

**LECTURE NOTE**  
**DISASTER MANAGEMENT**

# INTRODUCTION

## Definitions:

### 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 refers to ‘Bad or Evil star’.

- A disaster can be defined as “A serious disruption in the functioning of the community or a society causing wide spread material, economic, social or environmental losses which exceed the ability of the affected society to cope using its own resources”.
- A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk.
- A disaster happens when a hazard impacts on the vulnerable population and causes damage, casualties and disruption. Any hazard – flood, earthquake or cyclone which is a triggering event along with greater vulnerability (inadequate access to resources, sick and old people, lack of awareness etc) would lead to disaster causing greater loss to life and property.

### Hazards:

The word ‘hazard’ owes its origin to the word ‘hasard’ in old French and ‘az-zahr’ in Arabic meaning ‘chance’ or ‘luck’.

- Hazard may be defined as “a dangerous condition or event, that threat or have the potential for causing injury to life or damage to property or the environment.”
- Hazards can be grouped into two broad categories:
  1. Natural Hazard
  2. Manmade Hazard

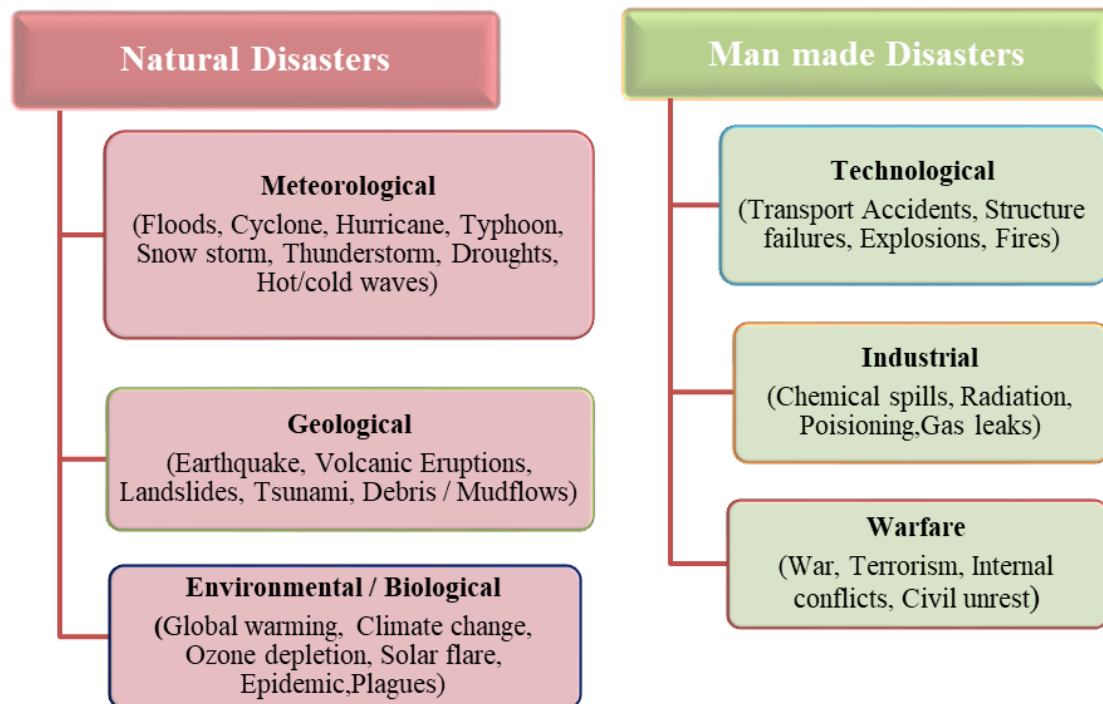
**Natural hazards** are hazards which are caused because of natural phenomena (hazards with meteorological, geological or even biological origin).

- Examples of natural hazards are cyclones, tsunamis, earthquake and volcanic eruption which are exclusively of natural origin.
- Landslides, floods, drought, fires are socio-natural hazards since their causes are both natural and manmade.
- For example flooding may be caused because of heavy rains, landslide or blocking of drains with human waste.

