agents are difficult to grow and maintain. Many break down quickly when exposed to sunlight and other environmental factors, while others, such as anthrax spores, are very long lived. Biological agents can be dispersed by spraying them into the air, by infecting animals that carry the disease to humans, and by contaminating food and water. Potentially, hundreds of human pathogens could be used as weapons; however, public health authorities have identified only a few as having the potential to cause mass casualties leading to civil disruptions.

Causes and Method of Delivery

There are number of causes why biological weapons are potentially more powerful agents to mass casualties leading to civil disruptions. To attract widespread attention and to harm a selected target, these outfits can utilize possibly any biological material, which fulfils some of the criteria of bio-weapons.

- Biological agents can be disseminated with readily available technology. Common agricultural spray devices can be adopted to disseminate biological pathogens of the proper particle size to cause infection in human population over great distances.

- The perpetrators can use natural weather conditions, such as wind and temperature inversions as well as existing building infrastructures (e.g. ventilation system) or air movement related to transportation (e.g. subway cars passing through tunnels) to disseminate these agents and thus to infect or intoxicate a large number of people.
- The expense of producing biological weapons is far less than that of other weapon systems.

The methods of bio-logical agent dissemination and delivery techniques include:

- Aerosols – biological agents are dispersed into the air, forming a fine mist that may drift for miles. Inhaling the agent may cause epidemic diseases in human beings or animals.
- Animals – some diseases are spread by insects and animals, such as fleas, mice, flies, mosquitoes, and livestock.
- Food and water contamination – some pathogenic organisms and toxins may persist in food and water supplies. Most microbes can be killed, and toxins deactivated, by cooking food and boiling water. Most microbes are killed by boiling water for one minute, but some require longer. Follow official instructions.
- Person-to-person – spread of a few infectious agents is also possible. Humans have been the source of infection for smallpox, plague, and theLassa viruses.

Types

There are three categories of biological agents potential enough to cause mass casualties. However, those in category A have the greatest potential for fear and disruption and most significant public health impacts. The list of these biological agents with a very brief description about them is given below.

- The disease anthrax is caused by the gram-positive, non-motile *Bacillus anthracis.* ***Anthrax*** has been a scourge of cattle and other herbivores for centuries. During the industrial revolution, the inhalation form was first recognized as an occupational pulmonary disease in workers in the wool industries of Europe. Anthrax makes an ideal biological weapon. The inhalation form of disease is highly lethal. The spores can maintain virulence for decades and they can be milled to the ideal particle size for optimum infection of the human respiratory tract. Different clinical forms of the disease are observed, depending on the route of exposure. Inhalational anthrax presents with non-specific symptoms that cannot be distinguished from many more common diseases based on early clinical manifestations or routine laboratory tests. Therefore, despite aggressive medical care sometimes develop rapidly progressive disease and dye.
- If used as a biological weapon, ***smallpox*** represents a serious threat to civilian population because of its case fatality rate of 30% or more among unvaccinated persons and the absence of specific therapy. Smallpox has long been considered as the most devastating of all infectious diseases and today its potential for devastation is far greater than at any previous time.

  Smallpox virus is a member of genus Orthopoxvirus, and it is closely related to the viruses causing cowpox, vaccinia and monkey pox. It is one of the largest DNA viruses known, and it has a bricklike appearance on electron microscopy. Transmission of this virus can occur in several different ways: generally by droplets, occasionally by aerosol, by direct contact with secretions or lesions from a patient, and rarely by formites contacted with the infection virus from a patient. Transmission risk increases if the index patient is coughing or sneezing or if he or she has hemorrhagic disease. Typically, the virus enters the respiratory mucosa and then travels to regional lymph nodes where it replicates. The incubation period from infection to onset of rash ranges from 7 to 17 days, averaging 12 to 14 days. Smallpox scabs remain infectious until they fall off, whereas chickenpox is no longer infectious once the lesions are crusted.

- The mere mention of the word ***plague*** conjures up many images because has already demonstrated a historical potential to kill millions of people across the globe. It is a disease that results from infection by non-motile, gram-negative coccobacillus *Yersinia pestis*. When stained, its bipolar appearance is often described as resembling a safety pin. Pestis has two important properties that differentiate it from B. anthracis- person-to-person transmissibility and a lack of spore production. Following the bite of an infected flea, plague bacilli are carried via the lymphatic to the regional lymph nodes where they multiply exponentially. This is only weapon besides smallpox, which can cause devastation beyond those persons who are initially infected. With modern air travel, containing an out break of plague could be challenging. A vaccine for plague does exist; however, it is no longer being produced, and it does not demonstrate efficacy against infection by aerosol.
- **Botulism** or Botulinum toxins are deadly. A toxin is any toxic substance that can be produced in an animal, plant, or microbe. The toxins produce serious disease in human beings. Many natural toxins can be produced by chemical synthesis or can be expressed artificially. Toxins are natural and non-volatile and generally do not penetrate intact skin, which happens in case of chemical weapons. There are different types of toxins and they are immunologically distinct, meaning that antibodies developed against one do not cross-react against others. Those that most commonly cause human disease are types A, B, and E. Humans can be intoxicated either by oral means, inhalation, or wound infection. Mass casualties can be produced through contamination of food source or by aerosol dissemination. The incubation period of botulism can range from as short as 24 to 36 hours to several days from the time of inhalation.
- ***Tularemia*** is caused by Francisella tularensis, which is a gram-negative, non-motile coccobacillus. Tularemia is a zoonotic disease acquired in a natural setting by humans through skin or mucous membrane contact with the body fluids or tissues of infected animals or from being beaten by infected deerflies, mosquitoes, or ticks. It can remain viable for weeks in the environment or in animal carcasses and for years if frozen. Unlike anthrax, which requires thousands of spores to infect someone, tularemia can cause illness with as few as 10 to 50 organisms. After an incubation period of 2 to 10 days, pneumonia symptoms develop associated with weight loss and nonproductive cough. The drug of choice for treatment is streptomycin with other aminoglycosides.

Major Events across the Globe

Documented Intentional Use of Biologicals

- Japan used plague bacilli in China during 1932-1945 causing 260,000 deaths
- Dispersal of anthrax spores due to accident in production unit in USSR caused 68 deaths in 1979
- In 1984, Osho followers used *Salmonella typhimurium* in salad in a restaurant in Oregaon, USA leading to 751 cases
- Shigella dysenteriae Type 2 employed in Texas, USA in 1996

- Anthrax through postal envelopes in USA in Oct-Nov 2001 leading to 22 cases and 5 deaths

Impact: Even a small-scale biological attack with a weapon grade agent on an urban center could cause massive morbidity and mortality, rapidly overwhelming the local medical capabilities. For example, an aerosolized release of little as 100kg of anthrax spores upwind of a metro city of a size of Washington D C has been estimated to have the potential to cause up to three millions of deaths.

Prevention & Mitigation Measures: General Measures of Protection

1. The general population should be educated and the made aware of the threats and risks associated with it.
   - Only cooked food and boiled/chlorinated/filtered water should be consumed
   - Insects and rodents control measures must be initiated immediately.
   - Clinical isolation of suspected and confirmed cases is essential.
2. An early accurate diagnosis is the key to manage casualties of biological warfare. Therefore, a network of specialised laboratories should be established for a confirmatory laboratory diagnosis.
3. Existing disease surveillance system as well as vector control measures have be pursued more rigorously.
4. Mass immunization programme in suspected area has to be vigorously followed up.
5. Enhancing the knowledge and skills of clinicians plays a vital role in controlling the adverse impact of the attack. As bio-terrorism related infections will remain rare events, creative ongoing strategies will be required to sustain attention to potential new cases.

Action Plan for Biological Disaster Management in India

Biological Disaster could arise from a source located either inside the country or outside the country (warfare). Management of such a situation could be dealt effectively only if there is a disaster plan well integrated in the system and also there is mechanism of post disaster evaluation.

Inter-Disaster Stage:

This is the period between two disasters in which pre-disaster planning in terms of system development should be done.

Action plan has following elements:

One of the simplest & easy method to suspect is to take notice of a situation during which more patients with similar ailments from a particular locality start consulting health guide at village level,

(a) **Constitution of a Crisis Management Structure**

- Identification of Nodal Officers for Crisis Management at District, State & Central Level.
- Identification of Focal points for control of epidemic at District, State & Central Level.
- Constitution of advisory committees - Administrative and Technical
- Preparation of contingency plan including Standing Operating Procedure at District, State & Central Level.

(b) System of Surveillance.

- System of information collection at District, State & Central Level.
- System of data analysis

- System for flow of information from District to State and to Central Level during crisis period.
- Establishment of control rooms at District, State & Central Level.

c) System of Epidemiological Investigation.

- System of field investigation
- System of active surveillance
- Arrangement for support facilities

(d) Confirmation of pathogens by laboratory set up.

- System of laboratory investigation at District, State & Central Level.
- Quality Control of Laboratory Practices.

(e) Training to different level workers.

Pre impact stage of warning (Early Detection):

Early warning signals: Early identification of an outbreak of disease of international public health importance shall require knowledge of early warning signals amongst all the echelons of health care providers. Some of the suggested early warning signals which must command quick investigation by professionals may include followings:

- Sudden high mortality or morbidity following acute infection with short incubation period
- Acute fever with haemorrhagic manifestations
- Acute fever with altered sensorium and malaria and JE excluded in endemic areas
- Even one case of suspected plague or anthrax
- Occurrence of cases which are difficult to diagnose with available clinical and laboratory support and their non-responsive to conventional therapies
- Clustering of cases/deaths in time and space with high case fatality rate
- Unusual clinical or laboratory presentations

A comprehensive list of all the trigger events that shall attract immediate attention of local public health machinery need to be developed by a group of experts.

- By suspicion: Management Plan should aim to identify crisis situation at a very early stage preferably confined to a limited area. This can be done only by suspecting danger of impending disaster by local health employees (at village by village health guide, at sub centre level by multi purpose worker and PHC level by doctors at PHC).
- Alertness of institution dealing with emergency health, medical services/ Confirmation by identified laboratories :-

If such a situation arises, after providing symptomatic treatment at PHC level, services of well **established laboratory at district or medical college level may be requisitioned to identify the organism** and also to seek guidance for specific treatment and management.

- Constant surveillance and monitoring till there is no risk of any outbreak.

Disaster Stage:

When disaster strikes following actions would be needed:

Public Health Control Measures:

Aim of control measures, is to contain the disease initially but eliminate ultimately by following public health measures:

- Identification of all infected individuals based on an established case definition

- Eliminating or reducing source of infection (Isolation and treatment of patients) identified by epidemiological and laboratory studies
- Interrupting Transmission of disease: Spread of disease depend of mode of transmission which could be prevented by:
  - Possibility of reducing direct contacts with patients;
  - Vector control: Rodents/Mosquitoes control.
  - Food control
  - Environmental control: Transmitted by water/air.
  - Control through sewerage system.
- Protecting persons at risk (Community) Immunisation and Health Education plays major role in protecting person at risk.

Trigger mechanism: The trigger mechanism is an emergency quick response mechanism like ignition switch when energized spontaneously sets the vehicle of management into motion on the road of disaster mitigation process.

- System of alert and mechanism of activation of Disaster Plan.
- Immediate organization of field operation for curative and preventive medical care including immunization.
- Checking of initial information on an epidemic.
- Preliminary analysis of the situation.
- Arrangement for laboratory support.
- Emergency health services advisory committee meeting to take stock of the situation and to advise further action.
- Field investigation about:
  - Safety pre-cautions
  - Case finding
- Deputation of Quick Response Teams
  - Search for source of infection and contact tracing
  - Special investigation for common source of infection.
- Analysis of investigation data to identify type, source of out break and mode of transmission:
  - Ecological data
  - Clinical data
  - Epidemiological data
  - Laboratory data
  - Entomological data
- General control measures to prevent further out break:
  - Protective measure for contacts & Community
  - Control of common source of outbreak like food water or mosquito etc.
  - Immunization, emergency mass immunization and specific immunization, mass chemoprophylaxis.

Post disaster stage:

Evaluation after disaster is most important step in disaster management in order to rectify deficiencies in the management and to record the entire operation for future guidance for which following measures are necessary:

- Evaluation of control measures
- Cost effectiveness

- Post-epidemic measures
- Sharing of experience
- System for documentation of events.

Management of Biological disaster on above principles and steps should be taken by the health authorities of the State Government with the available infrastructure.

Future Plan

The followings are the some of the key issues and concerns across the globe that need to be included in the future plan of bio-terrorism management.

- Since vaccines against a number of potential biological warfare agents have already been developed and some have already been in use, mass immunization of the population would be done on a priority basis.
- Vaccines against remaining agents would have to researched and developed.
- Mass public awareness before, during and after such an attack must be emphasized upon. The strategies that must be incorporated include accurate threat intelligence, physical countermeasures, medical countermeasures and education and training of physicians and ancillary health care providers including first-aid providers.

Dos & Don’ts in a Biological War Attack

Before:

· Children and older adults are particularly vulnerable to biological agents. Ensure from a doctor/the nearest hospital that all the required or suggested immunizations are up to date.

During:

- In the event of a biological attack, public health officials may not immediately be able to provide information on what you should do. It will take time to determine what the illness is, how it should be treated, and who is in danger. Close the doors and windows when a biological attack is imminent.
- Watch television, listen to radio, or check the Internet for official news and information including signs and symptoms of the disease, areas in danger, if medications or vaccinations are being distributed, and where you should seek medical attention if you become ill.
- The first evidence of an attack may be when you notice symptoms of the disease caused by exposure to an agent.
- Be suspicious of any symptoms you notice, but do not assume that any illness is a result of the attack.
- Use common sense and practice good hygiene.

However, if you notice of an unusual and suspicious substance nearby:

- Move away quickly.
- Cover your head and nose
- Wash with soap and water.
- Listen to the media for official instructions.
- Seek medical attention if you become sick.

If you are exposed to a biological agent:

1. Ultra efficient filter masks can be used
2. Follow official instructions for disposal of contaminated items such as bagand cloths.
3. Take bath with soap and put on clean clothes.

4. Seek medical assistance. If required and advised, stay away from othersor even quarantined.

After:

Pay close attention to all official warnings and instructions on how to proceed. The delivery of medical services for a biological event may be handled differently to respond to increased demand. The basic public health procedures and medical protocols for handling exposure to biological agents are the same as for any infectious disease. It is important for you to pay attention to official instructions via radio, television, and emergency alert systems.

Building fire

Definition of fire: Fire is the rapid oxidation of a material in the chemical process of combustion, releasing heat, light, and various reaction products. Slower oxidative processes like rusting or digestion are not included by this definition.

Fire safety: Fire safety refers to precautions that are taken to prevent or reduce the likelihood of a fire that may result in death, injury, or property damage, alert those in a structure to the presence of a fire in the event one occurs, better enable those threatened by a fire to survive, or to reduce the damage caused by a fire. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building. Threats to fire safety are referred to as *fire hazards*. A fire hazard may include a situation that increases likelihood a fire may start or may impede escape in the event a fire occurs.

Fire safety is often a component of building safety. Those who inspect buildings for violations of the Fire Code and go into schools to educate children on Fire Safety topics are fire department members known as *fire prevention officers*. The Chief Fire Prevention Officer or Chief of Fire Prevention will normally train newcomers to the Fire Prevention Division and may also conduct inspections or make presentations.

A fire safety station at a high school

Fire hoses built into a structure can sometimes be used by occupants to mitigate fires while the fire department is responding.

Key elements of a fire safety policy

- Building a facility in accordance with the version of the local building code
- Maintaining a facility and conducting yourself in accordance with the provisions of the fire code. This is based on the occupants and operators of the building being aware of the applicable regulations and advice.

Examples of these include:

- Not exceeding the maximum occupancy within any part of the building.
- Maintaining proper fire exits and proper exit signage (e.g., exit signs pointing to them that can function in a power failure)
- Placing and maintaining fire extinguishers in easily accessible places.
- Properly storing/using, hazardous materials that may be needed inside the building for storage or operational requirements (such as solvents in spray booths).
- Prohibiting flammable materials in certain areas of the facility.
- Periodically inspecting buildings for violations, issuing Orders To Comply and, potentially, prosecuting or closing buildings that are not in compliance, until the deficiencies are corrected or condemning it in extreme cases.
- Maintaining fire alarm systems for detection and warning of fire.
- Obtaining and maintaining a complete inventory of firestops.
- Ensuring that spray fireproofing remains undamaged.
- Maintaining a high level of training and awareness of occupants and users of the building to avoid obvious mistakes, such as the propping open of fire doors.
- Conduct fire drills at regular intervals throughout the year.

Some common fire hazards are:

- Blocked cooling vent
- Overloaded electrical system
- Fuel store areas with high oxygen concentration or insufficient protection
- Materials that produce toxic fumes when heated
- Objects that block fire exits
- Combustibles near or around the clothes dryer
- Incorrectly installed wiring
- Misuse of electrical appliances
- Lit candles left unattended
- Improperly-extinguished tobacco
- Failure to clean and maintain the clothes dryers exhaust duct
- Combustible solutions on clothes placed in the clothes dryer
- Flammables left near a hot water heater
- Fireplace chimneys not properly or regularly cleaned
- Misuse of wood burning stoves

Improper use and maintenance of gas stoves often create fire hazards

Fire code

The **Fire code** (also **Fire prevention code** or **Fire safety code**) is a model code adopted by the state or local jurisdiction and enforced by fire prevention officers within municipal fire departments. It is a set of rules prescribing minimum requirements to prevent fire and explosion hazards arising from storage, handling, or use of dangerous materials, or from other specific hazardous conditions. It complements the building code. The fire code is aimed primarily at preventing fires, ensuring that necessary training and equipment will be on hand, and that the original design basis of the building, including the basic plan set out by the architect, is not compromised. The fire code also addresses inspection and maintenance requirements of various fire protection equipment in order to maintain optimal active fire protection and passive fire protection measures.

A typical fire safety code includes administrative sections about the rule-making and enforcement process, and substantive sections dealing with fire suppression equipment, particular hazards such as containers and transportation for combustible materials, and specific rules for hazardous occupancies, industrial processes, and exhibitions.

Sections may establish the requirements for obtaining permits and specific precautions required to remain in compliance with a permit. For example, a fireworks exhibition may require an application to be filed by a licensed pyrotechnician, providing the information necessary for the issuing authority to determine whether safety requirements can be met. Once a permit is issued, the same authority (or another delegated authority) may inspect the site and monitor safety during the exhibition, with the power to halt operations, when unapproved practices are seen or when unforeseen hazards arise.

List of some typical fire and explosion issues in a fire code

- fireworks, explosives, mortars and cannons, model rockets (licenses for manufacture, storage, transportation, sale, use)
- certification for servicing, placement, and inspecting fire extinguishing equipment
- general storage and handling of flammable liquids, solids, gases (tanks, personnel training, markings, equipment)
- limitations on locations and quantities of flammables (e.g., 10 liters of gasoline inside a residential dwelling)
- specific uses and specific flammables (e.g., dry cleaning, gasoline distribution, explosive dusts, pesticides, space heaters, plastics manufacturing)
- permits and limitations in various building occupancies (assembly hall, hospital, school, theater, elderly care, child care, prisons, warehouses, etc)
- locations that require a smoke detector, sprinkler system, fire extinguisher, or other specific equipment or procedures
- removal of interior and exterior obstructions to emergency exits or firefighters and removal of hazardous materials
- permits and limitations in special outdoor applications (tents, asphalt kettles, bonfires, etc)
- other hazards (flammable decorations, welding, smoking, bulk matches, tire yards)
- Electrical safety code
- Fuel gas code

Public fire safety education

Fire prevention programs may include distribution of smoke detectors, visiting schools to review key topics with the students and implementing nationally recognized programs such as NFPAs "Risk Watch" & "Learn not to burn".

Other programs or props can be purchased by fire departments or community organizations. These are usually entertaining and designed to capture children's attention and relay important messages. Props include those that are mostly auditory, such as puppets & robots. The prop is visually stimulating but the safety message is only transmitted orally. Other props are more elaborate, access more senses and increase the learning factor. They mix audio messages and visual queues with hands-on interaction. Examples of these include mobile trailer safety houses and tabletop hazard house simulators.

All programs tend to mix messages of general injury prevention, safety, fire prevention and escape in case of fire. In most cases the fire department representative is regarded as the expert and is expected to present information in a manner that is appropriate for each age group.

Fire educator qualifications

The US industry standard that outlines the recommended qualifications for fire safety educators is NFPA 1035: Standard for Professional Qualifications for Public Fire and Life Safety Educator, 2005 Edition. This standard is currently being revised and the newest edition is slated for release in 2010. According to NFPA, 1035 specifically covers the requirements for Fire and Life Safety Educator Levels I, II, and III; Public Information Officer; and Juvenile Firesetter Intervention Specialist Levels I and II.

Target Audiences: According to the United States Fire Administration, the very young and the elderly are considered to be "at risk" populations. These groups represent approximately 33% of the population and they should receive fire safety information.

Protection and prevention:

Fire fighting services are provided in most developed areas to extinguish or contain uncontrolled fires. Trained firefighters use fire apparatus, water supply resources such as water mains and fire hydrants or they might use A and B class foam depending on what is feeding the fire. Fire prevention is intended to reduce sources of ignition. Fire prevention also includes education to teach people how to avoid causing fires. Buildings, especially schools and tall buildings, often conduct fire drills to inform and prepare citizens on how to react to a building fire. Purposely starting destructive fires constitutes arson and is a crime in most jurisdictions.

Structure fire

Model building codes require passive fire protection and active fire protection systems to minimize damage resulting from a fire. Most common form of active fire protection is fire sprinklers. To maximize passive fire protection of buildings, building materials and furnishings in most developed countries are tested for fire-resistance, combustibility and flammability. Upholstery, carpeting and plastics used in vehicles and vessels are also tested.

Methodology of Recording the Causes of Fire Disasters:

Fire risk analysis: a measure or a probability

Fire risk analysis is still an open question. It is always in two steps:

1. measure of severity
2. probability distribution

The measure of severity may also be separated into two parts:

1. definition of the scale that measures severity, such as number of fatalities and injured persons, dollars' worth of damage, area affected by flames or smoke, etc.
2. definition of the rules for calculating the specific severity measurement to be used for a particular fire

The probability distribution provides the probability, for each value, that the severity measure may have, i.e., the probability for every type of fire.
As actual fires reflect all the factors that affect ignition probability and fire severity, fire risk analysis usually begins with the calculation of fire prevention factors.

