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## UNIT 15 HYDROLOGICAL HAZARDS

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### 15.0 INTRODUCTION

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You have read natural hazards and geological hazards in the previous two units. Let us now learn about hydrological hazards. Any kind of extreme damage caused to human life, animals, environment by the fury of water predominantly, at times also accompanied by high speed winds, are termed as hydrological hazards. Which is/are the most common hydrological hazard/hazards experienced by Indian population? We would say abnormal tidal waves and excessive rains that cause flooding in coastal areas and plains resulting in huge loss to crops, property, cattle and human life. Due to abnormally long hours of rainfall, the pace of life in cities and countryside is adversely impacted. Flooding is a common hydrological hazard around monsoon period in India.

In this unit we will discuss the important natural hydrological hazards caused predominantly by water i.e. cyclones, typhoons, hurricanes, tsunamis, floods and droughts. We will also try to know the causes of these natural phenomenon and further also read some case studies to understand the gravity of destruction caused by them.

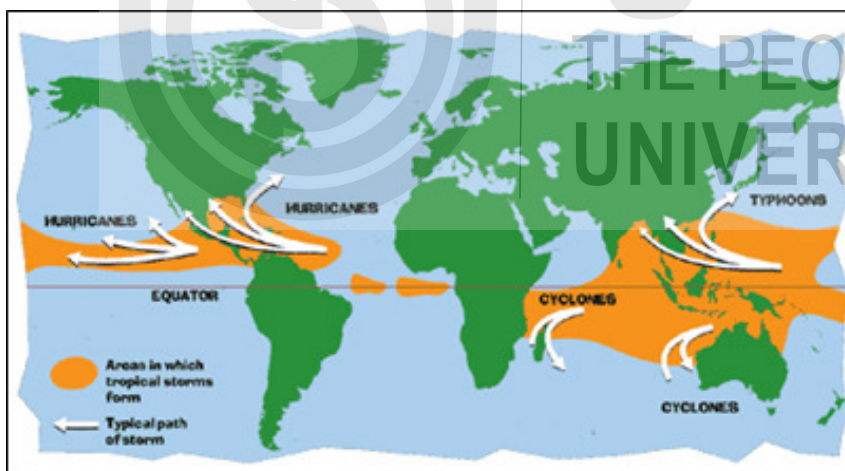
## 15.1 OBJECTIVES

- After studying this unit, you should be able to:
- Explain the types of hydrological hazards;
- Describe the causes of hydrological hazards;
- Describe the geographical distribution of the hydrological hazards;
- Explain the extent of destruction caused by the natural hydrological hazards; and
- Discuss about the case studies pertaining to hydrological hazards.

## 15.2 TYPES AND CAUSES OF HYDROLOGICAL HAZARDS

In this section we will discuss the various hydrological hazards and their causes in this section. We will also find out the conditions/factors that initiate and aggravate these natural phenomena's to the extent of being destructive.

*Cyclones, hurricanes, typhoons, are all forms of tropical storms which are named differently depending on their region of origin (Figure 15.1). Cyclones are tropical storms which are common in Australia, Bangladesh, Pakistan, and India. Hurricanes are tropical storms of America and central America. The tropical storms which originate in the western Pacific and China Sea are known as typhoons.*



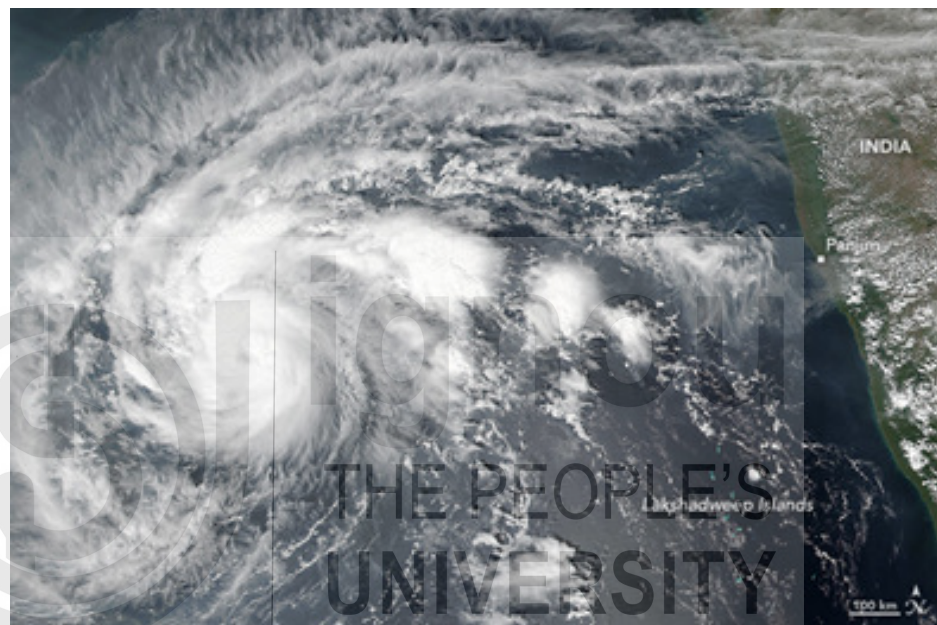
**Fig. 3.1: Tropical storms: Cyclones, hurricanes and typhoons.**  
(Source: <https://earthobservatory.nasa.gov/Features/Hurricanes/>)

*Tsunami* is a kind of hydrological hazard which is experienced mostly by people inhabiting coastal regions. When an earthquake hits the ocean floor it gives rise to massive/large sea wave called tsunami. The tsunami commonly floods the coastal region just like cyclones and can cause devastation of life and property.