**Manmade hazards** are hazards which are due to human negligence.

- Manmade hazards are associated with industries or energy generation facilities and include explosions, leakage of toxic waste, pollution, dam failure, wars or civil strife etc.

## Various Types of Disasters:



## Difference between Disaster and Hazard:

### Difference between disaster and hazard?

Hazard	Disaster
A hazard is a situation where there is a threat to life, health, environment or property.	A disaster is an event that completely disrupts the normal ways of a community. It brings on human, economical, and environmental losses to the community which the community cannot bear on its own.
Hazard are occurred at the place which has less population	Disasters are mainly occurred at over populated area.
Hazard is caused by negligence	Disaster is a results of differential behavior of nature due to many conditions.
Hazards are natural or manmade phenomenon that are a feature of our planet and cannot be prevented.	These hazards are termed as disasters when they cause widespread destruction of property and human lives.
In their dormant state, hazards just pose a threat to life and property.	Once a hazard becomes active and is no longer just a threat, it becomes a disaster.

## **Vulnerability:**

Vulnerability may be defined as “The extent to which a community, structure, services 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 terrains or a disaster prone area.”

Vulnerabilities can be categorized into:

1. Physical vulnerability
2. Socio-economic vulnerability

**Physical Vulnerability:** It includes notions of who and what may be damaged or destroyed by natural hazard such as earthquakes or floods. It is based on the physical condition of people and elements at risk, such as buildings, infrastructure etc; and their proximity, location and nature of the hazard. It also relates to the technical capability of building and structures to resist the forces acting upon them during a hazard event.

**Socio-economic Vulnerability:** The degree to which a population is affected by a hazard will not merely lie in the physical components of vulnerability but also on the socioeconomic conditions. The socio-economic condition of the people also determines the intensity of the impact. For example, people who are poor and living in the sea coast don't have the money to construct strong concrete houses. They are generally at risk and lose their shelters whenever there is strong wind or cyclone. Because of their poverty they too are not able to rebuild their houses.

## **Capacity:**

Capacity can be defined as “resources, means and strengths which exist in households and communities and which enable them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster”.

Capacities could be:

1. Physical capacity
2. Socio-economic capacity

**Physical Capacity:** People whose houses have been destroyed by the cyclone or crops have been destroyed by the flood can salvage things from their homes and from their farms. Some family members have skills, which enable them to find employment if they migrate, either temporarily or permanently.

**Socio-economic Capacity:** In most of the disasters, people suffer their greatest losses in the physical and material realm. Rich people have the capacity to recover soon because of their wealth. In fact, they are seldom hit by disasters because they live in safe areas and their houses are built with stronger materials.

## **Risk:**

Risk is a “measure of the expected losses due to a hazard event occurring in a given area over a specific time period. Risk is a function of the probability of particular hazardous event and the losses each would cause.”

- The level of risk depends upon:
  - Nature of the hazard
  - Vulnerability of the elements which are affected
  - Economic value of those elements
- A community/locality is said to be at ‘risk’ when it is exposed to hazards and is likely to be adversely affected by its impact.

## **Disaster Risk Reduction:**

Disaster Risk Reduction can take place in the following ways:

### **1. Preparedness:**

This protective process embraces measures which enable governments, communities and individuals to respond rapidly to disaster situations to cope with them effectively. Preparedness includes the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories and the training of personnel. It may also embrace search and rescue measures as well as evacuation plans for areas that may be at risk from a recurring disaster. Preparedness therefore encompasses those measures taken before a disaster event which are aimed at minimising loss of life, disruption of critical services, and damage when the disaster occurs.

### **2. Mitigation:**

Mitigation embraces measures taken to reduce both the effect of the hazard and the vulnerable conditions to it in order to reduce the scale of a future disaster. Therefore mitigation activities can be focused on the hazard itself or the elements exposed to the threat. Examples of mitigation measures which are hazard specific include water management in drought prone areas, relocating people away from the hazard prone areas and by strengthening structures to reduce damage when a hazard occurs. In addition to these physical measures, mitigation should also aim at reducing the economic and social vulnerabilities of potential disasters.