Fire prevention factors

It is essential to understand that the major factors in fire prevention are the initial input in any fire risk analysis approach, in order to organize a fire security system which is always designed on the basis of the development of fire and its resulting combustion products, i.e., smoke and gas. **Table** below lists the major factors in fire prevention. These concern the most important heat sources and flammable materials, the major factors that bring them together, and building practices that can affect the success of prevention.

Heat source	a. Fixed equipment
	b. Portable equipment
	c. Torches and other tools
	d. Materials for smoking and associated lighting implements
	e. Explosives
	f. Natural causes
	g. Exposure to other fires
Forms and types of ignitable materials	a. Building materials
	b. Interior and exterior finishes
	c. House contents and furnishings
	d. Stored materials and supplies
	e. Trash, lint and dust
	f. Combustible or flammable gases or liquids
	g. Volatile solids
Factors that bring heat and ignitable material together	a. Arson
	b. Misuse of heat source
	c. Misuse of ignitable material
	d. Mechanical or electrical failure

	e. Design, construction or installation deficiency
	f. Error in operating equipment
	g. Natural causes
	h. Exposure
Practices that affect prevention success	a. Housekeeping
	b. Security
	c. Education of occupants
	d. Control of fuel type, quantity and distribution

Fires develop in several stages, or "realms". **Table** below provides guidance on the technical definition of these realms. Within any realm a fire may either continue to grow or be unable to sustain continued development and die down. *It* includes a rough guide to the approximate flame sizes that may be used to describe the size of the realms. It also describes the major factors that influence growth within a realm. Absence of a significant number of factors indicate that the fire will self-terminate rather than continue to develop.

Realm	**Approximate range of fire extent**	**Main factors influencing spread of fire**
Pre-burning	Overheating to ignition	1. Amount and duration of heat flux 2. Surface area receiving heat
Initial burning	Ignition to radiation point	1. Fuel continuity (flame 250 ram high) 2. Material ignitability 3. Thickness 4. Surface roughness 5. Thermal inertia of the fuel
Vigorous burning	Radiation point to enclosure point (flame 250 ram to 1.5 m high)	1. Interior finish 2. Fuel arrangement 3. Feedback 4. Material ignitability 5. Thermal inertia of the fuel 6. Proximity of flames to walls
Interactive burning	Enclosure point to ceiling point (flame 1.5 m to flame touching ceiling)	1. Interior finish 2. Fuel arrangement 3. Feedback 4. Height of fuels 5. Proximity of flames to walls 6. Ceiling height 7. Room insulation 8. Size and location of openings
Remote burning	Ceiling point to full room involvement	1. Fuel arrangement 2. Ceiling height 3. Length/width ratio 4. Room insulation 5. Size and location of openings

Risk estimation and evaluation: A fire risk analysis designer must ascertain both the general and the particular conditions that influence the level of fire risk that can be tolerated in a given building or space.

- The acceptable levels of risk and the focus of fire safety analysis and strategy processes are concentrated under the following headings
- Safety
- Property protection
- Continuity of building or space operations

It is important, at this stage of the present analysis, to describe what is an acceptable risk. Fire risk analysis may be distinguished as:

1. Risk estimation, i.e., the estimation and analysis of the measure of severity and probability and their associated uncertainties
2. Risk evaluation, i.e., the additional steps required to be decided regarding the importance of a particular value of risk or a change in risk

A fire analysis that includes risk evaluation may be called a fire risk assessment in order to underline the fact that the analysis will support value judgments. *Acceptable risk is* the term used when the method of risk evaluation involves treating risk as a constraint. This method may seem attractive because it refuses to consider costs until or unless a sufficient degree of fire safety has been provided. In an acceptable risk approach, a certain level of risk is defined as acceptable, and all alternatives meeting that level are evaluated strictly on the basis of cost. When acceptable risk is not defined in terms of affordable risk, it is often defined in the following terms:

- historically acceptable risk (i.e., "anything in use for a long time is all right"), which may be overturned if public understanding of the magnitude of the risk changes dramatically
- unavoidable risk, such as the use of background radiation levels as a guide for acceptable exposure to medical X-rays

Most extreme version of an acceptable risk approach is the minimum risk approach. It is difficult to ascertain the level of risk that will be tolerated by the owner of a building, its occupants, and the community. It is often necessary to make a conscious effort to arouse sensitivity of the occupants to contents and purpose of the building (or the space it occupies), with regard to products of combustion. Consequently, fire safety criteria are often not identified in a clear, concise manner that enables the designer to provide appropriate protection for the realization of design objectives. It is unfortunately impossible to provide more than some general guidelines that must be considered in building design in order to assist in the identification of fire safety objectives. Specific objectives must be developed for each individual building or space.

Safety. The first step in safety fire risk analysis design is to identify the characteristic occupants of the building or the space (e.g., a stadium). What are the physical and mental capabilities of the occupants? What is the range of their activities and locations during the 24-hour, seven day-a-week period? Are special considerations needed for certain periods of the day or week? The interaction of the building's response to the fire with the actions of its occupants during the fire emergency determines the acceptable level of risk that the building design poses.

Property protection. Specific items of property that have a high monetary or other value must be identified in order to protect them adequately in case of fire.

Continuity of building operations. The third major design concern is the maintenance of operational continuity after a fire. The amount of "downtime" that can be tolerated before revenues begin to be seriously affected must be identified. Certain functions or locations are more essential for continued operation of the building than others. It is important to identify areas of the building that are particularly sensitive to space (or building) operations, so that adequate protection can be provided for the vital business operations that are conducted in them.

Building Fire Protection: Modern buildings built under the strict design and buildings codes of today have many fire protection systems installed by default. These systems assist with detection and response to fire related emergencies.

If you have questions or maintenance issues in regards to any of this equipment, please contact the Property and Campus Services - Maintenance Department on (03) 8344 6000.

Fire Break Glass Alarm (B.G.A.)

Buildings fitted with a "Fire - Break Glass Alarm" allow occupants to activate the fire alarm and alert the fire brigade easily. The red panel on the wall houses a small button that when depressed will contact the Fire Brigade. The Fire Brigade will respond instantly to the building. You should always try to ring University Security on x46666 to confirm the fire. The glass or perspex material is easy to break with your fist, elbow or a pen. Smashing the glass will sometimes activate the button automatically.

Fire Control Systems

Some buildings or sections of buildings are fitted with automatically activated sprinkler heads. On activation, the sprinklers discharge a fine mist of water to extinguish/contain a fire.

In other special risk locations such as flammable liquids storerooms, computer rooms (main frames), flood systems are used to extinguish fire. Where gaseous flooding systems are installed in normally occupied areas (e.g. computer rooms), a warning alarm is sounded prior to the discharge of gas into the room. A warning notice instructing personnel what to do should also be displayed.

Fire Indicator Panel (FIP)

The F.I.P. is the hub of the fire alarm system in a building. It is usually located on the ground floor near an entrance close to the nearest road. The panel may be located in a cabinet or on a wall. On the panel is a number of lights and buttons. These lights "indicate" which fire sensor has activated in the building. The FIP will automatically notify the fire brigade of an alarm when one of its sensors locates a fire. The FIP. will usually talk to the E.W.I.S. (where installed) and notify the building occupants that they need to evacuate.

Fire Hose Reels & Fire Hydrants

Canvas fire hoses attached to or adjacent to fire hydrant points are installed only for use by the Fire Brigade. They must not be used by untrained personnel as injury or excess property damage may result.

Fire Doors

Fire doors are installed to minimise the spread of fire, including the passage of smoke through a building. Fire doors may be automatically operated by heat activated mechanisms or smoke detectors. The securing of fire doors must be such that persons leaving an area via the fire door can do so without the use of keys or similar at all times. Fire doors must not be wedged open.

Smoke and Thermal Fire Detectors

The detection system in buildings may sense either heat or smoke or a combination of these. Smoke detectors are increasingly being used because of their earlier warning of an emergency situation. Smoke detectors may also be used to activate fire doors to isolate zones in the building.

Portable Fire Extinguishers

Portable fire fighting equipment such as fire extinguishers are designed to provide the user with an appliance to attend a small fire during its initial stage.

How to Prevent a House Fire: House fires kill and injure thousands yearly, and cost many more their valued possessions and memories. Here are some steps you can take to lessen the chance of your home becoming a part of this statistic.

Steps

- **Inspect your home**. You may need to recruit, or even hire, someone experienced in home electrical wiring, plumbing (gas), heating, and air conditioning.
- **Stay in the kitchen when using the range for cooking.** If you are leaving for just a minute, turn off all the burners on the range. Going to the basement for a can of tomatoes, or running out to check the mail, going to the bathroom, answering the phone in another part of the house? Simply turn off all the burners. After all, you are just leaving for a minute. You can immediately turn the pot or frying pan back on when you return. Doing this simple step will prevent one of the most common situations that cause house fires: unattended cooking. When cooking with oil, keep a lid or flat cookie sheet close by. If flames appear, simply suffocate the fire with the lid and immediately turn off stove or fryer to let it cool down. Do not try to move the pan. Do not use water. The super-heated water will explode into steam, and can cause severe burns, and oil can splash and spread fire.
- **Don't cook when drinking alcohol, using drugs, or are very tired.** Eat something prepared, make a cold sandwich, and go to sleep. Cook your meal later, when you are fully conscious.
- **Don't sit down or lie down when smoking.** Standing up will usually prevent you from falling asleep while smoking. Getting too tired? Put out the cigarette thoroughly in an ash tray or water-damp sink and go to bed. Cleaning out the ash tray? Place the ashes in the sink and dampen them, then scoop them up and place them in the trash can away from the house.

  Check the condition of your electrical system.

  - Look for improperly grounded receptacles. Many modern appliances require a "three pronged" (grounded) receptacle, but people will sometimes use an adapter to bypass this safety feature, or even break a ground prong off an appliance cord. Changing existing circuits to provide grounding is usually a job left to a professional electrician.

- Look in the attic and crawl spaces for wiring which has been damaged by pests or insects. Some old wiring is insulated with a material which insects eat or chew on, and squirrels or other rodents will often chew the thermoplastic insulation off of modern nonmetallic cable (Romex).
- Look for overloaded circuit breakers, panel boxes, or fuse boxes. Check for breakers or fuses which may have circuits "piggy-backed" on them. These are rated for single circuit protection, but sometimes in outdated or undersized panel boxes, people will put two or even more wires in the terminal of a single breaker or fuse.
- Notice flickering lights, or intermittent power surges. These conditions may be caused by outside influences, but if they occur often, they may indicate a bad connection or short in the circuit.
- Note breakers which "trip", or fuses that "blow" frequently. This is almost always a sign of an overloaded circuit or other wiring problem, usually of a most serious nature.
- Look at the individual breaker connections, especially in outdoor panel boxes, for corrosion, signs of thermal damage (smut or smokey residue near terminals) splices which are poorly taped or wire nutted, or abraded or damaged wire insulation.
- Check the ground cable. A failure in the building grounding system and bonding can be dangerous in regard to electrical shock, as well as fire. Look for loose split bolts, clamps, or other connecting devices, and corrosion.
- Be especially careful to notice any connections in wiring other than copper. Installed correctly, and with tight connections, aluminum wire is not excessively dangerous, but when connections are made to copper wires, an electrolytic reaction may occur, causing increased resistance in the connection which will generate excessive heat. If you are able to apply an antioxidant compound to aluminum connections, it will help decrease the risk of oxidation causing a short circuit at these locations.
- Look into possibility of installing a lightning protection system in home if you live in an area where lightning is a frequent problem. The savings from reduced damages to appliances may offset the cost of this upgrade.

❖ **Consider having a home sprinkler system installed, to extinguish fires when you are away and at home**.

❖ **Check the natural gas/LP gas system in your home**. You will want to look for loose fittings, leaking valves, faulty pilot lights, and debris or improperly stored flammable materials in areas near these appliances.

❖ Check the vent stacks on gas water heaters, furnaces, and clothes dryers.

❖ Check the automatic ignition systems or pilot lights on these fixtures, as well, particularly for any guards which are not properly installed, and for lint or dust buildup in the immediate area around them.

❖ Have the gas plumbing (pipes), valves, and regulators inspected by a professional any time you smell gas or suspect a leak.

- Check the Heating Ventilation and Air Condition unit (HVAC).
  Check the air conditioning and heating unit in your home. These systems operate with electric motors and air moving equipment which requires periodic maintenance.
  - Clean, or have your interior AC coils cleaned, and replace your return air filters regularly. This will prevent the fan motor from being overworked, and also save money on your energy bill. For window AC's, NEVER use extension cords!
  - Lubricate belt drive pulleys (where applicable), boss bearings on drive motors, and other equipment as needed.
  - Have the resistance coils or furnace burners cleaned and serviced at the beginning of the heating season, since debris may accumulate there while the system is off during the summer.
  - Listen to the system when it is operating. Squealing sounds, rumbling noises, or banging and tapping sounds may indicate loose parts or bearings which are seizing up.
  - If you have access to a snap-on amp meter, you may check the amperage draw on the high amperage circuit to your heating coils to make sure they are in the normal operating range. Higher than normal amperage draw on a circuit indicates unusual resistance, and in an electrical circuit, resistance is what causes heat, and ultimately, fires.

  Check your appliances.
  - Keep the range and hood clean. Grease fires are no fun.
  - Keep your stove and oven clean, especially watching for grease accumulation.
  - Check stove vent hoods, clean the filter regularly, and make sure that if it is equipped with an exterior vent, insects or birds do not build nests or otherwise impede the air flow through it.
  - Check the power cords for your appliances. Look for missing grounding prongs on the plugs and damaged insulation, and replace or repair them if defects are found.
  - Keep the lint trap and outside vent clean in your clothes dryer. Some dryers have internal ductwork which may become clogged and require servicing, so if the dryer is operating poorly, have it checked. Lint or other material collecting near the heat coils in clothes dryers is extremely dangerous. Stay nearby while using the dryer. Have a smoke alarm and fire extinguisher nearby. If you must leave the area for a minute, turn off the dryer. After all, you are not going to be away long, and you can immediately turn the dryer on when you return.

  Be very careful with space heaters.
  - Keep flammable materials (curtains, the couch) a safe distance (usually 3 feet) from portable heaters.
  - Set heaters where they are not in the traffic flow of the room.
  - As a rule, extension cords are not recommended with space heaters. Small, low wattage heaters may be an exception, but check the manufacturer's

recommendations prior to using an extension cord with one. Be SAFE, just don't use extension cords.
- Use space heaters only on solid, firm surfaces. They should never be placed on tables, chairs or other places where they may tip over. Replace old space heaters with ones that will automatically turn off if tipped over.

Maintain your fireplace correctly.
- Fire box cut away.
- Inspect the fire box (hearth) for cracks, damaged sheet metal (for inserts) and other hazards.
- Use glass fire doors or a wire mesh spark screen to prevent embers from popping out of the fireplace.
- Burn dry, seasoned wood to prevent creosote buildup in the chimney. Note that some woods, like cedar, pop excessively when burned, and should not be used in an open fireplace.
- Remove ash and unburned wood only when there are no embers or sparks in the fire box. Place ash in a metal (NOT plastic bucket) and place outside away from any buildings.
- Have your chimney inspected and cleaned at least once a year.

Never store flammable liquids near ignition sources.
- Keep gasoline, paint thinners, and other highly flammable liquids or materials in UL approved containers and out of the house.
- Do not store any flammable liquid in a garage or utility room with that has a pilot light equipped appliance in use in it. Be safe, keep these items outdoors, or in a separate outbuilding.

Never use extension cords for air conditioners. An overheated cord is like an out-of-control electric heater.

Be careful with candles, oil lamps, and other open flame illumination or decorations. Cover the flame with a wire cage to prevent something from falling or blowing onto the flame, and to prevent children and pets from coming in contact with the flame. Extinguish the fire when leaving the room, if even for a minute. After all, you'll be right back, and you can immediately relight the candle.

Use caution with holiday decorations, particularly Christmas trees. Natural Christmas trees are highly combustible when they become dry, and old, damaged, or low quality tree lights cause many fires when combined with an under watered or otherwise dry tree. Watch a video of a Christmas tree fire. It is amazing how fast it can destroy a room, and a home.

Be very careful in any situation where you use an extension cord for extended periods of time. Often, foot traffic, moving furniture, and other hazards damage these cords, causing a potential for a fire. Holiday decorations are often lit for weeks with these cords, and if you are using them, use a high quality cord with a sufficient rating for the intended purpose.

Teach your children not to play with lighters or matches. Children are often the cause and victims of fires, and should not be allowed access to matches or cigarette lighters. Consider getting a lockable box, and keeping matches and lighters locked up.

Do not pile up lawn clippings near a building. Fermenting lawn clippings can create heat, and catch on fire. Barn fires start this way from bales of hay with no electricity; house fires have been started from a pile of lawn clippings.

Be careful using a grill on a deck. Decks are flammable. Place non-flammable pads under your grill. Have a fire extinguisher readily available. Stay with your grill while cooking. Turn off propane if leaving, if even for a minute. After all, you'll be right back and can turn on the propane again.

Crate train dogs and use the crates when you are not home and awake, to prevent new dogs or puppies from chewing on electrical cords, or pets from urinating on electrical objects and starting a fire.

Confine new cats to a safe room, a small room with no places for the cat to crawl into to hide (such as into the refrigerator motor), and no electrical cords. Use the safe room until the cat is calm and no longer hiding. Provide cats with edible oat or wheat grass, to prevent them from chewing on electrical cords. Confine rabbits, chinchillas, and other pets when not supervising them, to prevent them from chewing on electrical cords, causing burns or electrical fires.

After Using Matches quickly place in or run under water to extinguish any invisible flame or heat source that could cause a fire in the trash can.

Tips

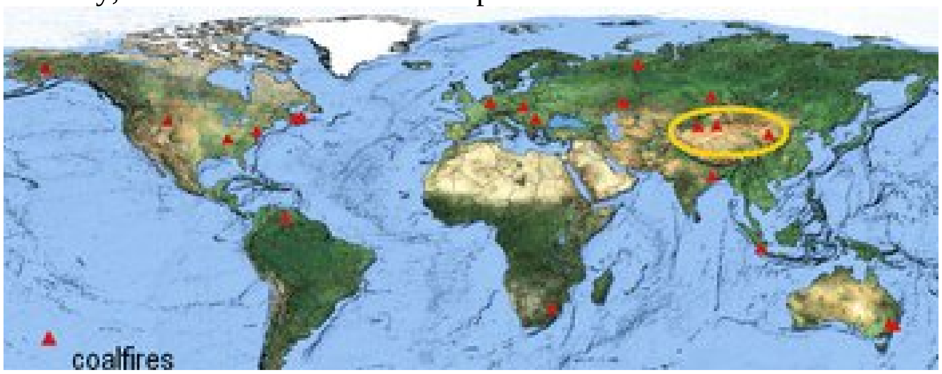
- Install and maintain fire alarms, smoke detectors, and carbon monoxide detectors. There have been countless lives saved using these inexpensive devices.
- If you suspect or notice electrical problems or strange odors, don't hesitate to have them checked by a competent person.
- Never store oily rags, especially rags saturated with mineral spirits, paint thinners, or linseed oil. Under certain conditions, these materials may spontaneously combust (start on fire without any known source).
- Store only the minimum amount of any combustible material in your home, and keep it in the original, or a UL approve container.
- Teach your children proper evacuation techniques in case of a fire. Practice family fire drills, with a meeting place outside (by the tree in the front yard, or at the mailbox or front gate. That way you will all know that everyone is safely outside. Never go back into a house on fire.
- Watch an educational video of a house fire with your older children. The smoke will be very black very quickly, unlike the fires on the movies. You have very little time to escape a fire.
- Do not block doors or windows which may be needed to escape fire.
- Contact your local Fire Department and request a Residential Home Survey. In most areas they will be happy to come out and give you advice and you are not required to do anything that they say if you don't want to. It is completely voluntary.

Warnings

- Never burn debris or allow debris to accumulate near your home.
- In case of a fire, get out of your home as quickly as possible, making sure all occupants are alerted and leave also.

Coal Fire

The term **coal fire** refers to a burning or smoldering coal seam, coal storage pile or coal waste pile. The adsorption of oxygen at the outer and inner surface of coal and resulting oxidation is an exothermic reaction. This leads to an increase in temperature within the coal accumulation. If the temperature exceeds approximately 80°C the coal can ignite and start to burn. This process, referred to as “spontaneous combustion”, is the most common cause for coal fires of large extent. Spontaneous combustion processes can be accelerated through human impact. Mining operations expose formerly covered coal to oxidation processes and additionally lead to the accumulation of large coal waste and storage piles. Coal fires can also be ignited by lightning, forest- or peat fires, mining accidents or careless human interaction. Uncontrolled coal seam fires are an environmental and economic problem of international magnitude. They occur in many countries worldwide including China, India, Russia, the United States, Indonesia, Venezuela, Australia, South Africa, Germany, Romania and the Czech Republic.



Global coal fire occurrence

Bulk storage of any combustible materials leads to fire risk in many large storage areas such as waste bunkers, wood or paper stockpiles and coal storage yards. Self-ignition usually starts within the bottom layers of a stockpile as a result of temperature increases in the material. Continuous monitoring of the surface layers enables a fast location of hot spots rapid response to coal fires at initial stage. It is obvious and well proven that coal fire fighting at the initial stage increases the probability to control and extinguish the fire it with low effort. The fires usually start as ‘hot spots’ in the coal accumulation. These are places where the generated heat cannot be dissipated efficiently while there is still enough oxygen to promote the oxidation reaction of the coal.

Why and when self-ignition may occur?