## **Disaster Management Cycle:**

Disaster Risk Management includes sum total of all activities, programmes and measures which can be taken up before, during and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses. The three key stages of activities that are taken up within disaster risk management are:

- (i) Pre-disaster
- (ii) Disaster occurrence
- (iii) Post disaster

**Pre-disaster (Before a disaster):**

It includes the activities taken to reduce human and property losses caused by a potential hazard. For example carrying out awareness campaigns, strengthening the existing weak structures, preparation of the disaster management plans at household and community level etc. Such risk reduction measures taken under this stage are termed as mitigation and preparedness activities.

**Disaster occurrence (During a disaster):**

It includes the initiatives taken to ensure that the needs and provisions of victims are met and suffering is minimized. Activities taken under this stage are called emergency response activities.

**Post-disaster (After a disaster):**

It includes the initiatives taken in response to a disaster with a purpose to achieve early recovery and rehabilitation of affected communities, immediately after a disaster strikes. These are called as response and recovery activities.

# EARTHQUAKES

## Definition:

Earthquake can be defined as the sudden shaking of the earth crust. It is one of the most destructive natural hazards. They may occur at any time of the year, day or night, with sudden impact and little warning.

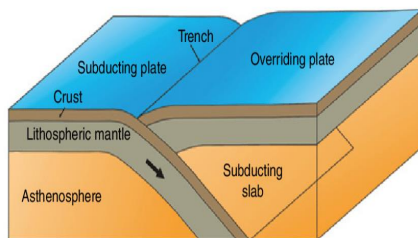
## Cause of Earthquake:

The earth's crust is a rocky layer of varying thickness ranging from a depth of about 10 kilometres under the sea to 65 kilometres under the continents. The crust is not one piece but consists of portions called 'plates' which vary in size from a few hundred to thousands of kilometres. The 'theory of plate tectonics' holds that the plates ride up on the more mobile mantle, and are driven by some yet unconfirmed mechanisms, perhaps thermal convection currents. When these plates contact each other, stress arises in the crust. These stresses can be classified according to the type of movement along the plate's boundaries:

- a) Pulling away from each other,
- b) Pushing against one another and
- c) Sliding sideways relative to each other.

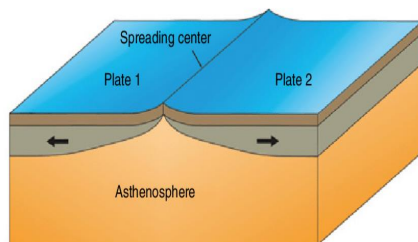
All these movements are associated with earthquakes.

Convergent plate boundary: subduction zone



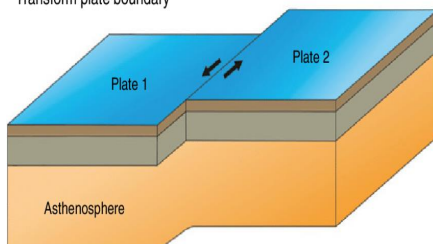
**Convergent** - where crust is destroyed as one plate dives under another.

Divergent plate boundary



**Divergent** - where new crust is generated as the plates pull away from each other.

Transform plate boundary



**Transformational** - where crust is neither produced nor destroyed as the plates slide horizontally past each other.

The areas of stress at plate boundaries which release accumulated energy by slipping or rupturing are known as 'faults'. The theory of 'elasticity' says that the crust is continuously stressed by the movement of the tectonic plates; it eventually reaches a point of maximum supportable strain. A rupture then occurs along the fault and the rock rebounds under its own elastic stresses until the strain is relieved. The fault rupture generates vibration called seismic (from the Greek 'seismos' meaning shock or earthquake) waves, which radiates from the focus in all directions. The point of rupture is called the 'focus' and may be located near the surface or deep below it. The point on the surface directly above the focus is termed as the 'epicentre' of the earthquake.