First the coal’s temperature begins to climb above ambient. At about 65°C-150°C measurable quantities of gas-aerosols, hydrogen and CO_2 gases announce the danger of possible combustion. As the temperature increases further, at about 315°C-370°C relatively large, visible particulates are emitted. Soon, as the hot spot heating rate increases in intensity, reaching about 400°C-425°C, incipient combustion, and ultimately self ignition and flame, will occur. The risk from fire exists anywhere significant amounts of coal are in use or storage. After all, coal is flammable and susceptible to a variety of ignition scenarios. One of the most frequent and serious causes of coal fires is spontaneous combustion. In fact, spontaneous combustion is one of the most prevalent and serious causes of coal fires. It has been a well-known, and long-feared, danger at coal storage sites all over the world. Coal reacts with atmospheric oxygen even at ambient temperatures and this reaction is exothermic. If the heat liberated during the process is allowed to accumulate, the rate of the above reaction increases exponentially and there is a further rise in temperature. When this temperature reaches the ignition temperature of coal, the coal starts to burn and the phenomena is described as spontaneous combustion. Preventing spontaneous combustion coal fires involves attention to many different factors. Among the most critical are the type, age, and composition of coal, how it is stored, and how it is used. Given the right kind of coal, oxygen, and a certain temperature and moisture content, coal will burn by itself. Spontaneous combustion has long been recognized as a fire hazard in stored coal. Spontaneous combustion fires usually begin as "hot spots" deep within the reserve of coal. The hot spots appear when coal absorbs oxygen from the air. Heat generated by the oxidation then initiated the fire. Such fires can be very stubborn to extinguish because of the amount of coal involved and the difficulty of getting to the seat of the problem. Moreover, coal in either the smoldering of flaming stage may produce copious amounts of CH_4 and CO_2 gases. In addition to their toxicity, these gases are highly explosive in certain concentrations, and can further complicate efforts to fight this type of coal fire. Even the most universal firefighting substance, water, cannot be used indiscriminately. Because of the remote possibility of a steam explosion, it is advisable that water be applied carefully and from a safe distance.

What may cause spontaneous coal combustion?

The following general factors contribute to spontaneous coal fires:

- Long coal handling procedures which allow long-time retention of coal, which increases the possibility of overheating.
- New coal added on top of old coal created segregation of particle sizes, which is a major cause of overheating.
- Insufficient, temperature probes installed in the coal bunker resulted in an excessive period of time before the fire is detected.
- Failure of equipment needed to fight the fire.
- Ineffective capability and use of CO2 suppression system.
- Delay in the application of water.
- Inadequate policies, procedures, and training of personnel prevented proper decision making, including the required knowledge to immediately attack the fire.

Environmental effects of coal: There are a number of adverse environmental effects of coal mining and burning.

Effects of mining:

- Release of carbon dioxide and methane, both of which are greenhouse gases causing climate change and global warming . Coal is the largest contributor to the human-made increase of CO_2 in the atmosphere.
- Waste products including uranium, thorium, and other radioactive and heavy metal contaminants
- Acid rain
- Acid mine drainage (AMD)
- Interference with groundwater and water table levels
- Impact of water use on flows of rivers and consequential impact on other land-uses
- Dust nuisance tunnels, sometimes damaging infrastructure
- Rendering land unfit for the other uses

Effects on water:

- Flood events can cause severe damage to improperly constructed or located coal haul roads, housing, coal crushing and washing plant facilities, waste and coal storage piles, settling basin dams, surface water diversion structures, and the mine itself. Besides the danger to life and property, large amounts of sediment and poor quality water may have detrimental effects many miles downstream from a mine site after a flood.
- Ground water supplies may be adversely affected by surface mining. These impacts include drainage of usable water from shallow aquifers; lowering of water levels in adjacent areas and changes in flow directions within aquifers; contamination of usable aquifers below mining operations due to infiltration or percolation of poor quality mine water; and increased infiltration of precipitation on spoil piles.
- Where coal or carbonaceous shales are present, increased infiltration may result in increased runoff of poor quality water and erosion from spoil piles; recharge of poor quality water to shallow groundwater aquifers; or poor quality water flow to nearby streams. This may contaminate both ground water and nearby streams for long periods. Lakes formed in abandoned surface mining operations are more likely to be acid if there is coal or carbonaceous shale present in spoil piles, especially if these materials are near the surface and contain pyrites.
- Sulphuric acid is formed when minerals containing sulphide are oxidised through air contact, which could lead to acid rain. Leftover chemicals deposits from explosives are usually toxic and increase the salt quantity of mine water and even contaminating it.

Effects on wildlife: Surface mining of coal causes direct and indirect damage to wildlife. The impact on wildlife stems primarily from disturbing, removing, and redistributing the land surface. Some impacts are short-term and confined to the mine site; others may have far reaching, long term effects.

- The effect on wildlife is destruction or displacement of species in areas of excavation and spoil piling. Mobile wildlife species like game animals, birds, and predators leave these areas. More sedentary animals like invertebrates, many reptiles, burrowing rodents and small mammals may be directly destroyed.
- If streams, lakes, ponds or marshes are filled or drained, fish, aquatic invertebrates, and amphibians are destroyed. Food supplies for predators are reduced by destruction of these land and water species. Animal populations displaced or destroyed can eventually be replaced from populations in surrounding ranges, provided the habitat is eventually restored. An exception could be extinction of a resident endangered species.
- Many wildlife species are highly dependent on vegetation growing in natural drainages. This vegetation provides essential food, nesting sites and cover for escape from predators. Any activity that destroys this vegetation near ponds, reservoirs, marshes, and wetlands reduces the quality and quantity of habitat essential for waterfowl, shore birds, and many terrestrial species
- Broad and long lasting impacts on wildlife are caused by habitat impairment. The habitat requirements of many animal species do not permit them to adjust to changes created by land disturbance. These changes reduce living space.

- Large mammals and other animals displaced from their home ranges may be forced to use adjacent areas already stocked to carrying capacity. This overcrowding usually results in degradation of remaining habitat, lowered carrying capacity, reduced reproductive success, increased interspecies and intra-species competition, and potentially greater losses to wildlife populations than the number of originally displaced animals.
- Degradation of aquatic habitats has often been a major impact from surface mining and may be apparent to some degree many miles from a mining site.
- In some situations, surface mining may have beneficial impacts on some wildlife. Where large, continuous tracts of forest, bush land, sagebrush, or grasslands are broken up during mining, increased edges and openings are created. Preferred food and cover plants can be established in these openings to benefit a wide variety of wildlife. Under certain conditions, creation of small lakes in the mined area may also be beneficial. These lakes and ponds may become important water sources for a variety of wildlife inhabiting adjacent areas. Many lakes formed in mine pits are initially of poor quality as aquatic habitat after mining, due to lack of structure, aquatic vegetation, and food species. They may require habitat enhancement and management to be of significant wildlife value.

Loss of topsoil: Removal of soil and rock overburden covering the coal resource, if improperly done, causes burial and loss of top soil, exposes parent material, and creates vast infertile wastelands.

Fly ash spills

Aerial photograph of Kingston Fossil Plant coal fly ash slurry spill

Strategies for Coal mine Disaster Prevention

Mine fires are caused due to spontaneous heating of coal and carbonaceous matter in the rocks. In coal mines the fires could be underground fires which have remained underground or may become surface fires, fires in coal benches in open cast mines, fires in overlying rock mass, fires in overburden dumps or fires in coal stacks. Such fires in the coalfields not only consume huge quantity of coal but also do not permit exploitation of coal in adjoining areas and in underlying coal seams. Combating mine fires, specially the underground fires that have remained underground and those that have become surface fires, is a costly proposition. The Trigger Mechanism should aim to prevent any further occurrence of the fires and quick liquidation of the existing fires. The information needed during preparedness is: zonation of existing coal mine fire affected regions, modelling/ simulation of potential land subsidence and related impact, assessment of loss of property/energy; for warning/prediction it is real time monitoring of coal fires, prediction of spread and depth, pollution extent; for relief it is delineation of affected areas, ways to arrest spread of fire, support to affected population, and for rehabilitation it is long-term measures to control spread, awareness creation among public, relocation of affected people. Mine Fire Hazard Assessment is by mine fire monitoring, hazard estimation and mapping. Mining situations which may lead to development of the mine fires have been outlined and Coal Mining Regulations, 1957 and subsequent circulars amply provide for the safeguards against mine fires. While for Disaster Warning System some experimentation has been done with the continuous monitoring systems of gases and temperature, there is practically no general prevailing disaster warning system in the Indian coal fields in respect of mine fires. The Directorate General of Mines Safety (DGMS) examines from all considerations each and every application for underground and surface mining and wherever necessary imposes conditions that require preparedness for taking actions in the case of occurrence of the mine fires, specially in the underground mines. The R&D activities in relation to mine fires address prevention and preparedness. Post disaster actions in respect of mine fires depend upon the type and location of fire. The most important fires are the ones that occur in the underground workings. The short-range and long range actions have been listed. The strategies for disaster prevention in respect of the mine fires should be viewed and developed from the following considerations:

1. Prevent spreading of existing fires and their mitigation.
2. Integrate preventive measures in mine planning and design.
3. Provision of periodical technical audit of mines in order to check deviations from the planned activities.
4. Create a fire mitigation fund for meeting expenditure on mitigation of existing fires.
5. Permit mines to sell reclaimed land at prevailing rates to recover the costs of reclamation and development of land. This may require some amendments in the Land Acquisition Act.
6. Evolving a scheme of reward and punishment for prevention, safeguarding and mitigation of mine fires.
7. Development of a catalogue of fire related characteristics of coal seams in Indian coalfields.
8. Development of a catalogue of details of mine fires prevailing in the Indian coalfields and actions being taken for their mitigation.
9. Assessment of potential fire areas in existing mines and suggesting preventive measures.
10. Strengthening R&D facilities at research and educational institutions.
11. Strengthening mine fire wings of the coal companies.

There are certain limitations in taking up mine fire management programme which need to be overcome through:

- Operational use of high technology (satellite/aerial data) for monitoring and estimation of extent and depth.
- Accelerating response time to meet needs of decision-makers.

- Mapping of fire-prone areas and appropriate planning Development of new tools such as thermal inertia mapping and AR interferometry for accurate information of fires.

The following recommendations are being made for the implementation of strategies for prevention of mine fires:

1. A comprehensive compendium of precise and accurate details of all existing mine fires in the Indian coalfields be prepared.
2. A workshop be organised with experts who should interact with the officials of the mining companies.
3. In the entire mining project proposals and related environmental management plans (EMPs), prevention of fire should be specifically addressed.
4. A comprehensive compendium on details of existing underground mines and open-cast mines be prepared coal field-wise so that the existing situation can be assessed for future occurrences of mine fires and hence implementation of preventive measures may be carried out.
5. Although a large number of claims have been made by R&D and educational institutions towards breakthroughs for mitigation and prevention of mine fires, a consolidated statement is not available. Hence, it will be advisable to direct the institutions to develop a compendium of achievements so far for the benefit of the industry.
6. The R&D and educational institutions may be directed to conduct studies addressing the problems faced by the mining industry in a time bound manner.
7. A high-powered committee comprising of real mining, mine fire, subsidence and environmental experts be formed to assess and oversee the actions being taken by the concerned agencies.
8. All the details be placed on a dedicated web-site with provision for continuous updating.
9. Wherever surface is likely to be affected by subsidence and their impacts with chances of fires, construction activities should not be permitted.
10. Actions should be initiated to relocate settlements from the coalfields that are threatened by mine fires.

Forest fire/ Wildfire

What causes forest fires?

Forest fire refers to the uncontrolled fire that erupts in the wilderness. It can be caused by many factors like lightning, volcanic eruptions and also human actions.

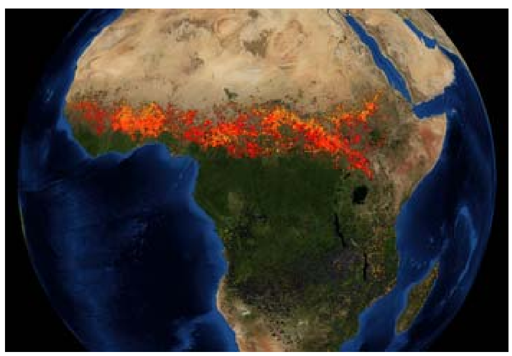
A wildfire in California, USA on 5 September 2008

A **wildfire** is any uncontrolled fire in combustible vegetation that occurs in the countryside or a wilderness area. Other names such as **brush fire**, **bushfire**, **forest fire**, **grass fire**, **hill fire**, **peat fire**, **vegetation fire**, **veldfire** and **wildland fire** may be used to describe the same phenomenon depending on the type of vegetation being burned. A wildfire differs from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to change direction unexpectedly, and its ability to jump gaps such as roads, rivers and fire breaks. Wildfires are characterized in terms of the cause of ignition, their physical properties such as speed of propagation, the combustible material present, and the effect of weather on the fire.

Wildfires occur on every continent except Antarctica. Fossil records and human history contain accounts of wildfires, as wildfires can occur in periodic intervals. Wildfires can cause extensive damage, both to property and human life, but they also have various beneficial effects on wilderness areas. Some plant spp. depend on the effects of fire for growth and reproduction, although large wildfires may also have -ve ecological effects.

Strategies of wildfire prevention, detection, and suppression have varied over the years, and wildfire management experts encourage further development of technology and research. One of the more controversial techniques is *controlled burning*: permitting or even igniting smaller fires to minimize the amount of flammable material available for a potential wildfire. While some wildfires burn in remote forested regions, they can cause extensive destruction of homes and other property located in the *wildland-urban interface*: a zone of transition between developed areas and undeveloped wilderness.

Characteristics



The distribution of wildfires on the African continent during the year 2002

The name *wildfire* was once a synonym for Greek fire but now refers to any large or destructive conflagration. Wildfires differ from other fires in that they take place outdoors in areas of grassland, woodlands, bushland, scrubland, peatland, and other wooded areas that act as a source of fuel, or combustible material. Buildings may become involved if a wildfire spreads to adjacent communities. While the causes of wildfires vary and the outcomes are always unique, all wildfires can be characterized in terms of their physical properties, their fuel type, and the effect that weather has on the fire.

Wildfire behavior and severity result from the combination of factors such as available fuels, physical setting, and weather. While wildfires can be large, uncontrolled disasters that burn through 0.4 to 400 square kilometers (100 to 100,000 acres) or more, they can also be as small as 0.0010 square kilometers (0.25 acres) or less. Although smaller events may be included in wildfire modeling, most do not earn press attention. This can be problematic because public fire policies, which relate to fires of all sizes, are influenced more by the way the media portrays catastrophic wildfires than by small fires.

Causes: The four major natural causes of wildfire ignitions are lightning, volcanic eruption, sparks from rockfalls, and spontaneous combustion. The thousands of coal seam fires that are burning around the world, such as those in Centralia, Burning Mountain, and several coal-sustained fires in China, can also flare up and ignite nearby flammable material. However, many wildfires are attributed to human sources such as arson, discarded cigarettes, sparks from equipment, and power line arcs (as detected by arc mapping). In societies experiencing shifting cultivation where land is cleared quickly and farmed until the soil loses fertility, slash and burn clearing is often considered the least expensive way to prepare land for future use. Forested areas cleared by logging encourage the dominance of flammable grasses, and abandoned logging roads overgrown by vegetation may act as fire corridors. Annual grassland fires in Southern Vietnam can be attributed in part to the destruction of forested areas by herbicides, explosives, and mechanical land clearing and burning operations during the Vietnam War.
The most common cause of wildfires varies throughout the world. In the United States, Canada, and Northwest China, for example, lightning is the major source of ignition. In other parts of the world, human involvement is a major contributor. In Mexico, Central America, South America, Africa, Southeast Asia, Fiji, and New Zealand, wildfires can be attributed to human activities such as animal husbandry, agriculture, and land-conversion burning. Human carelessness is a major cause of wildfires in China and in the Mediterranean Basin. In Australia, the source of wildfires can be traced to both lightning strikes and human activities such as machinery sparks and cast-away cigarette butts.

Fuel type

A surface fire in the western desert of Utah, US

Charred landscape following a crown fire in the North Cascades, US

The spread of wildfires varies based on the flammable material present and its vertical arrangement. For example, fuels uphill from a fire are more readily dried and warmed by the fire than those downhill, yet burning logs can roll downhill from the fire to ignite other fuels. Fuel arrangement and density is governed in part by topography, as land shape determines factors such as available sunlight and water for plant growth. Overall, fire types can be generally characterized by their fuels as follows:

- **Ground** fires are fed by subterranean roots, duff and other buried organic matter. This fuel type is especially susceptible to ignition due to spotting. Ground fires typically burn by smoldering, and can burn slowly for days to months, such as peat fires in Kalimantan and Eastern Sumatra, Indonesia, which resulted from a riceland creation project that unintentionally drained and dried the peat.

- **Crawling** or **surface** fires are fueled by low-lying vegetation such as leaf and timber litter, debris, grass, and low-lying shrubbery.
- **Ladder** fires consume material between low-level vegetation and tree canopies, such as small trees, downed logs, and vines. Kudzu, Old World climbing fern, and other invasive plants that scale trees may also encourage ladder fires.
- **Crown**, **canopy**, or **aerial** fires burn suspended material at the canopy level, such as tall trees, vines, and mosses. Ignition of a crown fire, termed *crowning*, is dependent on density of the suspended material, canopy height, canopy continuity, and sufficient surface and ladder fires in order to reach the tree crowns e.g., ground-clearing fires lit by humans can spread into the Amazon rain forest, damaging ecosystems not particularly suited for heat or arid conditions.

Physical properties

Wildfires occur when all of the necessary elements of a fire triangle come together in a wooded area: an ignition source is brought into contact with a combustible material such as vegetation, that is subjected to sufficient heat and has an adequate supply of oxygen from the ambient air. High moisture content usually prevents ignition and slows propagation, because higher temperatures are required to evaporate any water within the material and heat the material to its fire point. Dense forests usually provide more shade, resulting in lower ambient temperatures and greater humidity, and are therefore less susceptible to wildfires. Less dense material such as grasses and leaves are easier to ignite because they contain less water than denser material such as branches and trunks. Plants continuously lose water by evapotranspiration, but water loss is usually balanced by water absorbed from the soil, humidity, or rain. When this balance is not maintained, plants dry out and are therefore more flammable, often a consequence of droughts.

Experimental fire in Canada

A wildfire *front* is the portion sustaining continuous flaming combustion, where unburned material meets active flames, or the smoldering transition between unburned and burned material. As the front approaches, the fire heats both the surrounding air and woody material through convection and thermal radiation. First, wood is dried as water is vaporized at a temperature of 100°C (212°F). Next, the pyrolysis of wood at 230°C

(450°F) releases flammable gases. Finally, wood can smolder at 380°C (720°F) or, when heated sufficiently, ignite at 590°C (1,000°F). Even before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front warms the air to 800°C (1,470°F), which pre-heats and dries flammable materials, causing materials to ignite faster and allowing the fire to spread faster. High-temperature and long-duration surface wildfires may encourage flashover or *torching*: the drying of tree canopies and their subsequent ignition from below.

Wildfires have a rapid *forward rate of spread* (FROS) when burning through dense, uninterrupted fuels. They can move as fast as 10.8 kilometers per hour (6.7 mph) in forests and 22 kilometers per hour in grasslands. Wildfires can advance tangential to the main front to form a *flanking* front, or burn in the opposite direction of the main front by *backing*. They may also spread by *jumping* or *spotting* as winds and vertical convection columns carry *firebrands* (hot wood embers) and other burning materials through the air over roads, rivers, and other barriers that may otherwise act as firebreaks. Torching and fires in tree canopies encourage spotting, and dry ground fuels that surround a wildfire are especially vulnerable to ignition from firebrands. Spotting can create *spot fires* as hot embers and firebrands ignite fuels downwind from the fire. In Australian bushfires, spot fires are known to occur as far as 10 kilometers from the fire front.

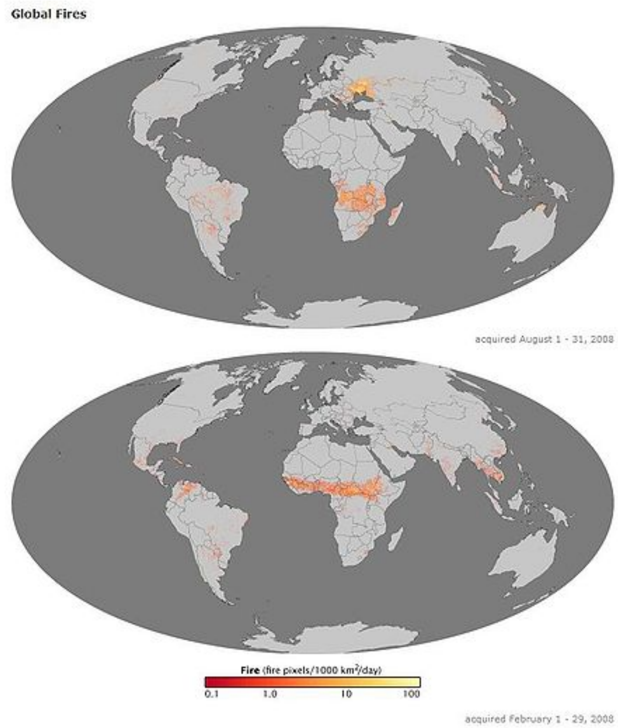
Especially large wildfires may affect air currents in their immediate vicinities by the stack effect: air rises as it is heated, and large wildfires create powerful updrafts that will draw in new, cooler air from surrounding areas in thermal columns. Great vertical differences in temperature and humidity encourage pyrocumulus clouds, strong winds, and fire whirls with the force of tornadoes at speeds of more than 80 kilometers per hour. Rapid rates of spread, prolific crowning or spotting, the presence of fire whirls, and strong convection columns signify extreme conditions.

Effect of weather

Heat waves, droughts, cyclical climate changes such as El Niño, and regional weather patterns such as high-pressure ridges can increase the risk and alter the behavior of wildfires dramatically. Years of precipitation followed by warm periods can encourage more widespread fires and longer fire seasons. Since the mid 1980s, earlier snowmelt and associated warming has also been associated with an increase in length and severity of the wildfire season in the Western United States. However, one individual element does not always cause an increase in wildfire activity. For example, wildfires will not occur during a drought unless accompanied by other factors, such as lightning (ignition source) and strong winds (mechanism for rapid spread).

Fire intensity also increases during daytime hours. Burn rates of smoldering logs are up to five times greater during the day due to lower humidity, increased temperatures, and increased wind speeds. Sunlight warms the ground during the day which creates air currents that travel uphill. At night the land cools, creating air currents that travel downhill. Wildfires are fanned by these winds and often follow the air currents over hills and through valleys. Fires in Europe occur frequently during the hours of 12:00 p.m. and 2:00 p.m. Wildfire suppression operations in the United States revolve around a 24-hour *fire day* that begins at 10:00 a.m. due to the predictable increase in intensity resulting from the daytime warmth.

Ecology



Global fires during the year 2008 for the months of August (top image) and February (bottom image), as detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite.

Wildfires are common in climates that are sufficiently moist to allow growth of vegetation but feature extended dry, hot periods. Such places include vegetated areas of Australia and Southeast Asia, the veld in southern Africa, the fynbos in Western Cape of South Africa, the forested areas of the United States and Canada, and the Mediterranean Basin. Fires can be particularly intense during days of strong winds, periods of drought, and during warm summer months. Global warming may increase the intensity and frequency of droughts in many areas, creating more intense and frequent wildfires.

Although some ecosystems rely on naturally occurring fires to regulate growth, many ecosystems suffer from too much fire, such as the chaparral in southern California and lower elevation deserts in the American Southwest. The increased fire frequency in these ordinarily fire-dependent areas has upset natural cycles, destroyed native plant communities, and encouraged the growth of fire-intolerant vegetation and non-native weeds. Invasive species, such as *Lygodium microphyllum* and *Bromus tectorum*, can grow rapidly in areas that were damaged by fires. Because they are highly flammable, they can increase the future risk of fire, creating a positive feedback loop that increases fire frequency and further destroys native growth.

In the Amazon Rainforest, drought, logging, cattle ranching practices, and slash-and-burn agriculture damage fire-resistant forests and promote the growth of flammable brush, creating a cycle that encourages more burning. Fires in the rainforest threaten its collection of diverse species and produce large amounts of CO_2. Also, fires in the rainforest, along with drought and human involvement, could damage or destroy more than half of the Amazon rainforest by the year 2030. Wildfires generate ash, destroy available organic nutrients, and cause an increase in water runoff, eroding away other nutrients and creating flash flood conditions. A 2003 wildfire in the North Yorkshire Moors destroyed 2.5 square kilometers (600 acres) of heather and the underlying peat layers. Afterwards, wind erosion stripped the ash and the exposed soil, revealing archaeological remains dating back to 10,000 BC. Wildfires can also have an effect on climate change, increasing the amount of carbon released into the atmosphere and inhibiting vegetation growth, which affects overall carbon uptake by plants.

Plant adaptation

Ecological succession after a wildfire in a boreal pine forest next to Hara Bog, Lahemaa National Park, Estonia.

The pictures were taken one and two years after the fire.

Plants in wildfire-prone ecosystems often survive through adaptations to their local fire regime. Such adaptations include physical protection against heat, increased growth after a fire event, and flammable materials that encourage fire and may eliminate competition. For example, plants of the genus *Eucalyptus* contain flammable oils that encourage fire and hard sclerophyll leaves to resist heat and drought, ensuring their dominance over less fire-tolerant species. Dense bark, shedding lower branches, and high water content in external structures may also protect trees from rising temperatures. Fire-resistant seeds and reserve shoots that sprout after a fire encourage species preservation, as embodied by pioneer species. Smoke, charred wood, and heat can stimulate the germination of seeds in a process called *serotiny*. Exposure to smoke from burning plants promotes germination in other types of plants by inducing the production of the orange butenolide.

Grasslands in Western Sabah, Malaysian pine forests, and Indonesian *Casuarina* forests are believed to have resulted from previous periods of fire. Chamise deadwood litter is low in water content and flammable, and the shrub quickly sprouts after a fire. Sequoia rely on periodic fires to reduce competition, release seeds from their cones, and clear the soil and canopy for new growth. Caribbean Pine in Bahamian pineyards have adapted to and rely on low-intensity, surface fires for survival and growth. An optimum fire frequency for growth is every 3 to 10 years. Too frequent fires favor herbaceous plants, and infrequent fires favor species typical of Bahamian dry forests.

Atmospheric effects

See also: Air pollution, Atmospheric chemistry, Haze, 1997 Southeast Asian haze, 2005 Malaysian haze, and 2006 Southeast Asian haze

A Pyrocumulus cloud produced by a wildfire in Yellowstone National Park

Most of the Earth's weather and air pollution reside in the troposphere, the part of the atmosphere that extends from the surface of the planet to a height of about 10 kilometers (6 mi). The vertical lift of a severe thunderstorm or pyrocumulonimbus can be enhanced in the area of a large wildfire, which can propel smoke, soot, and other particulate matter as high as the lower stratosphere. Previously, prevailing scientific theory held that most particles in the stratosphere came from volcanoes, but smoke and other wildfire emissions have been detected from the lower stratosphere. Pyrocumulus clouds can reach 6,100 meters (20,000 ft) over wildfires. Increased fire byproducts in the stratosphere can increase ozone concentration beyond safe levels. Satellite observation of smoke plumes from wildfires revealed that the plumes could be traced intact for distances exceeding 1,600 kilometers (1,000 mi). Computer-aided models such as CALPUFF may help predict the size and direction of wildfire-generated smoke plumes by using atmospheric dispersion modeling.

Wildfires can affect climate and weather and have major impacts on atmospheric pollution. Wildfire emissions contain fine particulate matter which can cause cardiovascular and respiratory problems. Forest fires in Indonesia in 1997 were estimated to have released between 0.81 and 2.57 gigatonnes (0.89 and 2.83 billion short tons) of CO_2 into the atmosphere, which is between 13%–40% of the annual carbon dioxide emissions from burning fossil fuels. Atmospheric models suggest that these concentrations of sooty particles could increase absorption of incoming solar radiation during winter months by as much as 15%.

Smoke trail- while looking towards Dargo from Swifts Creek, Victoria, Australia, 11 January 2007

Human involvement

The human use of fire for agricultural and hunting purposes during the Paleolithic and Mesolithic ages altered the preexisting landscapes and fire regimes. Woodlands were gradually replaced by smaller vegetation that facilitated travel, hunting, seed-gathering and planting. In recorded human history, minor allusions to wildfires were mentioned in the Bible and by classical writers such as Homer. However, while ancient Hebrew, Greek, and Roman writers were aware of fires, they were not very interested in the uncultivated lands where wildfires occurred. Wildfires were used in battles throughout human history as early thermal weapons. From the Middle ages, accounts were written of occupational burning as well as customs and laws that governed the use of fire. In Germany, regular burning was documented in 1290 in the Odenwald and in 1344 in the Black Forest. In 14th century Sardinia, firebreaks were used for wildfire protection. In Spain during the 1550s, sheep husbandry was discouraged in certain provinces by Philip II due to the harmful effects of fires used in transhumance. As early as the 1600s, Native Americans were observed using fire for many purposes including cultivation, signaling, and warfare. Scottish botanist David Douglas noted the native use of fire for tobacco cultivation, to encourage deer into smaller areas for hunting purposes, and to improve foraging for honey and grasshoppers. Charcoal found in sedimentary deposits off the Pacific coast of Central America suggests that more burning occurred in the 50 years before the Spanish colonization of the Americas than after the colonization. In the post-World War II Baltic region, socio-economic changes led more stringent air quality standards and bans on fires that eliminated traditional burning practices.

Wildfires typically occurred during periods of increased temperature and drought. An increase in fire-related debris flow in alluvial fans of northeastern Yellowstone National Park was linked to the period between AD 1050 and 1200, coinciding with the Medieval Warm Period. However, human influence caused an increase in fire frequency. Dendrochronological fire scar data and charcoal layer data in Finland suggests that, while many fires occurred during severe drought conditions, an increase in the number of fires during 850 BC and 1660 AD can be attributed to human influence. Charcoal evidence from the Americas suggested a general decrease in wildfires between 1 AD and 1750 compared to previous years. However, a period of increased fire frequency between 1750 and 1870 was suggested by charcoal data from North America and Asia, attributed to human population growth and influences such as land clearing practices. This period was followed by an overall decrease in burning in the 20th century, linked to the expansion of agriculture, increased livestock grazing, and fire prevention efforts.

Prevention

Wildfire prevention refers to the preemptive methods of reducing the risk of fires as well as lessening its severity and spread. Effective prevention techniques allow supervising agencies to manage air quality, maintain ecological balances, protect resources, and to limit the effects of future uncontrolled fires. North American firefighting policies may permit naturally caused fires to burn to maintain their ecological role, so long as the risks of escape into high-value areas are mitigated. However, prevention policies must consider the role that humans play in wildfires, since, for example, 95% of forest fires in Europe are related to human involvement. Sources of human-caused fire may include arson, accidental ignition, or the uncontrolled use of fire in land-clearing and agriculture such as the slash-and-burn farming in Southeast Asia.

In the mid-1800s, explorers from the HMS Beagle observed Australian Aborigines using fire for ground clearing, hunting, and regeneration of plant food in a method called fire-stick farming. Such careful use of fire has been employed for centuries in the lands protected by Kakadu National Park to encourage biodiversity. In 1937, U.S. President Franklin D. Roosevelt initiated a nationwide fire prevention campaign, highlighting the role of human carelessness in forest fires. Later posters of the program featured Uncle Sam, leaders of the Axis powers of World War II, characters from the Disney movie *Bambi*, and the official mascot of the U.S. Forest Service, Smokey Bear.

A prescribed burn in a Pinus nigra stand in Portugal

Wildfires are caused by a combination of natural factors such as topography, fuels, and weather. Other than reducing human infractions, only fuels may be altered to affect future fire risk and behavior. Wildfire prevention programs around the world may employ techniques such as *wildland fire use* and *prescribed or controlled burns*. *Wildland fire use* refers to any fire of natural causes that is monitored but allowed to burn. *Controlled burns* are fires ignited by government agencies under less dangerous weather conditions.Vegetation may be burned periodically to maintain high species diversity, and frequent burning of surface fuels limits fuel accumulation, thereby reducing the risk of crown fires. Using strategic cuts of trees, fuels may also be removed by handcrews in order to clean and clear the forest, prevent fuel build-up, and create access into forested areas. Chain saws and large equipment can be used to thin out ladder fuels and shred trees and vegetation to a mulch. Multiple fuel treatments are often needed to influence future fire risks, and wildfire models may be used to predict and compare the benefits of different fuel treatments on future wildfire spread. However, controlled burns are reportedly "the most effective treatment for reducing a fire’s rate of spread, fireline intensity, flame length, and heat per unit of area" according to Jan Van Wagtendonk, a biologist at the Yellowstone Field Station. Additionally, while fuel treatments are typically limited to smaller areas, effective fire management requires the administration of fuels across large landscapes in order to reduce future fire size and severity.

Building codes in fire-prone areas typically require that structures be built of flame-resistant materials and a defensible space be maintained by clearing flammable materials within a prescribed distance from the structure. Communities in the Philippines also maintain fire lines 5 to 10 meters wide between the forest and their village, and patrol these lines during summer months or seasons of dry weather. Fuel buildup can result in costly, devastating fires as new homes, ranches, and other development are built adjacent to wilderness areas. Continued growth in fire-prone areas and rebuilding structures destroyed by fires has been met with criticism. However, the population growth along the wildland-urban interface discourages the use of current fuel management techniques. Smoke is an irritant and attempts to thin out the fuel load is met with opposition due to desirability of forested areas, in addition to other wilderness goals such as endangered species protection and habitat preservation. The ecological benefits of fire are often overridden by the economic and safety benefits of protecting structures and human life. For example, while fuel treatments decrease the risk of crown fires, these techniques destroy the habitats of various plant and animal species. Additionally, government policies that cover the wilderness usually differ from local and state policies that govern urban lands.

A ponderosa pine stand in the Bitterroot National Forest in Montana in 1909, 1948, and 1989. The increase in vegetation density was attributed to fire prevention efforts since 1895.

Detection

Fast and effective detection is a key factor in wildfire fighting. Early detection efforts were focused on early response, accurate results in both daytime and nighttime, and the ability to prioritize fire danger. Fire lookout towers were used in the United States in the early 1900s and fires were reported using telephones, carrier pigeons, and heliographs. Aerial and land photography using instant cameras were used in the 1950s until infrared scanning was developed for fire detection in the 1960s. However, information analysis and delivery was often delayed by limitations in communication technology. Early satellite-derived fire analyses were hand-drawn on maps at a remote site and sent via overnight mail to the fire manager. During the Yellowstone fires of 1988, a data station was established in West Yellowstone, permitting the delivery of satellite-based fire information in approximately four hours.

Dry Mountain Fire Lookout in the Ochoco National Forest, Oregon, circa 1930

Currently, public hotlines, fire lookouts in towers, and ground and aerial patrols can be used as a means of early detection of forest fires. However, accurate human observation may be limited by operator fatigue, time of day, time of year, and geographic location. Electronic systems have gained popularity in recent years as a possible resolution to human operator error. These systems may be semi- or fully-automated and employ systems based on the risk area and degree of human presence, as suggested by GIS data analyses. An integrated approach of multiple systems can be used to merge satellite data, aerial imagery, and personnel position via Global Positioning System (GPS) into a collective whole for near-realtime use by wireless Incident Command Centers.

A small, high risk area that features thick vegetation, a strong human presence, or is close to a critical urban area can be monitored using a local sensor network. Detection systems may include wireless sensor networks that act as automated weather systems: detecting temperature, humidity, and smoke. These may be battery-powered, solar-powered, or *tree-rechargeable*: able to recharge their battery systems using the small electrical currents in plant material. Larger, medium-risk areas can be monitored by scanning towers that incorporate fixed cameras and sensors to detect smoke or additional factors such as the infrared signature of carbon dioxide produced by fires. Additional capabilities such as night vision, brightness detection, and color change detection may also be incorporated into sensor arrays.

Satellite and aerial monitoring can provide a wider view and may be sufficient to monitor very large, low risk areas. These more sophisticated systems employ GPS and aircraft-mounted infrared or high-resolution visible cameras to identify and target wildfires. Satellite-mounted sensors such as Envisat's Advanced Along Track Scanning Radiometer and European Remote-Sensing Satellite's Along-Track Scanning Radiometer can measure infrared radiation emitted by fires, identifying hot spots greater than 39 °C (102 °F). The National Oceanic and Atmospheric Administration's Hazard Mapping System combines remote-sensing data from satellite sources such as Geostationary Operational Environmental Satellite (GOES),

Wildfires across the Balkans in late July 2007 (MODIS image)

Moderate-Resolution Imaging Spectroradiometer (MODIS), and Advanced Very High Resolution Radiometer (AVHRR) for detection of fire and smoke plume locations. However, satellite detection is prone to offset errors, anywhere from 2 to 3 kilometers (1 to 2 mi) for MODIS and AVHRR data and up to 12 kilometers (7.5 mi) for GOES data. Satellites in geostationary orbits may become disabled, and satellites in polar orbits are often limited by their short window of observation time. Cloud cover and image resolution and may also limit the effectiveness of satellite imagery.

Suppression:

Wildfire suppression depends on the technologies available in the area in which the wildfire occurs. In less developed nations such as Thailand, the techniques used can be as simple as throwing sand or beating the fire with sticks or palm fronds. In more advanced nations, the suppression methods vary due to increased technological capacity. Silver iodide can be used to encourage snow fall, while fire retardants and water can be dropped onto fires by unmanned aerial vehicles, planes, and helicopters. Complete fire suppression is no longer an expectation, but the majority of wildfires are often extinguished before they grow out of control. While more than 99% of the 10,000 new wildfires each year are contained, escaped wildfires can cause extensive damage. Worldwide damage from wildfires is in the billions of euros annually. Wildfires in Canada and the US burn an average of 54,500 square kilometers (13,000,000 acres) per year.

Tanker 910 during a drop demonstration in December, 2006

Above all, fighting wildfires can become deadly. A wildfire's burning front may also change direction unexpectedly and jump across fire breaks. Intense heat and smoke can lead to disorientation and loss of appreciation of the direction of the fire, which can make fires particularly dangerous. For example, during the 1949 Mann Gulch fire in Montana, USA, thirteen smokejumpers died when they lost their communication links, became disorientated, and were overtaken by the fire. In the Australian February 2009 Victorian bushfires, at least 173 people died and over 2,029 homes and 3,500 structures were lost when they became engulfed by wildfire.

The Effects of Forest Fires on Animals

Nothing is more destructive to a forest environment than fire. This unpredictable element can quickly and easily devour miles of forest land, leaving a path of charred ruin in its wake. News programs often give detailed reports about property damage and measure the effects of forest fires in terms of dollars. However, these devastating events have another set of casualties: animals. The forest fauna experiences drastic changes when a fire seizes the land.

Injury and Mortality- One of the first and most direct effects a fire will have on forest animals is injury or death. This can be from the fire itself or from inhalation of toxic fumes produced within the blaze. Vertebrates are less likely to be greatly affected in this fashion. When vertebrate deaths do occur, there are usually no lasting effects on the population.

Spike in Food Supply- When a forest is damaged by fire, new and beneficial minerals are introduced to the soil. These nutrients stimulate the growth of enriched plant life, providing an abundance of food for forest-dwelling fauna. In some cases, animals will eat ash or the charred bark of trees and obtain beneficial minerals.

Population Growth- For the animals that benefit from the surge in the food supply, it is not uncommon for an increase in population to occur. This boom in forest animal births does not necessarily mean they will thrive over the long term. This is because the post-fire environment is barren and simplistic, offering little potential for long-term adjustment.

Forced Migration- Forest fires turn the area into a scorched and simplified habitat. While some animals are equipped to survive in this type of setting, others are not. Unfortunately, these animals are forced to vacate the altered habitat and seek new surroundings. These animals often perish when unable to locate new dwellings.

Forest Fires in India

The most common hazard in forests is forests fire. Forests fires are as old as the forests themselves. They pose a threat not only to the forest wealth but also to the entire regime to fauna and flora seriously disturbing the bio-diversity and the ecology and environment of a region. During summer, when there is no rain for months, the forests become littered with dry senescent leaves and twinges, which could burst into flames ignited by the slightest spark. The Himalayan forests, particularly, Garhwal Himalayas have been burning regularly during the last few summers, with colossal loss of vegetation cover of that region.

Oil Fire

Oil fires are oil wells/tanks that have caught on fire, and burn. Petroleum is highly inflammable. It is processed at high pressure and temperature. Oil fires can be the result of human actions, such as accidents or arson or natural events, such as lightning. They can exist on a small scale, such as an oil field spill catching fire, or on a huge scale, as in geyser-like jets of flames from ignited high pressure oil wells.

Effects

Oil well fires/tanks can cause the loss of millions of barrels of crude oil per day. Combined with the ecological problems caused by the large amounts of smoke and unburnt petroleum falling back to earth, oil tanks fires was seen in Jaipur and oil well fire generally 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. There are several techniques used to put out oil well fires, which vary by resources available and the characteristics of the fire itself. In essence the trade was started by Myron M. Kinley, who dominated the field in the early years. His lieutenant, Red Adair, went on to become the most famous of oil well firefighters.

Extinguishing the fires

The techniques include:

- Dousing with copious amounts of water
- Raising the plume- Inserting one metal casing 30 to 40 feet high over the well head (thus raising the flame above the ground). Liquid nitrogen or water is then forced in at the bottom to reduce the oxygen supply and put out the fire.
- Drill relief wells into the producing zone to redirect some of the oil and make the fire smaller. (However, most relief wells are used to pump heavy mud and cement deep into the wild well).
- Using a gas turbine to blast a fine mist at the fire. Water is injected to the compressor section of the turbine in large quantities. This does not harm the turbine. This technique is also used for cleaning turbines.
- Using dynamite to 'blow out' the fire by blasting fuel and oxygen from the flame and consuming oxygen in the combustion. This was one of the earliest effective methods and is still widely used. The first use was in California in 1913.
- Dry Chemical (mainly Purple K) can be used on small well fires such as those in refineries.

Special vehicles called "Athey wagons" as well as the typical bulldozer protected by corrugated steel sheeting are normally used in the process.

Air pollution

Air pollution is defined as an undesirable change in the physical, chemical or biological characteristics of air that may be harmful to human, other life, plants and cultural assets. In broad sense pollution is the thermodynamic disorder that is the byproduct of energy conversion and the use of resources.

Types of Air Pollutants: Two main groups of air pollutants based on their way of emission:

Primary pollutants: These emitted directly into the air are called primary pollutants e.g. particulates, sulfur dioxide, carbon monoxide, nitrogen oxides and hydro carbons.

Secondary pollutants: These are the pollutants produced through reactions between primary pollutants and normal atmospheric compounds e.g. ozone in lower atmosphere over urban areas. Products from photo chemical processes are called photoxidents, which mainly occur as a consequence of traffic immissions which have toxic and irritating effects. Under the influence of sunlight, nitrogen oxides and reactive hydro carbons enter into photo chemical reactions resulting in production of ozone and secondary products such as peroxides, aldehydes, free redicals and peroxiacetylnitrate (PAN).

Sources and effects of pollutants

Sulfur dioxide: The major anthropogenic source of Sulfur oxide (SO_2) is the burning of fossil fuels mostly coal in power plants. Adverse effects include corrosion of paint and metals and injury or death to animals and plants. SO_2 is an irritant gas with adverse effects on the respiratory tract of humans and animals and also on the assimilation apparatus of plants. Even after short-term influence SO_2 conc. above 0.2 mg/m^3 of air can cause serious disorders in the assimilation organs of conifers and necrotic changes. Building materials sensitive to acids such as lime stones, sand stone, marble etc. are corroded and destroyed.

Nitrogen oxides: They are emitted mainly in two forms: NO and NO_2. Nearly all NO_2 is emitted from automobiles and power plants that burn fossil fuels. Nitrous oxides (NO_x), mixture of NO, NO_2, N_2O_3 and N_2O_4, considerably contribute to air pollution. The human seems more endangered by nitrous gases than plants. In case of low conc. there are only scattered discolourations of leaves around the assimilation organs of coniferous and deciduous trees. If nitrogen oxides are inhaled, they react with hemoglobin and produce methamoglobin, but, after an initial irritant phase, they also bring about increased respiratory activity and oedemass of the lungs. It causes irritation of eyes, nose, throat and lungs and increase susceptibility to viral infections.

Carbon monoxide: Approximately 90% of the CO in atmosphere comes from the natural sources and remaining 10% comes from incomplete burning of organic compounds, fires and automobiles. It is hazardous to people with known heart disease, anemia or respiratory disease. It may cause birth defects. It may also cause death on long exposure to high conc.