- Earthquakes can be of three types based on the focal depth:
  - (i) Deep:- 300 to 700 kms from the earth surface
  - (ii) Medium:- 60 to 300 kms
  - (iii) Shallow: less than 60 kms
- The deep focus earthquakes are rarely destructive because by the time the waves reach the surface the impact reduces. Shallow focus earthquakes are more common and are extremely damaging because of their proximity to the surface.

### **Measurement of Earthquake:**

Earthquakes can be described by the use of two distinctively different scales of measurement demonstrating magnitude and intensity.

- Earthquake magnitude or amount of energy released is determined by the use of a **seismograph** which is an instrument that continuously records ground vibration. The scale was developed by a seismologist named Charles Richter. An earthquake with a magnitude 7.5 on the **Richter scale** releases 30 times the energy than one with 6.5 magnitudes. An earthquake of magnitude 3 is the smallest normally felt by humans. The largest earthquake that has been recorded with this system is 9.25 (Alaska, 1969 and Chile, 1960).
- The second type of scale, the earthquake intensity scale measures the effects of an earthquake where it occurs. The most widely used scale of this type was developed in 1902 by Mercalli an Italian seismologist. The scale was extended and modified to suit the modern times. It is called the **Modified Mercalli Scale**, which expresses the intensity of earthquake effect on people, structure and the earth's surface in values from I to XII. With an intensity of VI and below most of the people can feel the shake and there are cracks on the walls, but with an intensity of XII there is general panic with buildings collapsing totally and there is a total disruption in normal life.



## **Typical adverse effects:**

- Damage occurs to human settlement, buildings, structures and infrastructure, especially bridges, elevated roads, railways, water towers, pipelines, electrical generating facilities.
- Aftershocks of an earthquake can cause much greater damage to already weakened structures.
- Secondary effects include fires, dam failure and landslides which may block water ways and also cause flooding.
- Damage may occur to facilities using or manufacturing dangerous materials resulting in possible chemical spills.
- There may also be a breakdown of communication facilities.
- There are large number of casualties because of the poor engineering design of the buildings and close proximity of the people. About 95 per cent of the people who are killed or who are affected by the earthquake is because of the building collapse.
- There is also a huge loss to the public health system, transport and communication and water supply in the affected areas.

## **Possible risk reduction measures:**

**Community preparedness:** Community preparedness is vital for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is 'DROP, COVER and HOLD'.

**Planning:** The Bureau of Indian Standards has published building codes and guidelines for safe construction of buildings against earthquakes. Before the buildings are constructed the building plans have to be checked by the Municipality, according to the laid down bylaws. Many existing lifeline buildings such as hospitals, schools and fire stations may not be built with earthquake safety measures. Their earthquake safety needs to be upgraded by retrofitting techniques.

**Public education:** Public education is educating the public on causes and characteristics of an earthquake and preparedness measures. It can be created through sensitization and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students.

**Engineered structures:** Buildings need to be designed and constructed as per the building by laws to withstand ground shaking. Architectural and engineering inputs need to be put together to improve building design and construction practices. The soil type needs to be analyzed before construction. Building structures on soft soil should be avoided. Buildings on soft soil are more likely to get damaged even if the magnitude of the earthquake is not strong. Similar problems persist in the buildings constructed on the river banks which have alluvial soil.

# TSUNAMI

## Definition:

The term Tsunami has been derived from a Japanese term Tsu meaning 'harbor' and nami meaning 'waves'. Tsunamis are popularly called tidal waves but they actually have nothing to do with the tides. These waves which often affect distant shores, originate by rapid displacement of water from the lake or the sea either by seismic activity, landslides, volcanic eruptions or large meteoroid impacts. Whatever the cause may be sea water is displaced with a violent motion and swells up, ultimately surging over land with great destructive power.

## Causes of Tsunami:

The geological movements that cause tsunamis are produced in three major ways.

**Earthquake:** The most common of these are fault movements on the sea floor, accompanied by an earth-quake. They release huge amount of energy and have the capacity to cross oceans. The degree of movement depends on how fast the earthquake occurs and how much water is displaced.

**Landslide:** The second most common cause of the tsunami is a landslide either occurring under water or originating above the sea and then plunging into the water. The largest tsunami ever produced by a landslide was in Lituya Bay, Alaska 1958. The massive rock slide produced a wave that reached a high water mark of 50 - 150 meters above the shoreline.

**Volcano:** The third major cause of tsunami is volcanic activity. The flank of a volcano located near the shore or under water may be uplifted or depressed similar to the action of a fault, or, the volcano may actually explode. In 1883, the violent explosion of the famous volcano, Krakotoa in Indonesia, produced tsunami measuring 40 meters which crushed upon Java and Sumatra. Over 36,000 people lost their lives in this tyrant waves.

## Predictability:

There are two distinct types of tsunami warning:

a) International tsunami warning systems and

b) Regional warning systems.

- **International Tsunami Warning Systems:** Shortly after the Hilo Tsunami (1946), the Pacific Tsunami Warning System (PTWS) was developed with its operational center at the Pacific Tsunami Warning Center (PTWC) near Honolulu, Hawaii. The PTWC is able to alert countries several hours before the tsunami strikes. The warning includes predicted arrival time at selected coastal communities where the tsunami could travel in few hours. A tsunami watch is issued with subsequent arrival time to other geographic areas.

- **Regional Warning Systems** usually use seismic data about nearby earthquakes to determine if there is a possible local threat of a tsunami. Such systems are capable enough to provide warnings to the general public in less than 15 minutes. In India, the Survey of India maintains a tide gauge network along the coast of India. The day-to-day maintenance of the gauge is carried with the assistance from authorities of the ports. Apart from the tide gauge, tsunami can be detected with the help of radars. The 2004 Indian Ocean tsunami, recorded data from four radars and recorded the height of tsunami waves two hours after the earthquake. It should be noted that the satellites observations of the Indian Ocean tsunami would not have been of any use in delivering warnings, as the data took five hours to process and it was pure chance that the satellites were overhead at that time. However, in future it is possible that the space-based observation might play a direct role in tsunami warning.

### **Typical adverse effects:**

- Local tsunami events or those less than 30 minutes from the source cause the majority of damage. The force of the water can raze everything in its path.
- It is normally the flooding affect of the tsunami that causes major destruction to the human settlements, roads and infrastructure thereby disrupting the normal functioning of the society.
- As the waves withdraw towards the ocean they sweep out the foundations of the buildings, the beaches get destroyed and the houses carried out to sea.
- Damage to ports and airports may prevent importation of needed food and medical supplies.
- Apart from the physical damage, there is a huge impact on the public health system.
- Deaths mainly occur because of drowning as water inundates homes. Many people get washed away or crushed by the giant waves and some are crushed by the debris, causes.
- Availability of drinking water has always been a major problem in areas affected by a disaster.
- Sewage pipes may be damaged causing major sewage disposal problems.
- Open wells and other ground water may be contaminated by salt water and debris and sewage.
- Flooding in the locality may lead to crop loss, loss of livelihood like boats and nets, environmental degradation etc.

### **Possible risk reduction measures:**

In certain tsunami prone countries some measures have been taken to reduce the damage caused on shore. Japan has implemented an extensive programme of building tsunami walls of up to 4.5m (13.5 ft) high in front of populated coastal areas. Other localities have built flood gates and channels to redirect the water from incoming tsunamis. However, framed structures in the area. The wall may have succeeded in slowing down and moderating the height of the tsunami but it did not prevent major destruction and loss of life.

### **Site Planning and Land Management:**

Site planning determines the location, configuration, and density of development on particular sites and is, therefore, an important tool in reducing tsunami risk.

- The designation and zoning of tsunami hazard areas for such open-space uses as agriculture, parks and recreation, or natural hazard areas is recommended as the first land use planning strategy. This strategy is designed to keep development at a minimum in hazard areas.
- In areas where it is not feasible to restrict land to open-space uses, other land use planning measures can be used. These include strategically controlling the type of development and uses allowed in hazard areas, and avoiding high-value and high occupancy uses to the greatest degree possible.