Photochemical oxidants: They results from atmospheric interactions of nitrogen oxide and sun light. e.g. O_3 and other photochemical oxidants such as PANs (peroxyacetylnitrates) occur with photochemical smog. At high conc. O_3 kills leaf tissue and even can kills whole plant if pollutant level remains high. O_3 effect on animals including human, involves various kinds of damage, especially to eyes and the respiratory system. The consequences of O_3 or photo-oxidants exposure in plants become manifest as spot necroses, first blue green, latter almost white. In tobacco plants, spot necroses appear on leaf surfaces and these symptoms are so called "Weather flecks" or ozone flecks. Tip necroses occur in other plants *eg.,* onion leaves.

Hydrocarbons: Over 80% of hydrocarbons such as methane, butane and propane etc. are emitted through natural sources. The most important anthropogenic source is the automobile. e.g. gasoline in car's tank may spill and evaporates in atmosphere. The adverse effects of hydrocarbons are numerous. At specific concentration they are toxic to plants and animals or may be converted into harmful compounds through chemical changes in the atmosphere. It is true that very low amounts of ethylene are produced by many plants themselves and that ethylene has the characteristics of a phyto-hormone and is increasingly excreted under stress conditions. Ethylene exposure causes chloroses and necroses which were accompanied by the leaf edges curling up often followed by a wrapping of the leaf stem in tomato. In many plants, the youngest leaves react first. Further symptoms are growth depression and fading phenomena.

Hydrogen sulfide: It is produced from natural sources such as geysers, swamps and bogs and as well as human sources such as petroleum refining and metal smelting. It is highly toxic and corrosive gas. It causes health problem ranging from toxicity to death of humans and other animals. Hydrogen sulfide is a cell and enzyme poison, which can cause severe poisoning and nervous damage in human and animals. Moreover, it can also effect plant enzymes and thus it produces irreversible damage.

Hydrogen fluoride: It is released from aluminium production, coal gasification and the burning of coal in power plants. Even at very low concentration (1ppb) may cause problems for plants and animals. Damage caused by hydrogen fluoride can be clearly recognized by the discolouration of the edges and tip of leaves, mostly brown in popular and black in birch leaves and leaves curling up at the edges. Hydrogen fluoride emissions cause necroses at the apical part of fruits. They can result in deterioration in fruit flavour.

Chlorine and hydrogen chloride: They cause severe damage in plants. Elementary chlorine and hydrogen chloride are used for the production of synthetic materials and insecticides. There is an increasing production of hydrogen chloride containing waste gases in the combustion of PVC containing plastic wastes. Chloride and hydrogen chloride vapours sink to the ground and therefore affect in close vicinity of emitter. The inhalation of these gases at higher concentrations leads to severe health damage. The mucous membrane of the respiratory tract is destroyed.

Ammonia: In the vicinity of intensive animal keeping, conifers respond most sensitively to ammonia and alkylamine containing waste gases produced by decomposition of urea and uric acid or by the combustion of animal faeces. The needles of conifers turn red brown and drop off. Ammonia often causes a dark brown to black colouring of the leaves of deciduous trees and potato leaves. Turnip show bright spots on young shoots or leaves.

Particulate matter: Farming adds considerable particulates to the atmosphere, as do desertification and volcanic eruptions. Particulate matters are smoke, soot or dust, air born asbestos and small particles of heavy metals as arsenic, copper, lead and zinc, which are usually emitted from industrial facilities such as smelters (Table 2). Among most fine particulates (<2.5 µm diameter) are sulphates and nitrates.

Fine particles are easily inhaled into the lungs where they can be absorbed by the blood stream or remain embedded for a long period of time. Particulate matter is particularly hazardous to the elders, and those with respiratory problems such as asthma. Adverse effect of fly ashes is mainly seen in the pollution of vegetables and fodder plants. Fly ash sedimentation on fodder plants leads to a depreciation of feed-stuffs, reduced feed intake by animals, decreased milk production and some times physiological damage in pasture animals. In spite of the initial positive effects of their Ca and Mg content, long term dust sedimentations can also leads to considerable disturbances in the nutrient balance of soils used for agriculture and horticulture. The alkaline dust emitted by kilns and other sources in cement plants are mixture of K, Ca and Al contain minerals. They cause imbalance in nutrient content of soils and some time cause considerable yield reductions in orchards. The dust containing heavy metal particles affect growth and yield in agriculture and horticulture. The accumulation of lead, zinc and arsenic oxides in upper layers of soil leads to root depression and thus growth disturbances in plants. In extreme cases the growth of cultivated plants can be completely stunted.

Sources of Air Pollution

The two major kinds of air pollution sources are stationary sources and mobile sources.

1. Stationary sources:

i) Point sources: These sources emit air pollutants from one or more controllable sites such as smoke stacks of power plants at industrial sites.

ii) Fugitive sources: These sources generate air pollutants from open areas exposed to wind processes. e.g. dirt roads, construction sites, farm lands, surface mines, storage piles and other exposed areas from where particulates may be removed by wind.

iii) Area sources: These are the locations from which air pollutants are emitted from well defined areas within which are several sources. e.g. small urban communities or areas of intense industrialization within urban complexes or agricultural areas sprayed with herbicides and pesticides.

2. Mobile sources: These are emitters of air pollutants which move from place to place while yielding emissions. e.g. automobiles trucks, buses, aircrafts, trains etc.

Dispersion of air pollution

In the course of the transmission of air pollutants from source to the site where they take effect as emissions, they are affected by emissions source parameters, meteorological and geographical factors. These determine how far and where waste gases are transmitted and which concs. are to be reckoned within the emission area.

A. Emission source parameters

- Temperature of waste gases
- Outlet speed of gases
- Height of chimney
- Physical-chemical properties of emission

B. Weather factors

i) Wind direction: All types of pollution are carried alongwith air stream in down wind direction.

ii) Wind speed: In case of constant emission, the conc. of air pollution depends on wind speed and exchange. The more air stream over the chimney within a period of time, the lower the waste gases concentration per m^3 air. Generally speaking, emission exposure will therefore be lower in plain areas than in hilly and mountainous where air exchange is impeded. The vertical exchange increases with wind speed and irregular relief of the land.

iii) Thermic turbulence: Convection or thermic turbulence cause vertical exchange, which helps in dispersion of pollutants in higher atmosphere.

iv) Inversion: Radiational cooling during night results in inverse temperature gradient called as inversion. Temperature inversion stable atmosphere, which is a favourable condition for air pollution. The plume of waste gases remains at chimney height.

v) Precipitation: It results in certain cleaning of the air. Rain drops absorbs pollutant gases during their fall through air and carry them to ground, this form of emission is called wet deposition. When gas and dust particles reach ground, vegetation without help of rain called as dry deposition. When clouds are formed, gas and dust particles are incorporated into the drops of water in the course of hours and carried in long distances and fall to the ground with rain, called rain out.

C. **Geographic conditions:** Vegetation and buildings increase the irregularity of the ground and thus turbulence. So, they promote sedimentation of air borne dusts. The relief influences the wind direction. Hills at night angles to wind direction and deeply cut valleys are particularly problematic when low chimneys stand in front of or in them.

Control measures of air pollution

Air pollution control may be defined as the various measures taken to meet certain emission standards. These measures may include changes in processes/raw materials or modification of equipment. Another method is the installation of devices at the end of process equipment to treat the exhaust gas stream. These devices are called air pollution control equipment. In the coming section, we shall focus on the equipments that are used for the control of particulate matter.

Particulate control devices:

1. **Force field settlers:** These are equipments that use a field of force for the collection of particulate. There are three types of force fields: gravitational, centrifugal and electrical. **Gravitational settling chambers** utilize gravitational force, centrifugal collectors utilize centrifugal force and **electrostatic precipitators** utilize electric field.
2. **Fabric filters:** They are based on the principle of filtration for the removal of particulates.
3. **Scrubbers:** They remove particulates from the exhaust gas stream by using water droplets for capturing them.

Of the above, electrostatic precipitator and fabric filters possess the highest collection efficiencies.

Some of the general control measures:

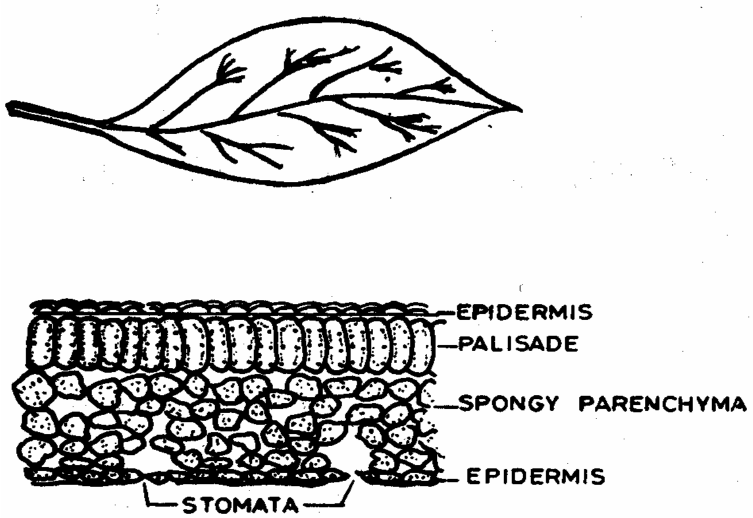
1. Tall chimneys should be installed in industries to reduce air pollution on ground.
2. Better designed fuel burning equipments should be used in homes and industries so that complete burning of fuel takes place.
3. Renewable and non-polluting sources of energy like solar energy and wind energy should be used e.g. solar cookers, wind machines etc.
4. Motor, vehicles should be maintained properly.
5. Strict emission control for automobiles e.g. Euro-II.
6. Zero pollutant automobiles should be manufactured and used. e.g. electric cars.
7. There should be increased control on industrial activities and household activities that are known to contribute to air pollution.
8. More trees should be planted.

Effects of Air Pollution on Plants

Air pollution has long been known to adversely affect the plants. Initially, it was the sulphur dioxide that was considered a dangerous pollutant. Now, with the advent of different pesticides and new industrial processes, the range of harmful pollutants has multiplied tremendously. Some-times, vegetation over hundreds of km away from the source of the pollutant has been found to be affected.

Knowledge of leaf structure is essential to understand the damage on plants due to air pollutants. Leaf has a network of denser structures, the veins, all interconnected to the base or stem of the leaf. The leaf veins act as the transport system for water and food, just like blood vessels in animals. The leaf tissue is in layers with a skin or epidermis layers on top and bottom and the photosynthetic cells in between. The stomata are the entrances in the leaf bottom (and in some leaves in the top) through which CO_2 enters to play its role in photo-synthesis. These openings are protected by pairs of specialized guard cells which open and close to allow gases to enter or leave the leaf. Such gases of course, include pollutants like sulphur dioxide.

The primary factor, which controls gas absorption by the leaves, is the degree of opening of the stomata. When the stomata are wide open, absorption is maximum and vice versa. Consequently, the same conditions that enhance the absorption of the gas (CO_2 for photosynthesis), predispose the plant to injury (by absorbing a pollutant gas like SO_2). The conditions that cause the stomata to open are high light intensity (especially in the morning hours), high relative humidity, and adequate moisture supply to the roots of the plant and moderate temperatures.



Most plants close their stomata at night and are therefore much more resistant at night than in the day-time. But some plants like the potato, which do not close their stomata at night are as sensitive in the dark as in the light.

Major hazards

i) A fog of three days occurred in Meuse valley (Belgium) in 1930 due to the air pollution caused by steel, power, sulphuric acid and zinc plants and resulted in death of 60 people, hundreds of people became ill and cattle became sick.

ii) About 4000 people died and thousand hospitalized for respiratory troubles due to a polluted fog (smoke and SO_2) in December, 1952 at London (England).

iii) A severe smog caused by photochemical smoke and PAN occurred in 1945 at Los Angles (U. S. A) and resulted in reduction in visibility, irritation to eyes and damage to vegetation.

iv) Photochemical oxidant reacts with SO_2, resulted in acid mist at Tokyo (Japan) in June, 1970 and about 6000 people suffered with eye irritation, sore throat and breathing difficulty.

v) In Bhopal (India), release of deadly methyl isocynate released due to failure of vent scrubber system on 3rd December, 1984 as a result of poised air pollution about 2500 people died and one lac people severely affected by suffocation and cardiac failure.

Water pollution

Water pollution involves any contaminated water, whether from chemical, particulate, or bacterial matter that degrades the water's quality and purity. Water pollution can occur in oceans, rivers, lakes, and underground reservoirs, and as different water sources flow together the pollution can spread.

Causes of water pollution include:

- Increased sediment from soil erosion
- Improper waste disposal and littering
- Leaching of soil pollution into water supplies
- Organic material decay in water supplies

The effects of water pollution include decreasing the quantity of drinkable water available, lowering water supplies for crop irrigation, and impacting fish and wildlife populations that require water of certain purity for survival. The sign of water pollution are bad taste, massive weed growth in water bodies, emission of disgusting odour, decrease in aquatic life, oil can be seen floating on surface of water bodies or deposited as scum on breaches etc. Water pollution, pollutants will be classified into nine categories: Oxygen demanding wastes, disease causing agents, plant nutrients, synthetic organic compounds, oil, inorganic chemicals, sediments and radioactive materials.

Sources of water pollution

The sources which cause water pollution can be classified into four categories:

i) Municipal and domestic oxygen demanding wastes which contains decomposable organic matter and pathogenic agents. Municipal and domestic wastes includes waste water from homes, commercial establishment, consist of domestic refuge, municipal garbage and other wastes like animal wastes, crops and yard wastes and garbages are mainly of organic origin.

ii) Most of the Indian rivers and fresh water streams are seriously polluted by industrial wastes or effluents which come along waste water of different industries such as petrochemical complexes, fertilizer factories, oil refineries, pulp and paper, textile, sugar and steel mills, tanneries, distilleries, coal washeries, synthetic material plants for drugs, fibers, rubber etc.

iii) Agricultural wastes includes sediments, fertilizers, pesticides and farm animals wastes which reach to water bodies through runoff and by leaching through soil to groundwater. Excessive use of agrichemicals like fertilizers, pesticides such as BHC, DDT etc. made them an integral part of chemical and biochemical cycles of the earth. Even these pesticides have been detected in Arctic region.

Major hazards

i) The “itai-itai’ disease in Japan due to cadmium poisoning was traced due to discharge of waste water from a mine processing Cu, Zn in ‘Jintsee River’. The river water is used in paddy crop irrigation. Similarly Minmata was caused in 1955 by mercury poisoning.

ii) Lake Zurich in Switzerland and lake Erie in Canada are classic examples of induced eutrophication.

iii) Discharge of large quantities of oil along with the effluents from an oil refinery set the river aflame and resulted in suspension of water supply to the town and the refinery near Monghya, Bihar in 1968.

iv) Hoogly at Calcutta is receiving waste from power station, paper, jute, textile and chemical mills at an average rate of 52 tones/day. The water quality is worst than 4th grade as proposed by WHO.

v) The water of 'Yamuna' at Okhala industrial area for about 48 kms stretch is unfit ever for irrigation purposes.

vi) Discharge of untreated waste water from a group of dye industries into the Kalu River near Mumbai, resulted in lowering of pH to 4.0.

Deforestation

The expansion of agricultural and industrial needs, population growth, poverty, landlessness and consumer demand are the major driving forces behind deforestation. Most deforestation is due to conversion of forests to agricultural land. According to the World Resource Institute Washington DC (U.S.A.), rainforest destruction rates are 214000 acres per day and 78 million acres per year. Forests are extremely important to the survival of human beings on earth. Plants and animals, along with microorganisms, comprise life on Earth. Herbivorous animals sustain their life by consuming plants. Carnivorous animals and birds kill herbivorous animals for food; therefore indirectly they also depend on plants. Sea creatures eat aquatic plants and humans consume crop plants. A large variety of birds feed on seeds. There would rarely be any animal or bird who do not use plants directly or indirectly to satisfy their food requirements.

Deforestation is the process of cutting the forests and converts into arable land, wasteland, industrial or urban area. In the ancient times, much of the earth's land surface had been covered by forests. But through the years, there have been so many activities for the development of societies. Agriculture has to be boosted because the growing population needs more food. Land has to be converted into residential lots where people could build shelters. Forests also had to be sacrificed for infrastructure. Some forests were converted into large airports or urban centers. After mid 20th century Industrialization and deforestation are interrelated. People had primarily slashed and burned forests so they could convert the forested land into areas where they could plant rice, corn, and other staple crops. Deforestation has had a negative impact on rainfall, resulting in droughts and water shortage. The loss of forests also causes desertification. The roots of trees dig deep into the ground, penetrating several layers. They hold together these layers and prevent the formation of dust and thus maintain the topsoil intact. In the absence of trees, dust is formed and heavy rainfall and high sunlight damage the topsoil in clearings of the tropical rainforests. In this way with every rainfall, the availability of fertile land decreases. The same effect is caused with heavy winds and storms. Therefore deforested

areas appear desert-like. In such circumstances, the forest will take much longer to regenerate itself and the land will not be suitable for agricultural use for quite some time.

It has also been established that deforestation has contributed to the current global warming. Forests help in the reduction of carbon monoxide in the air. Aside from climate change, landslides and flash floods are also attributed to deforestation. Because there are not much enough trees to absorb rainfall in the land anymore, water from rain just flows through the surface and further denudes land.

Forests and disaster vulnerability

World Research and experience have shown that forest ecosystem play an important role in reducing the vulnerability of communities to disasters, both in terms of reducing their physical exposure to natural hazards and providing them with the livelihood resources. The degradation of these ecosystems is exacerbating vulnerabilities around the world, as the following examples illustrate. Before the Indian Ocean tsunami, 2004 had seen the deforestation-disaster vulnerability link given high profile following a series of natural disasters. Scientists and the media were quick to highlight the link between these events and the country's high level of deforestation that has cleared 98% of its forests. In the Philippines, flash floods and landslides left more than 1,600 people dead or missing. The powerful cyclone that hit India's Orissa coast in October1999 provided another powerful example of deforestation and disaster vulnerability. Much of the damage caused by the cyclone occurred in the extensively-deforested new settlement areas along Orissa's coast as the storm surge ripped through a 100-km long denuded stretch, the Ersama block, killing thousands of people within minutes. The calamity of the Indian Ocean tsunami offers an opportunity to reassess the role of forests in natural disaster prevention and mitigation. It also presents a policy space to make significant progress in the global commitment to forest conservation.

Benefits of planting native trees

1. Plants help stop global warming by reducing the greenhouse gases
2. They reduce soil erosion and water pollution
3. They provide habitat for native wildlife
4. They improve human health by producing oxygen and improving the quality of air

Facts about the benefits by planting the tree

1. Absorbs more than a ton of harmful greenhouse gases over its lifetime (U.S. Environmental Protection Agency)
2. One tree produces enough oxygen for four people every day (Tree Canada Foundation)
3. Tree provides the equivalent cooling effect of ten room-size air conditioners operating 20 hours a day (U.S. Department of Agriculture)
4. Tree provides an estimated $273 of environmental benefits in every year of its life (American Forests)

Industrial wastewater pollution

Industry is a huge source of water pollution, it produces pollutants that are extremely harmful to people and the environment. Many industrial facilities use freshwater to carry away waste from the plant and into rivers, lakes and oceans.

Pollutants from industrial sources include:

- **Asbestos –** This pollutant is a serious health hazard and carcinogenic. Asbestos fibres can be inhaled and cause illnesses such as asbestosis, lung cancer, intestinal cancer and liver cancer.
- **Lead –** This is a metallic element and can cause health and environmental problems. It is a non-biodegradable substance so is hard to clean up once the environment is contaminated. It is harmful to the health of many animals, including humans, as it can inhibit the action of bodily enzymes.
- **Mercury** - This is a metallic element and can cause soil health and environmental problems. It is a non-biodegradable substance so is hard to clean up once the environment is contaminated. It is also harmful to animal health as it can cause illness through mercury poisoning.
- **Nitrates –** The increased use of fertilizers means that nitrates are more often being washed from the soil and into rivers and lakes. This can be very problematic to marine environments.
- **Phosphates** - The increased use of fertilizers means that phosphates are more often being washed from the soil and into rivers and lakes which can be very problematic to marine environments.
- **Sulphur –** This is a non-metallic substance that is harmful for marine life.
- **Oils –** Oil does not dissolve in water, instead it forms a thick layer on the water surface. It is also harmful for fish and marine birds.
- **Petrochemicals –** This is formed from gas or petrol and can be toxic to marine life.

Accidents

Accidents are the most horrifying moments in the life of human beings. The life which we are leading is always unpredictable. On account of accident there is sometimes death of the persons and in some accidents the person suffers from serious injuries. Some of the injured persons become incapacitated for the rest of the life. That is why the term accident is defined as a specific, identifiable and unusual set of incidents in which the human life has a deep impact. Accidents are off various types. The common types are internal and external accidents. In the case of internal accident the accidents taking place like burns due to sudden fires, sudden slippage, wound during cooking etc. As per the external accidents are concerned, the sudden fire, road accident, air accident and others are the possible causes. Carelessness, inexperience and attitude are associated with the occurrence of accidents.

Road Accidents

The road infrastructure and its management are more advanced in western countries as compared to the India. The roads are broader so that the chances of accidents are less. India has a vast road network of 3.32 million km of which the national highways and State highways together account for 195000 km. The number of vehicles has been growing at a rapid pace of 12 per cent per annum since the Eighties and consequently traffic on the roads is growing at 7 to 10 per cent per annum. The mostly road accidents have occurred due to overtaking on two lane roads. Such accidents could occur at any time and any place, and often involve multiple injuries or deaths. More than 20 million people are severely injured or killed on the world's road each year. The mostly accidents occurs due to rapid increase of vehicles, bad roads, untrained drivers, slackness of traffic police, lack of obeying the traffic rules etc. The citizens of India are not aware about their own safety and quite frequently meet with accidents. In India, more than 80000 people are killed and around 400000 people injured by the road accident in every year. The total annual deaths due to road accidents have crossed 1.18 lakh, according to the latest report of National Crime Records Bureau. The report also defined the period between 3-6pm and early in the morning hours as the most accident prone phase during the day as drivers felt stressed out and were often half-asleep while driving.

Causes of Road accidents: The road accidents occurs due to fault of drivers pedestrian, mechanical defect in vehicles, bad conditions of road, bad weather and other reasons like non functioning of signals, absence of reflectors, cattle/animals on the road during night etc. The lack of knowledge of traffic rules to drivers and road users, over speeding, overloading, drunken driving are the major reasons of road accidents in the country.

Table: Road Accidents Statistics of India: 1970-2004

Sr #	Year	Total # of road accidents	Total # of persons killed	# of accidents per 10000 vehicles	# of persons killed per 10000 vehicles
1	1970	114100	14500	814.42	103.50
2	1980	153200	24000	338.86	53.09
3	1990	282600	54100	147.56	28.25
4	1991	295131	56278	138.08	26.33
5	1992	275541	60113	117.22	25.57
6	1993	284646	60380	111.60	23.67
7	1994	325864	64463	117.81	23.31
8	1995	351999	70781	116.19	23.36
9	1996	371204	74665	109.87	22.10
10	1997	373671	76977	100.09	20.62
11	1998	385018	79919	93.07	19.32
12	1999	386456	81966	86.12	18.27
13	2000	391449	78911	80.12	16.15
14	2001	405637	80888	73.76	14.71
15	2002	407497	84674	69.16	14.37
16	2003	406726	85998	60.70	12.83
17	2004	429910	92618	59.12	12.74

Source: Website of The Department of Road Transport and Highway, GoI http://morth.nic.in/writereaddata/sublinkimages/table-86816824487.htm

One can avoid the accidents by following the safety rules mentioned below:

1. Drivers should keep to the vehicle in left side, allow the traffic in the opposite side to pass you on the right side.
2. Overtake only on the right side.
3. Do not raise the speed when being overtaken by another vehicle.
2. Slow down the vehicle when passing the road junctions, railway crossing, and villages/town.
3. Drive slowly when passing a procession, repairs of the roads, near the schools.
4. Stop the vehicle when passing the zebra crossing by the pedestrians.
5. Drive the vehicle with the speed limit as per issued by the Motor vehicle act.
6. Always obey the traffic or safety rules.

Government should also take steps for minimizing the road accidents such as:

1. Provide the assistance for setting up the Driving schools.
2. Provision of refresher courses to drivers or general public of heavy motor vehicles.
3. More stringent in issuing licenses.
4. Reduce the number of vehicles on the roads.
5. Be strict about usage of helmets.
6. Make separate lanes for heavy vehicles.
7. Awareness campaign on road safety rules among road users through audio visual print media.
8. Speed controlling measures such as speed bumps, rumble strips, road markings, traffic signs, and roundabouts.
9. School children need to be imparted road safety education specifying the various safety measures to be adopted while on the road.
10. Government should care the improvements of road and facilities for road users on highways.

Rail accidents

Indian Railways, over 63,000 km long, is the world’s fourth largest network behind the US, Russia and China. Considering the huge number of passengers, the frequency of travel and the vast distances covered, rail transport are very safe. The rail accidents may be caused by human or system failure, which may affect normal movement of rail services with loss of human life or property. An analysis of the accident statistics reveals that derailments constitute a majority of the accidents followed by unmanned level crossing accidents.

In Railways, disaster is defined as a major train accident leading to heavy causalities and disruption to traffic for a long period. Train accidents are further classified as consequential train accidents and other train accidents. Consequential train accidents include train accidents having serious repercussion in terms of loss of human life/ human injury/ loss of Railway property/ interruption to rail traffic. Some worst accidents occurred in India where trains have collided, gone off the tracks or fallen in the river.

Major train accidents since 2006

18 August 2006: Two carriages caught fire on Chennai-Hyderabad Express near Secundrabad railway station.

9 November 2006: About 40 died and 15 injured in a West Bengal rail accident.

1 December 2006: A portion of 150-year-old bridge being dismantled collapsed over a passing train in Bihar's Bhagalpur district, killing 35 and injuring 17.

14 November 2009: The Delhi-bound Mandore Express derailed with some portion of the track piercing its AC compartment, leaving seven passengers dead and over 60 injured in in Bassi town near Jaipur.

21 October 2009: 22 people were killed and 26 injured when the Goa Express rammed the Mewar Express at Banjana on the Mathura-Vrindavan section of the Northern Railway in Uttar Pradesh.

19 July 2010: 89 people were killed and more than hundred others injured when Bhagalpur-Ranchi Vananchal Express was hit from behind by the speeding Sealdah-bound Uttarbanga Express at Sainthia station in Birbhum district of West Bengal.

Air Accidents

The data for the air accidents that have taken place across the globe clearly project fewer deaths when compared to any other modes of transport. Of all the means, air travel is considered the safest to travel. There have been a few major air accidents over the Indian skies. The recent Air India Express flight from Dubai to Mangalore…people who never thought that this would be the very end of their life the moment they boarded the flight. It is definitely one of the worst crashes in the decade. At the same time, there have been road accidents and rail mishaps which have claimed even more lives.

Causes of plane crash/air accident may occur

Although air travel is one of the safest forms of transportation, accidents do happen with dramatic and terrifying results. The causes of these aviation accidents vary greatly depending on specific circumstances and problems that may develop during the flight process.

- Piloting errors
- Faulty equipment
- Violations of FAA regulations
- Design or structural problems
- Flight service negligence
- Air traffic controller error
- Third party carrier selection negligence
- Maintenance or repair negligence
- Fueling error
- Inclement weather

Other causes of aviation accidents include bird hazards, mid-air collisions, air traffic control errors, structural defects, lack of maintenance, air show accidents, and search and rescue operations. These incidents can be completely avoided through careful preparation and effective safety techniques. When flight crew and pilots do their jobs correctly, aviation accidents

Air accidents due to Inclement Weather

Sometimes Aircraft accidents occur due to inclement weather. Although poor weather conditions are beyond the control of pilots, airlines, and flight crew, these people have a responsibility for the safety of their passengers. When the decision is made to go ahead with a flight despite weather advisories, the lives of others are put at risk.

Light aircraft are most affected by winds, larger aircrafts can be unexpectedly moved around as well. When this occurs a sense of panic may fill the cabin as passengers question their own safety and the competence of their pilots.

Turbulence is a stream of irregular winds that can influence the steadiness of an airplane flight. Although it is usually impossible to predict, turbulence and other wind conditions can be avoided or managed effectively by experienced pilots.

As anyone might suspect, flying in the snow can be a dangerous adventure. Pilots should not fly in whiteout conditions such as blizzards. At these times visibility is often so poor that instruments must be relied upon almost exclusively to determine one’s position and surroundings. Extreme temperatures can cause some mechanical operations to jam and cause ice to form on aircraft.

When pilots attempt to fly in unsafe weather conditions they not only endanger their own lives, but also the lives of passengers and people on the ground.

Rain and thunderstorms can be extremely hazardous to aviation. Turbulence, cumulus clouds, high winds, ice, hail, lightning, loss of visibility, electrostatic discharge, tornadoes, altimetry errors, and wet runways often accompany rain and must be managed by pilots and flight crews. In most situations, pilots are instructed to avoid severe thunderstorms and rain due to the risks they may pose for passengers and crew. In 1999, American Airlines Flight 1420 crashed while attempting to land in a thunderstorm in Little Rock, Arkansas. The large amount of rainfall had made the runway slick, causing the plane to lose control and break apart.

Following is the chronology of accidents involving aircraft in the country:

- Jul 7, 1962: Alitalia flight from Sydney crashes into a hill near Mumbai, 94 killed
- Jan 1, 1978: Air India flight crashes into Arabian Sea; 213 killed
- Jun 21, 1982 : Air India flight crashes at Mumbai airport, 17 of 111 passengers killed
- Oct 19, 1988 : Air India flight crashes at Ahmedabad, 124 out of 129 passengers killed
- Feb 14, 1990: Air India flight crashes at Bangalore, 92 out of 146 passengers killed
- Aug 16, 1991: Air India flight crashes at Imphal, 69 killed
- Apr 26, 1993: Air India flight crashes at Aurangabad airport, 55 of 118 passengers killed
- Nov 12, 1996: Saudi Arabian Airlines flight collides midair with Kazakhastan Airlines plane near Charki Dadri in Haryana, all 349 on board killed
- July 17, 2000: Alliance Air flight crashed at Patna Airport, killing 60 passengers.
- Sep 4, 2009: One of the engines of Air India flight catches fire at Mumbai airport, 21 injured
- May 22, 2010: AIR INDIA crashes at Mangalore, India, killing 166 passengers.

Unit-III

Disaster Management System

It is the action that deals with reducing human suffering and property loss. Disaster management is a complex process that requires a system to be in place at the national, state, district and local level, comprising of different components and participating stakeholders. The disaster management department should coordinate among different components.

Disaster Management Cycle

The efforts at the local level may not be enough, in terms of expertise, equipment and finances, thus disaster management assistance is needed from outside the region, usually from the national level and international agencies, including the Red Cross and foreign government.

I. Disaster Management Components: The five important components of disaster management are:

1. **Prevention:** It is the action taken to eliminate/avoid natural hazards and their effects.
2. **Preparedness:** Disaster preparedness encompasses those actions, which are taken to limit the impact of natural hazard by structuring response and establishing a mechanism for effecting a quick and orderly reaction.
3. **Mitigation:** It includes the measures taken to reduce both the effect of the hazard and vulnerable conditions to it in order to reduce the scale of a future disaster. Therefore, mitigation measures can be focused on the hazard itself or the elements exposed to the threat.
4. **Response:** It includes emergency management by various organizations to be taken in responding disaster. Many services that need to be mobilized at a moment's notice and functioning for an indeterminate period in coordinate manner under stressful circumstances. The ability of agency to manage crises is critically dependent on the availability and flow of real time information from monitory systems, thematic data bases and decision support systems that are linked through national network.

5. **Recovery:** It is concerned with providing relief after the disaster has occurred. It deals with providing food and shelter to the disaster victims, restoring normal conditions and providing financial and technical assistance to rebuild.

Collective and participative action is required over a long period of time for disaster management in all stages from the pre-disaster stage to relief, rehabilitation and re-construction. Various stake-holders who must work together in this include government departments, NGO's, local population, community based organizations, panchayats, paramilitary organization, military services, media and even the common people.

The steps required under different components of disaster management system for effective results have been outlined in the following text:

1. **Prevention/Mitigation:**
    - Preventing disasters construction of flood control dams
    - Plantations
    - Establishment of seismic stations
    - Forewarning systems
    - Training of disaster management personnel.
    - Minimizing the effect of disaster
    - Meteorological stations
    - Tsunami warring system
2. **Preparedness:**
    - Mock drills need to be conducted
    - Safe places to be identified and made known to local population of area
    - Volunteers who would respond to be identified & trained them
    - Local disaster management teams to be formed
    - Trained as many as people as possible particularly in disaster prove areas
    - Establishment of disaster protection centre
    - Communication system including hotlines not affected by breakdown in electric supply and other disturbances
    - Essential equipments should be ready
    - Air transport should be ready
3. **Response:**
    - Temporary shelters in the form of tents or tin sheds, large enough to accommodate one family
    - Food is provided to people living in the relief camps, initially in cooked form and later on as rations when facilities of cooking become available
    - Safe drinking water facilities are provided, usually starting with tankers and afterwards through pipes
    - Water is also needed for cooking food, washing and bathing and these facilities have to be arranged so that the people living in the relief camps begin to lead near normal lives as early as possible
    - Relief camps are also provided with electric supply with the help of generators
    - A medical centre is started in the camp itself to attend to the health problems of the people

- Livelihood options such as employment in road and building construction help the people in earning money so that they can start looking after themselves and not continue to depend on the government and other aid agencies
- Education for children, particularly the young ones who cannot go to far places is arranged in or near the camp itself

4. Recovery: Rehabilitation and reconstruction is a long term activity that starts soon after the beginning of relief operations. It is advisable to prepare a comprehensive plan to address these issues so that an integrated effort is put in place. This plan is formulated on the basis of the post-impact survey and damage assessment that is carried out in the aftermath of the disaster. It indicates the physical activities, time frame, finances required and the probable sources from where this will come. The steps under this component include:

- Activities such as reconstruction of roads, buildings, bridges and other infrastructure, in respect of both public as well as private property that has been damaged or destroyed
- Existing roads may be widened, earthquake resistant structures constructed, underground cables laid, deeper foundations of bridges dug and other measures of similar nature taken
- Restoring water pipelines and relaying new ones in a planed manner for meeting the needs of the present population and to meet the projected increase in future
- Electric supply lines and telephone cables are laid
- New enterprises involving employment generation are encouraged in the affected area
- Educational facilities need to be strengthened, existing buildings of schools and colleges repaired and expanded
- Medical facilities are strengthened to provide improved health care for the affected population
- The rehabilitation plan must include improved agriculture and horticulture activities, animal husbandry, soil and water conservation

II. Efforts to mitigate natural disasters at international / global level: The United Nations General Assembly through as resolution launched the International Decade for Natural Disaster Reduction (IDNDR, 1990-2008) in 1989. The decade, it was envisaged, would enable governments to focus on hazard vulnerability and risk assessment, disaster prevention, sustainable development, effective early warning systems, sharing of knowledge and transfer of technology. It emphasized on concerted international action, particularly in developing countries to handle loss of life, property damage, social and economic disruption caused by natural disaster. The IDNDR secretariat located in Geneva is a part of the United Nations Department of Humanitarian Affairs. The IDNDR Scientific and Technical committee is an advisory body with experts in different fields such as economics, social science, engineering, public health, industry, geology, meteorology etc. A group of well-known personalities, the special high-level council promote global awareness of disaster reduction. A United Nations inter-agency group work regularly with the IDNDR secretariat, as well as a contact group of Geneva based diplomatic missions. IDNDR publishes a quarterly magazine ‘Stop Disasters’ and conducts a promotional campaign on the *second*

Wednesday of each October, designated as the 'International Day for Natural Disaster Reduction.

1. **Yokohama Strategy and Plan of Action for safer world:** World conference on Natural Disaster Reduction Guidelines for Natural Disaster prevention, preparedness and mitigation was held at Yokohama, Japan, during 23-27 May, 1994. The conference adopted Yokohama strategy and related plan of action for the rest of decade and beyond.

Organization for Disaster Management

- IDNDR, 1990 – 2000 and Department of Humanitarians Affairs (DHA)
  - Secretariat at Geneva, Switzerland
  - Scientific and Technical committee
- National Organization for Disaster Management
  - Advisory Committee
  - National Disaster Management Authority
  - National Executive Committee
  - Sub-Committees
- State Level Organization
  - State Executive Committee
  - State Disaster Management Authority
  - Sub-committee
  - Advisory Committee
- District Level Organization
  - Local Authority
  - District Disaster Management Authority
  - Sub Committee
  - Advisory Committee

1. **Hyogo Framework for Action:** The world conference on Disaster Reduction was held at Kobe, Japan during 18-22 January, 2005. The conference had adopted the Hyogo Framework for Action (HFA) 2005-15: Building the Resilience of Nations and Communities to disasters. HFA prescribed 5 Priorities for Action (PFA), further divided into a set of 11 Activities and 51 sub-activity and at least 148 action points.

HFA mandated the International Strategy for Disaster Reduction (ISDR) to develop "generic, realistic and measurable indications" for assessing the progress in the implementation of the framework, keeping in mind available resources of individual states. Once the first stage has been completed, states shall be encouraged to develop or refine indicators at the national level reflecting their individual disaster risk reduction priorities, drawing upon the generic indicators.

2. **International strategy for disaster reduction:** ISDR was set-up at the end of International Decade for National Disaster Reduction, observed by the global community during the 1990s, to carry forward the mission "building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as integral component of sustainable development with the goal of reducing human, social, economic and environmental losses due to the natural hazards and related technological and environmental disasters."

3. **Inter-Agency Task Force (IATF):** An Inter-Agency Task Force comprising representatives of 16 agencies, organizations and programs of United Nation System, a regional entities and eight civil society and professional organizations provide the policy

guidance to the International Strategy for disaster reduction secretariat for the discharge of its functions.

A working group of ISDR prepared a draft paper on the development of indicators which was discussed in the 11th IATF meeting held on 25th May, 2005. The draft of paper developed tentative global benchmarks and indicators without indicating how data on various processes shall be collected and compiled. It was decided that an online dialogue may be held to obtain views and comments on the draft. Mr. Philip Buckle and Mr. Graham Marsh, who moderate this dialogue and submitted general endorsement of the draft. Technical session of ITAF was held on 21st November, 2005 during its 12th meeting to discuss a few national perspectives. The Indian perspective was presented by National Institute for Disaster Management (NIDM) to further carry forward the dialogue of development of indicators. It was emphasized that most of the activities and sub activities of the 'Priorities for Action' are to be implemented by the member countries and therefore, the global indicators must be developed on the basis of realistic national indicators.

III. Efforts for Disaster Management at National Level: The subject of disaster management does not find mention directly in any of the three lists, i.e. Union (National), State and Concurrent list in the 7th schedule of constitution. However the governments are provided financial assistance for meeting expenditure on identified natural calamities on the basis of the recommendations of the Finance Commission in order to ensure that the assistance is used only for calamity relief. A calamity Relief Fund has been constituted by each state, where annual assistance is credited and utilized on the basis of guidelines issued by the Union Ministry of Finance.

However, the legislation on disaster management has been related to entry 23 (social security and social insurance) in the concurrent list of the constitution and the states would also be able to enact their own legislation on the subject. In fact, the states of Gujarat and Bihar have already enacted their respective disaster management legislations.

The environment (Protection) Act 1986 which was passed for the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property. The ministry of Environment and forest prepared and published the Rules on 'Emergency Planning, Preparedness and Response for chemical accidents in 1996 only.

The Public Liability Insurance Act, 1991 caste a responsibility on the owner of a unit producing hazardous substance, as defined in the environment (Protection) Act, 1986, to provide immediate relief where death or injury to any person or damage to any property due to any accident to the extent indicated in the schedule to the Act.

On the basis of the recommendation of the group of ministers on Internal Security, the subject of disaster management (including man made disasters) was transferred from the ministry of agriculture to the ministry of home affairs in February, 2002 (except drought and epidemics which remain with the ministry of agriculture and ministry of health, respectively and the specific disasters allocated to other ministries/Departments).

Since the existing machinery was adhoc in nature and was created by executive order therefore, a need was felt to provide statutory machinery which can be more effective and efficient. For this purpose disaster management Act has been passed in 2005 by the parliament which specifies the role of Nation, State, District administration in planning and management of disasters.

1. The National Disaster Management Authority (NDMA)

(A) Composition, Tenure and Conditions of Service

✦ The National Authority consists of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following :
- the Prime Minister of India is the Chairperson of the National Authority, Ex-officio;
- other members, not exceeding nine, to be nominated by the Chairperson of the National Authority; and
- the Chairperson of the National Authority may designate one of the members nominated to be the Vice-Chairperson of the National Authority.

(B) Powers and functions of National Authority

✦ Subject to the provisions of this Act, the National Authority has the responsibility for laying down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster.

✦ The National Authority may-
- lay down policies on disaster management;
- approve the National Plan;
- approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;
- 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; and
- lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

✦ The Chairperson of the National Authority shall, in the case of emergency, have power to exercise all or any of the powers of the National Authority but exercise of such powers shall be subject to ex-post facto ratification by the National Authority.

(C) Appointment of officers and other employees of the National Authority

The Central Government shall provide the National Authority with such officers, consultants and employees, as it considers necessary for carrying out the functions of the National Authority.

(D) Meetings of National Authority

The National Authority shall meet as and when necessary and at such time and place as the Chairperson of the National Authority may think fit.

2. State Disaster Management Authority

(A) Establishment of State Disaster Management Authority

1. Every State Government shall, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.
2. A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members :
   - the Chief Minister of the State, who shall be Chairperson, ex-officio;
   - other members, not exceeding eight, to be nominated by the Chairperson of the State Authority; and
   - the Chairperson of the State Executive Committee, ex-officio.
3. The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice-Chairperson of the State Authority.
4. The Chairperson of the state Executive Committee shall be the Chief Executive Officer of the State Authority, ex, officio;

   Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority:

   Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.
5. The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

(B) Powers and functions of State Authority

(1) Subject to the provisions of this Act, a State Authority shall have the responsibility for laying down policies and plans for disaster management in the State.

(2) Without prejudice to the generality of provisions contained in sub-section (1), the State Authority may-

- (a) lay down the State disaster management policy;
- (b) approve the State Plan in accordance with. the guidelines laid down by the National Authority,
- (c) approve the disaster management plans prepared by the departments of the Government of the State;
- (d) lay down guidelines to be followed by the departments of the Government of the State for the purposes of integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance therefore;
- (e) coordinate the implementation of the State Plan;

(f) recommend provision of funds for mitigation and preparedness measures;
(g) review the development plans of the different departments of the State and ensure that prevention and mitigation measures are integrated therein, and
(h) review the measures being taken for mitigation, capacity building and preparedness by the departments of the Government of the State and issue such guidelines as may be necessary.

(3) The Chairperson of the State Authority shall, in the case of emergency, have power to exercise all or any of the powers of the State Authority but the exercise of such powers shall be subject to ex postfacto ratification of the State Authority.

(C) Guidelines for minimum standard of relief by State Authority

The State Authority shall lay down detailed guidelines for providing standards of relief to persons affected by disaster in the State:

Provided that such standards shall in no case be less than the minimum standards in the guidelines laid down by the National Authority in this regard.

(D) Meetings of the State Authority

(1) The State Authority. shall meet as and when necessary and at. such time and place as the Chairperson of the. State Authority may think fit.

(2) The Chairperson. of the State Authority shall preside over the meetings of the State Authority.

(3) If for any reason, the Chairperson of the State Authority is unable to attend the meeting of the State Authority, the Vice-Chairperson of the State Authority shall preside at the meeting.

(E) Appointment of officers and other employees of State Authority

The State Government shall provide the State Authority with such officers, consultants and employees, as it considers necessary, for carrying out the functions of the State Authority.

(F) Constitution of advisory committee by the State Authority-

(1) A State Authority may, as and when it considers necessary, constitute an advisory committee, consisting of experts in the field of disaster management and having practical experience of disaster management to make recommendations on different aspects of disaster management.

(2) The members of the advisory committee shall be paid such allowances as may be prescribed by the State Government.

2. (A) Constitution of State Executive Committee

(1) The State Government shall, immediately after issue of notification under sub-section (1) of section 14, constitute a State Executive Committee to assist the State Authority in the performance of its functions and to coordinate action in accordance with the guidelines laid down by the State Authority and ensure the compliance of directions issued by the State Government under this Act.