### **Engineering structures:**

Most of the habitation of the fishing community is seen in the coastal areas. The houses constructed by them are mainly of light weight materials without any engineering inputs. Therefore there is an urgent need to educate the community about the good construction practices that they should adopt such as:

- Site selection – Avoid building or living in buildings within several hundred feet of the coastline as these areas are more likely to experience damage from tsunamis.
- Construct the structure on a higher ground level with respect to mean sea level.
- Elevate coastal homes: Most tsunami waves are less than 3 meters in height. Elevating house will help reduce damage to property from most tsunamis.
- Construction of water breakers to reduce the velocity of waves.
- Use of water and corrosion resistant materials for construction.
- Construction of community halls at higher locations, which can act as shelters at the time of a disaster.

### **Flood management:**

Flooding will result from a tsunami. Tsunami waves will flood the coastal areas. Flood mitigation measures could be incorporated.

# CYCLONES

## Definition:

Cyclone is a region of low atmospheric pressure surrounded by high atmospheric pressure resulting in swirling atmospheric disturbance accompanied by powerful winds blowing in anticlockwise direction in the Northern Hemisphere and in the clockwise direction in the Southern Hemisphere. They occur mainly in the tropical and temperate regions of the world.

Cyclones are known by different names in different parts of the world:

- **Typhoons** in the Northwest Pacific Ocean west of the dateline
- **Hurricanes** in the North Atlantic Ocean, the Northeast Pacific Ocean east of the dateline, or the South Pacific Ocean.
- **Tropical cyclones** -the Southwest Pacific Ocean and Southeast Indian Ocean.
- **Severe cyclonic storm** (the North Indian Ocean)
- **Tropical cyclone** (the Southwest Indian Ocean)
- **Willie-Willie** in Australia
- **Tornado** in South America

## General Characteristics:

Cyclones in India are moderate in nature. Some of the general characteristics of a cyclone are:

1. Strong winds
2. Exceptional rain
3. Storm surge

The development of a cyclone covers three stages namely

### **(a) Formation and initial development state:**

Four atmospheric/ oceanic conditions are necessary for the formation of a cyclone:

- A warm sea temperature in excess of 26 degree centigrade, to a depth of 60 meters, which provides abundant water vapour in the air by evaporation.
- High relative humidity (degree to which the air is saturated by water vapor) of the atmosphere to a height of about 7000 meters, facilitates condensation of water vapor into droplets and clouds, releases heat energy and induces drop in pressure.

- Atmospheric instability (an above average decrease of temperature with altitude) encourages considerable vertical cumulus cloud convection when condensation of rising air occurs.
- A location of at least 4-5 latitude degrees from the Equator allow the influence of the force due to the earth's rotation (Coriolis force) to take effect in inducing cyclonic wind circulation around low pressure centers.

**(b) Fully matured:**

The main feature of a fully mature tropical cyclone is a spiral pattern of highly turbulent giant cumulus thundercloud bands. These bands spiral inwards and form a dense highly active central cloud core which raps around a relatively calm zone. This is called the "eye" of a cyclone. The eye looks like a black hole or a dot surrounded by thick clouds. The outer circumference of the thick cloud is called the 'eye wall'.

**(c) Weakening or decay:**

A tropical cyclone begins to weaken as soon as its source of warm moist air is abruptly cut off. This is possible when the cyclone hits the land, on the cyclone moves to a higher altitude or when there is the interference of another low pressure.

**Indian Hazard Zones:**

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

**Warning:**

- Low pressure and the development can be detected hours or days before it causes damage.
- The satellites track the movement of these cyclones based on which the people are evacuated from areas lively to be affected. It is difficult to predict the accuracy.
- Accurate landfall predictions can give only a few hours' notice to threatened population.
- India has one of the best cyclone warning systems in the world. The India Meteorological Department (IMD) is the nodal department for wind detection, tracking and forecasting cyclones.
- Cyclone tracking is done through INSAT satellite.
- Cyclone warning is disseminated by several means such as satellite based disaster warning systems, radio, television, telephone, fax, high priority telegram, public announcements and bulletins in press. These warnings are disseminated to the general public, the fishing community especially those in the sea, port authorities, commercial aviation and the government machinery.

## **Typical Adverse effects:**

High winds cause major damage to infrastructure and housing, in particular fragile constructions. They are generally followed by heavy rains and floods and, in flat coastal areas by storm surge riding on tidal waves and inundating the land over long distances of even up to 15 kilometres inland.

**Physical damage:** structures will be damaged or destroyed by the wind force, flooding and storm surge. Light pitched roofs of most structures especially the ones fitted on to industrial buildings will suffer severe damage.

**Casualties and public health:** caused by flooding and flying elements, contamination of water supplies may lead to viral outbreaks, diarrhoea, and malaria.

**Water supplies:** Ground and pipe water supply may get contaminated by flood waters. Crops and food supplies – high winds and rains ruin the standing crop and food stock lying in low lying areas. Plantation type crops such as banana and coconut are extremely vulnerable. Salt from the sea water may get deposited on the agricultural land and increase the salinity. The loss of the crop may lead to acute food shortage.

**Communication:** severe disruption in the communication links as the wind may bring down the electricity and communication towers, telephone poles, telephone lines, antennas and satellite disk and broadcasting services. Transport lines (road and rail) may be curtailed, Lack of proper communication affects effective distribution of relief materials.

## **Possible Risk Reduction Measures:**

**Coastal belt plantation** - Green belt plantation along the coastal line in a scientific interweaving pattern can reduce the effect of the hazard. Providing a cover through green belt sustains less damage. Forests act as a wide buffer zone against strong winds and flash floods. Without the forest the cyclone travel freely inland. The lack of protective forest cover allows water to inundate large areas and cause destruction. With the loss of the forest cover each consecutive cyclone can penetrate further inland.

**Hazard mapping** – Meteorological records of the wind speed and the directions give the probability of the winds in the region. Cyclones can be predicted several days in advance. The onset is extensive and often very destructive. Past records and paths can give the pattern of occurrence for particular wind speeds. A hazard map will illustrate the areas vulnerable to cyclone in any given year. It will be useful to estimate the severity of the cyclone and various damage intensities in the region. The map is prepared with data inputs of past climatological records, history of wind speed, frequency of flooding etc.

**Land use control** designed so that least critical activities are placed in vulnerable areas. Location of settlements in the floodplains is at utmost risk. Sitting of key facilities must be marked in the land use. Policies should be in place to regulate land use and building codes should be enforced.

**Engineered structures** – structures need to be built to withstand wind forces. Good site selection is also important. Majority of the buildings in coastal areas are built with locally available materials and have no engineering inputs. Good construction practice should be adopted such as: -

- Cyclonic wind storms inundate the coastal areas. It is advised to construct on stilts or on earth mound.
- Houses can be strengthened to resist wind and flood damage. All elements holding the structures need to be properly anchored to resist the uplift or flying off of the objects. For example, avoid large overhangs of roofs, and the projections should be tied down.
- A row of planted trees will act as a shield. It reduces the energy.
- Buildings should be wind and water resistant.
- Buildings storing food supplies must be protected against the winds and water.
- Protect river embankments.
- Communication lines should be installed underground.
- Provide strong halls for community shelter in vulnerable locations.

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

**Improving vegetation cover** – The roots of the plants and trees keep the soil intact and prevent erosion and slow runoff to prevent or lessen flooding. The use of tree planted in rows will act as a windbreak. Coastal shelterbelt plantations can be developed to break severe wind speeds. It minimizes devastating effects. The Orissa calamity has also highlighted the need for urgent measures like shelterbelt plantation along cyclone-prone coastal areas. Species chosen for this purpose should not only be able to withstand the impact of strong cyclonic winds, but also check soil erosion.