(2) The State Executive Committee shall consist of the following members, namely:
(a) the Chief. Secretary to the State Government, who shall be Chairperson, ex-officio,
(b) four Secretaries to the Government of the State of such departments as the State Government may think fit, ex-officio.

(3) The Chairperson of the State Executive Committee shall exercise such powers and perform such functions as may be prescribed by the State Government and

such other powers and functions as may be delegated to him by the State Authority.

(4) The procedure to be followed by the State Executive Committee exercise of its powers and discharge of its functions shall be such as be prescribed by the State Government.

2. (B) Functions of the State Executive Committee

(1) The State Executive Committee shall have the responsibility for implementing the National Plan and State Plan and act as the coordinating and monitoring body for management of disaster in the state.

(2) Without prejudice to the generality of the provisions of sub-section (1), the State Executive Committee may -

(a) coordinate and monitor the implementation of the National Policy, the National Plan and the State Plan,

(b) examine the vulnerability of different parts of the State to different forms of disasters and specify measures to be taken for their prevention or mitigation;

(c) lay down guidelines for preparation of disaster management plans by the departments of the Government of the State and the District Authorities;

(d) monitor the implementation of disaster management plans prepared by the departments of the Government of the State and District Authorities,

(e) monitor the implementation of the guidelines laid down by the State Authority for integrating of measures for prevention of disasters and mitigation by the departments in their development plans and projects,

(f) evaluate preparedness at all governmental or nongovernmental levels to respond to any threatening disaster situation or disaster and give directions, where necessary, for enhancing such preparedness;

(g) coordinate response in the event of any threatening disaster situation or disaster;

(h) give directions to any Department of the Government of the State or any other authority or body in the State regarding actions to be taken in response to any threatening disaster situation or disaster;

(i) promote general education, awareness and community training in regard to the forms of disasters to which different gard parts of the State are vulnerable and the measures that may be taken by such community to prevent the disaster, mitigate and respond to such disaster;

(j) advised assist and coordinate the activities of the Departments of the Government of the State, District Authorities, statutory bodies and other governmental and non-governmental organizations engaged in disaster management;

(k) provide necessary technical assistance or give advice to District Authorities and local authorities for carrying out their functions effectively;

(l) advise the State Government regarding all financial matters in relation to disaster management;

(m) examine the construction, in any local area in the State and, if it is of' the opinion that the standards laid for such construction, for the prevention of disaster is not being or has not been followed, may direct the District

Authority or the local authority, as the case may be, to take such action as may be necessary to secure compliance of such standards;

(n) provide information to the National Authority relating to different aspects of disaster management;

(o) lay down, review and update State level response plans and guidelines and ensure that the district level plans are prepared, reviewed and updated;

(p) ensure that communication systems are in order and the disaster management drills are carried out periodically; and

(q) perform such other functions as may be assigned to it by the State Authority or as it may consider necessary.

2. (C) Powers and functions of State Executive Committee in the event of threatening disaster situation

For the purpose of, assisting and protecting the community affected by disaster or providing relief to such community or, preventing or combating disruption or dealing with the effects of any threatening disaster situation, the State Executive Committee may

(a) control and restrict, vehicular traffic to, from or within, the vulnerable or affected area;

(b) control and restrict the entry of any person into, his movement within and departure from a vulnerable or affected area;

(c) remove debris, conduct search and carry out rescue operations;

(d) provide shelter, food, drinking water, essential provisions, healthcare and services in accordance with the standards laid down by the National Authority and State Authority;

(e) give direction to the concerned Department of the Government of the State, any District Authority or other authority, within the local limits of the State to take such measure or steps for rescue, evacuation or providing immediate relief saving lives or property, as may be necessary in its opinion;

(f) require any department of the Government of the State or any other body or authority or person in charge of any relevant resources to make available the resources for the purposes of emergency response, rescue and relief;

(g) require experts and consultants in the field of disasters to provide advice and assistance for rescue and relief;

(h) procure exclusive or preferential use of amenities from any authority or person as and when required;

(i) construct temporary bridges or other necessary structures and demolish unsafe structures which may be hazardous to public;

(j) ensure that non-governmental organisations carry out their activities in an equitable and non-discriminatory manner;

(k) disseminate information to, public to deal with any threatening disaster situation or disaster; and

(1) take such steps as the Central Government or the State Government may direct in this regard or take such other steps as are required or warranted by the form of any threatening disaster situation or disaster.

2. (D) State Plan

(1) There shall be a plan for disaster management for every State to be called the State Disaster Management Plan.

(2) The State Plan shall be prepared by the State Executive Committee having regard to the guidelines laid down by the National Authority and after such consultation with local authorities, district authorities and the people's representatives as the State Executive Committee may deem fit.

(3) The State Plan prepared by the State Executive Committee under sub-section (2) shall be approved by the State Authority.

(4) The State Plan shall include-

(a) the vulnerability of different parts of the State to different forms of disasters;

(b) the measures to be adopted for prevention and mitigation of disasters;

(c) the manner in which the mitigation measures shall be integrated with the development plans and projects;

(d) the capacity building and preparedness measures to be taken;

(e) the roles and responsibilities of each Department of the Government of the State in relation to the measures specified in clauses (b), (c) and (d) above; and

(f) the roles and responsibilities of different Departments of the Government of the State in responding to any threatening disaster situation or disaster.

(5) The State Plan shall be reviewed and updated annually.

(6) Appropriate provisions shall be made by the State Government for financing for the measures to be carried out under the State Plan.

(7) Copies of the State Plan referred to in sub-sections (2) and (5) shall be made available to the Departments of the Government of the State and such Departments shall draw up their own plans in accordance with the State Plan.

2. (E) Constitution of sub-committees by State Executive Committee

(1) The State Executive Committee may, as and when it considers necessary, constitute one or more sub-committees, for efficient discharge of its functions.

(2) The State Executive Committee shall, from amongst its members, appoint the Chairperson of the sub-committee referred to in sub-section (1)

(3) Any person associated as an expert with any sub-committee may be paid such allowances as may be prescribed by the State Government.

3. (A) Establishment of Funds by State Government

(1) The State Government shall, immediately after notifications issued for constituting the State Authority and the District Authorities, establish for the purposes of this Act the following funds, namely:

(a) the fund to be called the State Disaster Response Fund;

(b) the fund to be called the District Disaster Response Fund;

(c) the fund to be called the State Disaster Mitigation Fund; and

(d) the fund. to be called the District Disaster Mitigation Fund.

(2) The State Government shall ensure that the funds established:

- under clause (a) of sub-section Executive Committee (1) is available to the State
- under sub-clause (c) of sub-section (1) is available to the State Authority, and
- under clauses (b) and (d) of sub-section (1) are available to the District Authority.

3. (B) State Government to take Measures

(1) Subject to the provisions of this Act, each State Government shall take all measures specified in the guidelines laid down by the National Authority and such other measures as it deems necessary or expedient, for the purpose of disaster management.

(2) The measures which the State Government may take under subsection (1) include measures with respect to all or any of the following matters, namely:

- (a) coordination of actions of different departments of the Government of the State, the State Authority, District Authorities, local authority and other non-governmental organisations;
- (b) cooperation and assistance in the disaster management to the National Authority and National Executive Committee, the State Authority and the State Executive Committee, and the District Authorities;
- (c) cooperation with, and assistance to, the Ministries or Departments of the Government of India in disaster management, as requested by them or otherwise deemed appropriate by it;
- (d) allocation of funds for measures for prevention of disaster mitigation, capacity-building and preparedness by the departments of the Government of the State in accordance with the provisions of the State Plan and the District Plans;
- (e) ensure that the integration of measures for prevention of disaster or mitigation by the departments of the Government of the State in their development plans and projects;
- (f) integrate in the State development plan, measures to reduce or mitigate the vulnerability of different parts of the State to different disasters,
- (g) ensure the preparation of disaster management plans by different departments of the State in accordance with the guidelines laid down by the National Authority and the State Authority,
- (h) establishment of adequate warning systems up to the level of vulnerable communities;
- (i) ensure that different departments of the Government of the State and the District Authorities take appropriate preparedness measures; ensure that in a threatening disaster situation or disaster, the resources of different departments of the, Government of the State are made available to the National Executive Committee or the State Executive Committee or the District Authorities, as the case may be, for the purposes of effective response, rescue and relief in any threatening disaster situation or disaster;
- (k) provide rehabilitation and reconstruction assistance to the victims of any disaster; and
- (l) such other matters as it deems necessary or expedient for the purpose of securing effective implementation of provisions of this Act.

Responsibilities of Departments of the State Government

It shall be the responsibility of every department of the Government of a State to:

(a) take measures necessary for prevention of disasters, mitigation, preparedness and capacity-building in accordance with the guidelines laid down by the National Authority and the State Authority;

(b) integrate into its development plans and projects, the measures for prevention of disaster and mitigation;

(c) allocate funds for prevention of disaster, mitigation, capacity building and preparedness;

(d) respond effectively and promptly to any threatening disaster situation or disaster in accordance with the State Plan, and in accordance with the guidelines or directions of the National. Executive Committee and the State Executive Committee;

(e) review the enactments administered by it, its policies, rules and regulations with a view to incorporate therein the provisions necessary for prevention of disasters, mitigation or preparedness;

(f) provide assistance, as required by the National Executive Committee, the State Executive Committee and District Authorities, for

- drawing up mitigation, preparedness and response plans, capacity building, data collection and identification and training of personnel in relation to disaster management;
- assessing the damage from any disaster;
- carrying out rehabilitation and reconstruction

(g) make provision for resources in consultation with the State Authority for the implementation of the District Plan by its authorities at the district level.

(h) make available its resources to the National Executive Committee or the State Executive Committee or the District Authorities for the purposes of responding promptly and effectively to any disaster in the State, including measures for:

- providing emergency communication with a vulnerable or affected area,
- transporting personnel and relief goods to and from the affected area,
- providing evacuation, rescue, temporary shelter or other immediate relief,
- carrying out evacuation of persons or live-stock from an area of any threatening disaster situation or disaster,
- setting up temporary bridges, jetties and landing places, and
- providing drinking water, essential provisions, healthcare and services in an affected area;

(i) such other actions as may be necessary for disaster management.

(C) Disaster Management Plan of Departments of State

(1) Every department of the State Government, in conformity with the guidelines laid down by the State Authority, shall

(a) Prepare a disaster management plan which shall lay down the following:

- the types of disasters to which different parts of the State are vulnerable;
- integration of strategies for the prevention of disaster or the mitigation of its effects or both with the development plans and programmes by the department;
- the roles and responsibilities of the department of the State in the event of any threatening disaster situation or disaster and emergency support function it is required to perform;
- present status of its preparedness to perform such roles or responsibilities or emergency support function under subclause (iii);

- the capacity-building and preparedness measures proposed to be put into effect in order to enable the Ministries or Departments of the Government of India to discharge their responsibilities under section 37;

(b) annually review and update the plan referred to in clause (a); and

(c) furnish a copy of the plan referred to in clause (a) or clause (b), as the case may be, to the State Authority.

(2) Every department of the State Government, while preparing the plan under sub-section (1), shall make provisions for financing the activities specified therein.

(3) Every department of the State Government shall furnish an implementation status report to the State Executive Committee regarding the implementation of the disaster management plan referred to in subsection (1).

3. District Disaster Management Authority

(A) Constitution of District Disaster Management Authority

(1) Every State Government shall, as soon as may be after issue of notification under sub-section (1) of section 14, by notification in the Official Gazette, establish a District Disaster Management Authority for every district in the State with such name as may be specified in that notification.

(2) The District Authority shall consist of the Chairperson and such number of other members, not exceeding seven, as may be prescribed by the State Government, and unless the rules otherwise provide, it shall consist of the following :

(a) the Collector or District Magistrate or Deputy Commissioner, as the case may be, of the district who shall be Chairperson, ex-officio;

(b) the elected representative of the local authority who shall be the co-Chairperson, ex-officio:

Provided that in the Tribal Areas, as referred in the Sixth Schedule to the Constitution, the Chief Executive Member of the district council of autonomous district, shall be the Co-Chairperson, ex-officio;

(c) the Chief Executive Officer of the District Authority, ex-officio,

(d) the Superintendent of Police, ex-officio;

(e) the Chief Medical Officer of the district, ex-officio;

(f) not exceeding two other district level officers, to be appointed by the State Government.

(3) In any district where Zila Parishad exists, the Chairperson thereof shall be the co-Chairperson of the District Authority.

(4) The State Government shall appoint an officer not below the rank of Additional Collector or Additional District Magistrate or Additional Deputy Commissioner, as the case may be, of the district to be the Chief Executive Officer of the District Authority to exercise such powers and perform such functions as may be prescribed by the State Government and such other powers and functions as may be delegated to him by the District Authority.

(B) Powers of Chairperson of District Authority

(1) The Chairperson of the District Authority shall, in addition to presiding over the meetings of the District Authority, exercise and discharge such powers and functions of the District Authority as the District Authority may delegate to him.

(2) The Chairperson of the District Authority shall, in case of an emergency, have power to exercise all or any of the powers of the District Authority but the

exercise of such powers shall be subject to ex-post facto ratification of the District Authority.

(3) The District Authority or the Chairperson of the District Authority may, by general or special order, in writing delegate such of its or his powers and functions, under sub-section (1) or (2), as the case may be, to the Chief Executive Officer of the District Authority, subject to such conditions and limitations, if any, as it or he deems fit.

(C) **Meetings:** The District Authority shall meet as and when necessary and at such time and place as the Chairperson may think fit.

(D) Constitution of Advisory Committees and other Committees

(1) The District Authority may, as and when it considers necessary, constitute one or more advisory committees and other committees for the efficient discharge of its functions.

(2) The District Authority shall, from amongst its members, appoint Chairperson of the Committee referred to in sub-section (1).

(3) Any person associated as an expert with any committee or sub-committee constituted under sub-section (1) may be paid such allowances as may be prescribed by the State Government.

(E) Appointment of Officers and other Employees of District Authority

The State Government shall provide the District Authority with officers, consultants and other employees as it considers necessary carrying out the functions of District Authority.

(F) Powers and functions of District Authority

(1) The District Authority shall act as the district planning, coordinating and implementing body for disaster management and take measures for the purposes of disaster management in the district in accordance with the guidelines laid down by the National Authority and state Authority.

(2) Without prejudice to the generality of the provisions of sub-section (1), the District Authority may

- prepare a disaster management plan including district response plan for the district,
- coordinate and monitor the implementation of the National Policy, State Policy, National Plan, State Plan, and District Plan;
- ensure that the areas in the district vulnerable to disasters are identified and measures for the prevention of disasters and the mitigation of its effects are undertaken by the departments of the Government at the district level as well as by the local authorities;
- ensure that the guidelines for prevention of disasters, mitigation of its effects, preparedness and response measures as laid down by the National Authority and the State Authority are followed by all departments of the Government at the district level and the local authorities in the district;
- give directions to different authorities at the district level and local authorities to take such other measures for the prevention or mitigation of disasters as may be necessary;

- lay down guidelines for prevention of disaster management plans by the department of the Government at the districts level and local authorities in the district,
- Monitor the implementation of disaster management plans prepared by the Departments of the Government at the district level;
- lay down guidelines to be followed by the Departments of the Government at the district level for purposes of integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance therefore;
- monitor the implementation of measures referred to in clause (viii);
- review the state of capabilities for responding to any disaster or threatening disaster situation in the district and give directions to the relevant departments or authorities at the district level for their upgradation as may be necessary;
- review the preparedness measures and give directions to the concerned departments at the district level or other concerned authorities where necessary for bringing the preparedness measures to the levels required for responding effectively to any disaster or threatening disaster situation;
- organise and coordinate specialised. training programmes for different levels of officers, employees and voluntary rescue workers in the district;
- facilitate community training and awareness programmes for prevention of disaster or mitigation with the support of local authorities, governmental and non-governmental organisations;
- set-up, maintain, review and upgrade the mechanism for early warnings and dissemination of proper information to public;
- prepare, review and update district level response plan and guidelines;
- coordinate response to any threatening disaster situation or disaster;
- ensure that the Departments of the Government at the district level and the local authorities prepare their response plans in accordance with the district response plan;
- lay down guidelines for, or give direction to, the concerned Department of the Government at the district level or any other authorities within the local limits of the district to take measures to respond effectively to any threatening disaster situation or disaster;
- advise, assist and coordinate the activities of the Government at the district level, statutory governmental and nongovernmental organisations in the disaster management; of the Departments bodies and other districts engaged;
- coordinate with, and give guidelines to, local authorities in the district to ensure that measures for the prevention or mitigation of threatening disaster situation or disaster in the district are carried out promptly and effectively;
- provide necessary technical assistance or give advise to the local authorities in the district for carrying out their functions;
- review development plans prepared by the Departments of the Government at the district level, statutory authorities or local authorities with a view to make necessary provisions therein for prevention of disaster or mitigation;

- examine the construction in any area in the district and, if it is of the opinion that the standards for the prevention of disaster or mitigation laid down for such construction is not being or has not been followed, may direct the concerned authority to take such action as may be necessary to secure compliance of such standards;
- identify buildings and places which could, in the event of any threatening disaster situation or disaster, be used as relief centers or camps and make arrangements for water supply and sanitation in such buildings or places;
- establish stockpiles of relief and rescue materials or ensure preparedness to make such materials available at a short notice;
- provide information to the State Authority relating to different aspects of disaster management;
- encourage the involvement of non-governmental organisations and voluntary social-welfare institutions working at the grassroots level in the district for disaster management;
- ensure communication systems are in order, and disaster management drills are carried out periodically; and
- perform such other functions as the State Government or State Authority may assign to it or as it deems necessary for disaster management in the District.

(G) Powers and Functions of District Authority in the Event of any Threatening Disaster Situation or disaster

For the purpose of assisting, protecting or providing relief to the community, in response to any threatening disaster situation, the District Authority may-

(a) give directions for the release and use of resources available with any Department of the Government and the local authority in the district;
(b) control and restrict vehicular traffic to, from and within, the vulnerable or affected area;
(c) control and restrict the entry of any person into, his movement within and departure from, a vulnerable or affected area;
(d) remove debris, conduct search and carry out rescue operations;
(e) provide shelter, food, drinking water and essential provisions, healthcare and services;
(f) establish emergency communication systems in the affected area;
(g) make arrangements for the disposal of the unclaimed dead bodies;
(h) recommend to any Department of the Government of the State or any authority or body under that Government at the district level to take such measures as are necessary in its opinion;
(i) require experts and consultants in the relevant fields to advise and assist as it may deem necessary;
(j) procure exclusive or preferential use of amenities from any authority or person;
(k) construct temporary bridges or other necessary structures and demolish structures which may be hazardous to public or aggravate the effects of the disaster;
(l) ensure that the non-governmental organisations carry out their activities in an equitable and non-discriminatory manner; and

(m) take such other steps as may be required or warranted. to be taken in such a situation.

(H) District Plan

(1) There shall be a plan for disaster management for every district of the State.

(2) The District Plan shall after consultation with the National Plan and the State Authority be prepared by the District Authority, local authorities and having regard to the Plan, to be approved by the State.

(3) The District Plan shall include

- (a) the areas in the district vulnerable to different forms of disasters;
- (b) the measures to be taken, for prevention and mitigation of disaster, by the Departments of the Government at the district level and local authorities in the district;
- (c) the capacity-building and preparedness measures required to be taken by the Departments of the Government at the district level and the local authorities in the district to respond to any threatening disaster situation-or disaster;
- (d) the response plans and procedures in the event of a disaster, providing for
  - allocation of responsibilities to the Departments of the Government at the district level and the local authorities in the district;
  - prompt response to disaster and relief thereof;
  - procurement of essential resources;
  - establishment of communication links; and
  - the dissemination of information to the public;
- (e) such other matters as may be required by the State Authority.

(4) The District Plan shall be reviewed and updated annually.

(5) The copies of the District Plan referred to in sub-sections (2) and (4) shall be made available to the Departments of the Government in district.

(6) The District Authority shall send a copy of the District Plan to state Authority which shall forward it to the State Government.

(7) The District Authority shall, review from time to time, the implementation of the Plan and issue such instructions to different departments of the Government in the district as it may deem necessary for the implementation thereof.

(I) Plans by different authorities at district level and their implementation

Every office of the Government of India and of the State Government at the district level & local authorities shall, subject to prevision of District Authority,

(a) prepare a disaster management plan setting out the following, namely:

- provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
- provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
- the response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) coordinate the preparation and the implementation of its plan with those of the other organisations at the district level including local authority, communities and other stakeholders;

(c) regularly review and update the plan, and

(d) submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

(J) Requisition by the District Authority

The District Authority may by order require any officer or any department at the district level or any local authority to take such measure for the prevention or mitigation of disaster, or to effectively respond to it, as may be necessary, and such officer or department shall be bound to carry out such order.

4. Local Authorities

Functions of the Local Authority

(1) Subject to the directions of the District Authority, a local authority shall-
  (a) ensure that its officers and employees are trained for disaster management;
  (b) ensure that resources relating to disaster management are so maintained as to be readily available for use in the event of any threatening disaster situation or disaster;
  (c) ensure all construction projects under it or within its jurisdiction conform to the standards and specifications laid down for prevention of disasters and mitigation by the National Authority, State Authority and the District Authority;
  (d) carry out relief, rehabilitation and reconstruction activities in the affected area in accordance with the State Plan and the District Plan.

(2) The local authority may take such other measures as may be necessary for the disaster management.

- **National Training Institute for Disaster Management**

  Government has created few institutes for planning for disasters and emergency preparedness training that offer short-term courses. Notable amongst them being, the National Centre for Disaster Management (NCDM) set-up by the Indian Institute of Public Administration and the Centre for Disaster Management set-up by Y.S. Chavan Academy of Development Administration conduct workshops and seminars for civil servants and government officials. Similarly, the Disaster Management Institute, Bhopal set-up after the gas tragedy conducts awareness programmes for NGOs and the public at large. Some other Training Institutes offering courses in the field are listed below:

  - Guru Gobind Singh Indraprastha University, Delhi
  - Centre for Disaster Management, Pune
  - PRT Institute of Post-graduate Environmental Education, Bhopal
  - National Civil Defence College, Nagpur
  - Sikkim Manipal University of Health, Medical and Technology
  - The Indira Gandhi National Open University (IGNOU) was the first to offer a six month certificate course in disaster management for +2 students. A Diploma Course in Disaster Management has also been started. The programme is offered through distance mode.
  - IGNOU also offers a comprehensive programme on community awareness in disaster preparedness.
  - Himachal Pradesh University offer Diploma in Diaster Management

➢ **National Institute of Disaster Management (NIDM)**

NIDM set-up by Ministry of Home Affairs, Government of India, is a centre for excellence and learning in the field of disaster management. It is a premier resource institution for human resource development, training, capacity building, applied research, implementation and dissemination of information and knowledge for holistic disaster mitigation, preparedness, response and recovery, towards sustainable development.

1. **Objectives:**
- Professionalizing disaster risk management in India and the region by developing an independent cadre of trained emergency and mitigation managers.
- Building disaster-resilient communities by promoting public awareness to instill a culture of preparedness.
- Filling knowledge gaps by providing a common platform for collation and sharing of information and experiences with practitioners of disaster management.
- Providing policy assistance to facilitate multi-disciplinary and sectoral support for prevention strategies, technical assistance, implementation techniques and know-how dissemination with respect to natural and man-made disasters.
- Networking and building partnerships with governments, institutions of learning and training the corporate sector, international agencies, NGOs and civil society organizations, to synergize disaster mitigation efforts.
- Developing mechanisms for risk financing risk transfer and insurance for effective disaster management.
- Mainstreaming disaster risk management into development planning.
- Working as a resource institution for the national and state governments for policy, planning and capacity building.

2. **Mobilizing HRD Resources:** NIDM's efforts at human resources development in key areas of disaster risk training have been initiated and include:
- Nation-wide Training Need Analysis for the National Human Resource Plan.
- National Human Resource Development Plan on Disaster Management.
- Development of Capacity-building Framework for Disaster Management Centers at State-level institutions.
- Partnerships with National and International Training Institute.
- Professional Course on Disaster Management.

3. **Looking Ahead:** NIDM has identified the following key areas for intervention and expansion:
- disaster management policy, planning and techno-legal regime.
- Framework for NGOs and civil society capacity building.
- Framework and training modules for reconstruction and rehabilitation of disaster affected areas.
- Socio-psychological issues in disaster management.
- Gender issue in disaster management.
- Urban risk mitigation.
- Launching a mass awareness campaign.
- Focusing on school awareness and safety programmes.
- Programmes addressing special needs to vulnerable groups.
- Risk financing and cost-benefit analysis of disaster mitigation schemes.
- Strengthening the national GIS laboratory.

- Knowledge management and dissemination at the national level.
- Establishing a disaster management laboratory for simulation.
- Setting up a model emergency operation centre for training.
- Mainstreaming disaster management into the education sector.
- Developing a national-level dynamic database of trained human resource personnel in the field of disaster management.

4. **NIDM Partners:** NIDM works in close association with the following national and international organizations:

- Ministers of the government of India
- State Governments
- Centre for Disaster Management (CDM)/State Administrative Training Institute (ATIs)
- State Institute of Rural Development (SIRDs)
- Indian Space Research Organization (ISRO)
- National Remote Sensing Agency (NRSA)
- Central Board of Secondary Education (CBSE)
- National Council for Education, Research and Training (NCERT)
- Indian Institute of Technology (Pawai, Kharagpur, Roorkee)
- Council for Scientific and Industrial Research (CSIR) Laboratories, Structural Engineering Research Centre (SERC) Chennai
- Institute of Insurance and Risk Management (IIRM), Hyderabad
- All India Institute of Local Self-Government, Pune
- Federation of India Chambers of Commerce and Industry (FICCI)
- Financial Institutions
- The World Bank Institute, Washington, DC
- United Nations Development Program (UNDP), India
- United Nations Children's Fund, India
- United States Agency for International Development (USAID)
- Federal Emergency Management Agency (FEMA), USA
- India Meteorological Department (IMD)

IV. National Disaster Management Framework

Expected Outputs	Areas of intervention	Agencies to be involved and resource linkages
1. Institutional Mechanisms		
Nodal agency for disaster management at the national level with appropriate system	(i) Constitution of National Emergency Management Authority with appropriate legal, financial and administrative powers (ii) Roles and responsibilities of the NEMA - Coordinating multihazard mitigation, prevention, preparedness and response programmers. - Policies for disasters risk reduction and mitigation. - Preparedness at all levels. - Coordination of response.	Ministries/ Departments of Health, Water resources, Environment and Forests, Agriculture Railways, Atomic energy, Defenses, Chemicals, Science and Technology, Rural Development,

	- Coordination of post-disaster relief and rehabilitation. - Amendment of existing laws, procedures, instructions.	Road Transport and Highways, etc.
Creation of State Departments of Disaster Management	Departments of Relief and Rehabilitation to be predestinated as Department of Disaster Management with enhanced areas of responsibility to include mitigation prevention and preparedness.	State government / UT Administration
Setting up State Disaster Management Authorities	(i) State Disaster Management authority to be headed by the Chief Minister (ii) The authority to lay down policies and monitor mitigation, prevention and preparedness as also oversee response.	Ministers of Agri, Home, Disaster Management, Water Resources, Health, Road and Transport, Civil Supplies, Environment and Forests, Rural Development, Urban Development and Public Health Engineering Departments as members.
II. Disaster Mitigation / Prevention		
Disaster mitigation / prevention to be mainstreamed into the development process.	i) Each ministry/Department which has a role in mitigation / prevention will make, appropriate outlays for schemes addressing mitigation / prevention. ii) Where there is a shelf of projects/schemes, projects/schemes contributing to mitigation to be given apriority. iii) Wherever possible schemes / projects in areas prone to natural hazards to be so designed as to contribute to mitigation and preparedness. iv) Projects in vulnerable areas / areas prone to natural hazards to be designed to withstand natural hazards.	Ministries / Department of Government of in India/State Govt. /UT Administration
Techno-legal regime	i) Regular review of building codes and its dissemination.	Bureau of Indian Standards/ Ministry of Urban Development.
	ii) Construction in seismic zones III, IV and V to be as per BIS codes / National Building codes.	State Urban Development Department / Urban Local Bodies.

	iii) Construction in vulnerable to designed as to withstand the wind hazards as per BIS codes / National Building codes.	State Urban Development Department / Urban Local Bodies.
	iv) Comprehensive review and compliance of : - Town and Country Planning Acts - Development Control Regulations. - Planning Building Standards Regulations.	State Urban Development Department / Urban Local Bodies.
	v) Put in place appropriate techno-financial regime.	
	vi) Capacity enhancement of Urban local bodies to enforce compliance of techno-legal regimes	
Land-use Planning and Zoning regulations	i) Legal framework for land-use planning and zoning regulations to be reviewed	Ministry of Urban Development, Department of Land Resources
	ii) Zoning regulations to be enforced.	Ministry of Environment and forests (GOI)
Plan schemes for vulnerability reduction and preparedness	State Government to formulate Plan schemes and submit to planning commission	State Governments
III. Legal/Policy Framework		
Disaster Management to be listed in List-III [Con-current List] of Seventh Schedule to the Constitution	i) Bill to be drafted. ii) Bill to be brought before parliament	Ministry of Home Affairs / Ministry of Law (Legislative Department)
State disaster management Acts	Model act to be circulated to the state	Ministry of Home Affairs, State Government.
National Policy on Disaster Management	i) Mainstreaming disaster management into planning and development process. ii) Mandate safe construction. iii) Coordinated action by all relevant departments as per policy	Ministry of Home affairs, Ministry of Finance, Planning Commission, Ministry of Environment and Forests, Rural Development, Urban Development and other relevant Ministers to be consulted.

State to enunciate Policy on disaster management State disaster management codes	i) Mainstreaming disaster management into planning and development process. ii) Mandate safe construction. iii) Coordinated action by all relevant departments as per policy amendment of existing relief codes / scarcity codes / famine codes to incorporate mitigation, preparedness and planning measures at all levels from community to state, constitution of emergency support teams / disaster management teams committee / state disaster management authorities, delegation of administrative and financial powers to disaster incident managers, etc. protocol to update the inventory of resources and plans.	State Government.
IV. Preparedness and Response		
National Emergency response Force / Specialist Response Teams	i) Designation of units for conversation into specialist response teams. ii) Designation training centers iii) Training of trainers iv) Procurement of equipment. v) Training of teams	Ministry of Home Affairs Central Industrial Security Force / Indo - Tibetan Borders Police / Boarder Security Force / Central Reserve Policy Force.
Specialized Response Teams at State-level	i) Designation of units for conversion into specialist response teams ii) Designation of training centers. iii) Training of trainers. iv) Procurement of equipment using CRF resources. v) Training of teams.	State Department of Disaster Management / State Home Department. State Police Training College / State Fire Training Institute.
V. National Network of Emergency Operation Centers (NNEOCs)		
Setting up emergency operations Centre (EOC) at national level	i) Multi-hazard resistant construction ii) Communication system linkages iii) Mobile EOCs for on site disaster information management	Central Public Works Department for Central Public Works Ministry of Home Affairs
State level EOC	i) Multi-hazard resistant construction	State Governments

District level EOC	ii) Communication system linkages iii) Mobile EOCs for on site disaster information management	
Putting incident Command system in Place	i) Multi-hazard resistant construction ii) Communication system linkages	Ministry of Home Affairs / Department of Personal and training / Lal Bahadur Shastri National Academy of Administration / State Governments / Administrative Training Institutes.
Emergency Support Function Plan	i) Designate nodal training centers. ii) Putting in place protocols SOP for Incident command system.	Central Governments Ministries / Departments, State Governments.
India Disaster Resource Network	i) Department/agencies which perform emergency support functions to draw up ESF plans, constitute teams, and set apart resources in advance so that post-disaster response is prompt.	Ministry of Home affairs
Communication linkages which will be functional even post-disaster	i) A web enabled GIS-based resource inventory listing out all the necessary resources for emergency response available at the district and state level throughout the country so that resources can be mobilized at short notice. ii) Set-up services, draw up and install programmes. iii) Half yearly updating	Affairs State Govt.
Regional Response Centers	i) Draw up communication plan. ii) Obtain sanctions. iii) Put communication network in place	Ministry of Home Affairs Directorate Coordination of Police Wireless
Training in response to be made a part of training curriculum of CPMFS and state police forces	i) Identify location of regional response centers. ii) Identify caches of equipment required. iii) Obtain sanctions. iv) Put teams and caches of equipments in place.	State Govt.

State Disaster Management Plans	i) Draw up capsules ii) Train trainers.	Ministry of Home Affairs, Boarder Security Force/ Indo-Tibetan Boarder Police/Central Reserve Police Force / Central Industrial Security Force.
District Disaster Management Plans	i) Plan to be drafted under the supervision of the Chief Secretary. ii) Plan will include mitigation, preparedness and response elements. iii) The plan will be multi-disciplinary to be drawn up in conjunction / consultation with all relevant department concerned with mitigation, preparedness and response.	Ministry of Home affairs, State Government State Government / State Disaster Management Authorities. State Governments/State Disaster Management Authorities.

V. Financial Arrangements: Financial assistance from national and international agencies is very vital for post-disaster management as in the absence of funds, relief, rehabilitation and reconstruction suffers. This form of assistance is useful for providing food and medical facilities to the effected people and for other activities including establishment and operation relief camps over a long period of time.

National and international assistance is used for providing building materials, technical equipment, facilitating agriculture re-establishment, feeding programmes, launching food for work programmes and extending support for livelihood opportunities. Reconstruction also needs outside assistance for planning and implementing interventions.

Agencies: National organizations and department agencies that can provide technical, equipment, training and financial assistance in disaster management in an area includes the following:

1. Central Government departments and organizations, like disaster management, agriculture, rural development, transport, science and technology, space and earth science etc.
2. Non-governmental organizations.
3. Technical and research organizations and institutes like the National Institute of Disaster Management
4. Red Cross Society.

International assistance for disaster management can be obtained from the following agencies and organizations:

1. Foreign governments or their departments.
2. United Nations Organization and its organs like the Food and Agriculture Organization and United Nations Development Programme.

3. International aid agencies like the International Red Cross Society and World Vision.
4. International funding agencies like the World Bank and Asian Development Bank.
5. International technical agencies like the World Meteorological Organization.

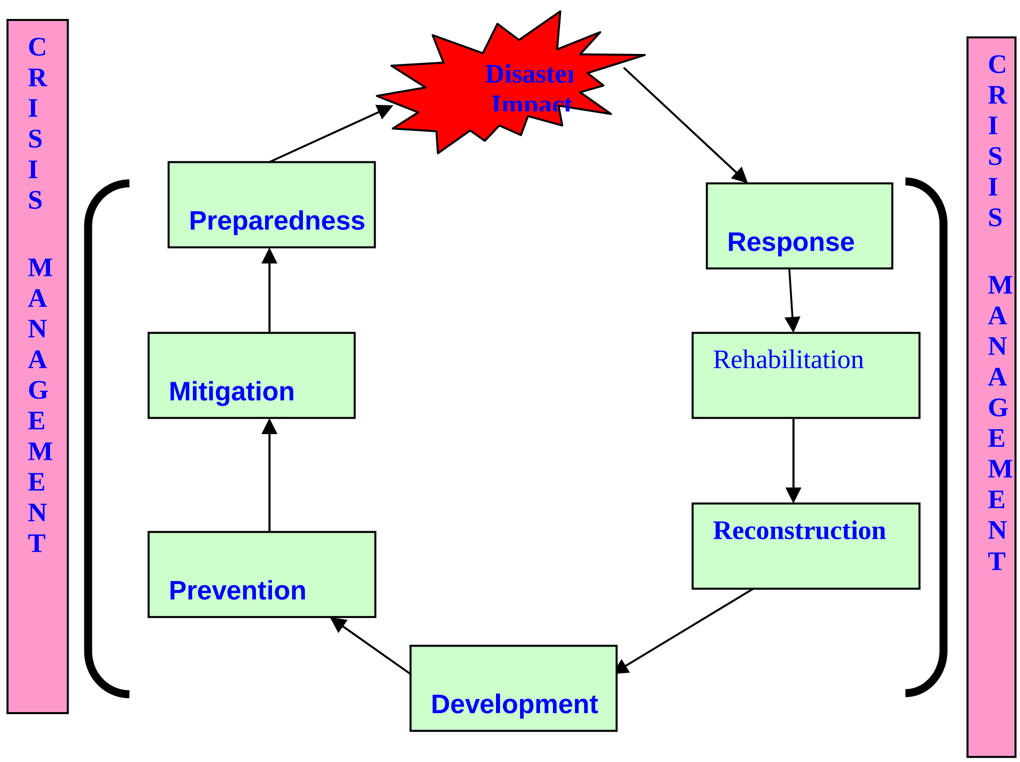
VI. National Disaster Response Force (NDRF)

1. There shall be constituted a National Disaster Response Force for the purpose of specialist response to a threatening disaster situation or disaster.

2. Subject to the provisions of Disaster Management 2005 Act, the Force shall be constituted in such manner and, the conditions of service of the members of the Force, including disciplinary provisions therefore, be such as may be prescribed.

Control, direction etc.: The general superintendence, direction and control of the Force shall be vested and exercised by the National Authority and the command and supervision of the Force shall vest in an officer to be appointed by the Central Government as the Director General of the National Disaster Response Force.

Disaster Management Cycle



Government of India [GoI], Ministry of Home Affairs [MHA] and United Nations Development Programme [UNDP] have signed an agreement on August 2002 for implementation of ***"Disaster Risk Management"*** Programme to reduce the vulnerability of the communities to natural disasters, in identified multi–hazard disaster prone areas.

Goal : 'Sustainable Reduction in Natural Disaster Risk" in some of the most hazard prone districts in selected states of India'.

The four main ***objectives*** of this program are:

1. National capacity building support to the Ministry of Home Affairs

2. Environment building, education, awareness programme and strengthening the capacity at all levels in natural disaster risk management and sustainable recovery
3. Multi-hazard preparedness, response and mitigation plans for the programme at state, district, block and village/ward levels in select programme states and districts
4. Networking knowledge on effective approaches, methods and tools for natural disaster risk management, developing and promoting policy frameworks

Hazard: "Is the potential for a natural or human-caused event to occur with negative consequences". A hazard can become an emergency; when the emergency moves beyond the control of the population, it becomes a disaster.

Emergency: "Is a situation generated by the real or imminent occurrence of an event that requires immediate attention". Paying immediate attention to an event or situation as described above is important as the event/situation can generate negative consequences and escalate into an emergency. The purpose of planning is to minimize those consequences.

Disaster: "Is a natural or human-caused event which causes intensive negative impacts on people, goods, services and/or the environment, exceeding the affected community's capability to respond" .

Risk: "Is the probability that loss will occur as the result of an adverse event, given the hazard and the vulnerability" (key words) Risk (R) can be determined as a product of hazard (H) and vulnerability (V). i.e. R = H x V

Vulnerability: "Is the extent to which a community's structure, services or environment is likely to be damaged or disrupted by the impact of a hazard".

Disaster Management: Is more than just response and relief (i.e., it assumes a more proactive approach) Is a systematic process (i.e., is based on the key management principles of *planning*, *organizing,* and *leading* which includes *coordinating* and *controlling*) Aims to reduce the negative impact or consequences of adverse events (i.e., disasters cannot always be prevented, but the adverse effects can be minimized) Is a system with many components.

Twelve most common challenges for any Disaster Management Plan

1. **Inter-organizational coordination:** Collaboration between intervening emergency response agencies cannot be stressed enough.
2. **Sharing information**: This task can become complicated by the amount of equipment needed and the number of people involved. In most incidences, two-way radios are the only reliable form of communications across distances between mobilized response units. Landline and mobile phones can become overloaded and communication via radio frequency is unreliable due to differing band usage amongst responding agencies.
3. **Resource management**: A command centre must be established to take control of the distribution of supplemental personnel, equipment, and supplies among multiple organizations and identify which resources have arrived or are en route. Command must also determine where those resources are most needed and brief all agencies or volunteers before entering the disaster scene.
4. **When advance warnings** are possible: Evacuation from areas of danger can be the most effective life-saving strategy before and during a disaster. Communication channels must be in place to allow numerous agencies access to

information about detected potential threats. And clearly defined criteria must be established as to when and where to evacuate so all agencies understand the procedure.

5. **The public tends to underestimate risks and downplay warnings:** This is especially true if messages are ambiguous or inconsistent. All warnings should be issued from a credible source and information on how to determine individual risk factors must be conveyed to members of the affected population with clear guidelines on what actions should be taken.
6. **Search and rescue:** This is an important aspect of post-disaster response. But due to it's very nature, cannot be planned for in advance as casualties are often treated at the scene. Efforts for search and rescue teams can also become complicated by multiple jurisdictions involved during a disaster as well as by the efforts of bystanders who are trying to help.
7. **Using the mass media to deliver warnings to the public:** Local media agencies should be tasked with educating the public on how to avoid health problems post disaster. Information on food and water safety, injury and disease prevention should be disseminated through TV and radio.
8. **Triage:** Untrained personnel and bystanders involved with the initial search and rescue often bypass established field triage and first aid stations because they do not know where these posts are located or because they want to get the victims to the closest hospital. Established protocols between emergency medical services and area hospitals will ensure more even distribution of casualties.
9. **Patient tracking:** This issue can arises because most people who are evacuating a scene do not use local shelters and therefore their whereabouts are not recorded through official agencies.
10. **Hospital or healthcare agency damage:** In the event that local medical facilities are incapacitated or overloaded with disaster related casualties, an alternate site should be determined prior to an emergency.
11. **Volunteer management:** Donation and volunteer management can become problematic during a disaster since most efforts are focused on mobilizing all available participants and the available resources may exceed needs.
12. **Plan for organized improvisation**: Be prepared to respond to the disruption of shelters, utilities, communication systems, and transportation. Regardless of how thorough your disaster management plan may be, preplanning must always anticipate the unexpected. And Public health officials must develop mutually agreed procedures, maintaining frequent training exercises to keep their systems coordinated.

International Day for Risk Reduction

Every year, on the ***2nd Wednesday of October***, the world marks the
International Day for Risk Reduction

Suggested Readings

- *Disaster Management By Gupta HK*
- *Coping with Catastrophe: A Handbook of Disaster Management By Hodgkinson PE & Stewart M*
- *Disaster Management. By* Sharma *VK*
- Disaster Management *By G.K. Ghosh*
- Disaster Management *By RB Singh*
- Disaster Management: Through the New Millennium *By Ayaz Ahmad*
- Disaster Management *By B Narayan*
- Modern Encyclopedia of Disaster and Hazard Management *By BC Bose*
- Disaster Management *By Nikuj Kumar*
- Disaster Management - Recent Approaches *By Arvind Kumar*
- Disasters: A quick FAQ *by Srinivas, H* (2005)
- The Disaster Management Cycle by *Warfield, C* (2005)
- Alibek, K and Handelman, S (1999). Biohazards. Random House: New York
- Roberts, B (1993). New Challenges and new policy properties for the 1990s. In Biological Weapons: Weapons of the Future. Washington: Centre for Strategic & International Studies.
- Acharya, SK; Sarkar, A; Roy, P and Sharangi, AB (2009) Disaster management: Concept, people and perception. Agrotech Publishing Academy, Udaipur, *pp* 176.
- Disaster Management: Future Challenges and Opportunities (Eds) Jagbir Singh, IK International Publishing House, New Delhi, 2007 *pp* 351
- Negi, SS; Singh, B and Singh, NP (2009) Principal and practices of disaster management. Dehradun, *pp* 254
- Goyal, SL (2007) Disaster administration and management, Deep & Deep Publications Pvt. Ltd., New Delhi *pp* 626

Web Resources

- http://www.revenueharyana.gov.in/
- http://www.ndmindia.nic.in/
- http://www.nidm.net/
- http://saarc-sdmc.nic.in/index.asp
- http://www.unisdr.org/
- http://www.disastermgmt.org/http://www.drmonline.net/
- http://en.wikipedia.org/wiki/Wikipedia:WikiProject_Disaster_management
- http://www.ifrc.org/what/disasters/reducing/day.asp
- http://www.gdrc.org/uem/disasters/1-what_is.html
- http://creativecommons.org/licenses/by-nc/2.5/ca/
- www.cdc.gov * www.fema.org
- www.nbc-med.org