*Floods and droughts* are hydrological hazards which are outcome of excessive and absolutely no rains. Floods on landlocked areas occur due to incessant rains for days whereas drought conditions arise when there is scarcity of rain. The coastal areas can also experience floods owing to inundation of ocean water in coastal areas due to various reasons such as cyclones, tsunamis, heavy downpour etc.

## 15.2.1 Cyclones

Cyclone is defined as any large system of inward spiralling winds that circulates about a centre of low atmospheric pressure. Cyclones circulate in a counterclockwise direction in the northern hemisphere whereas in the southern hemisphere they circulate in a clockwise direction. Cyclonic winds are generally associated with precipitation i.e. rain or snow. The above definition gives you a fair idea that cyclone spins around the low pressure centre. This centre of the storm is also compared to an eye and there is not much action around the eye or the centre, but the real action is under, especially around the arms from where the rain and strong winds are caused (Figure 15.2). The cyclones have a tendency to occur on land and over water and the commonality between them is that they form a spiral like whirlwind which moves at a very high speed.



**Figure 15.2 The cyclone Chapala**

(Source: <https://earthobservatory.nasa.gov/NaturalHazards/view.php>)

### Common Types of Cyclones:

- **Tropical cyclone:** Tropical cyclone is mostly referred to as ‘Cyclone’ and it originates in tropical oceans. The tropical cyclones are designated with names such as typhoon and hurricanes depending on their geographical location. The tropical cyclones can also be differentiated by their wind speeds.
- **Polar cyclone:** As the name suggests, it is characteristic of polar regions. Common in places like Greenland, Siberia and Antarctica. Polar cyclones are strongest in freezing winter months.
- **Mesocyclone:** When a thunderstorm cloud spins a mesocyclone is formed. Mesocyclone is an outcome of an intermediate stage between normal clouds and partly spinning clouds near the ground which can eventually change to a tornado.
- **Tornado:** A tornado, also known as a ‘Twister’ in America is a high intensity rotating whirlwind that is in touch with both the earth surface and a towering cloud with flat base.

## 15.2.2 Hurricanes

Hurricanes are oceanic storms generated in the tropical northern Atlantic Ocean. They rise from oceans and commonly strike the coastal areas of southeast US, Gulf of Mexico, parts of central America, northeast of South America and Caribbean. The winds which drive these swirling storms are of the order of 119 kilometres per hour or even higher. If the hurricanes reach land it pushes enormous quantity of oceanic water in the coastal regions forming a wall of ocean water commonly known as *storm surge*. The heavy downpour, mighty winds and storm surge together cause flooding on land and can be catastrophic. Recent examples of devastation caused by Hurricanes ‘Harvey’ and ‘Irma’ to coastal parts of North America have been witnessed by all through television channels! Scale of hurricanes based on the speed of the wind also called the Saffir-Simpson Hurricane Scale is given in table 15.1. The categories of hurricane is based on the sustained wind speeds.

**Table 15.1: Saffir-Simpson Hurricane Scale**

(Source:<http://www.nhc.noaa.gov/aboutsshws.php>)

Category	Wind speed	Types of damage due to hurricane winds
<b>Category 1</b>	119-153 km/hr (74-95 mph)	<b>Very dangerous winds will produce some damage:</b> Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
<b>Category 2</b>	154-177 km/hr (96-110 mph)	<b>Extremely dangerous winds will cause extensive damage :</b> Causes power failure and outages for weeks, roof tops of the houses blown and trees uprooted with the ferocious wind velocity.
<b>Category 3</b>	178-208 km/hr (111-129 mph)	<b>Devastating damage will occur:</b> Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
<b>Category 4</b>	209-251 km/hr (130-156 mph)	<b>Catastrophic damage will occur:</b> Strong house structures experience potential damage with loss of most of the roof structure. The trees get snapped and uprooted. Electricity poles are blown away with the wind velocity causing power outages for a stretch of weeks or months. The hurricane prone areas are not inhabitable for long stretch of period.

<b>Category 5</b>	252 Km or higher/hr (157 or higher mph)	<b>Catastrophic damage will occur:</b> A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
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### 15.2.3 Typhoons

A typhoon is a type of tropical cyclone which originates in the western part of the North Pacific Ocean. Northwestern Pacific Basin alone accounts for one-third of tropical cyclones originating in oceans every year. Typhoons in the northwestern Pacific form throughout the year unlike the hurricanes and tropical cyclones which occur during summers. Typhoons are common during June to November and also occur during December to May. A term ‘Super Typhoon’ is used in context of a typhoon which is equivalent to a devastating category 4/5 hurricane. Around 25 to 30 typhoons are reported from the north western Pacific basin and only 6 to 10 hurricanes are reported from the Atlantic Ocean, annually.

### 15.2.4 Tsunamis

A *tsunami* is large sea wave which originates by displacement of a large volume of water on the ocean basin. There can be many reasons for displacement of large volumes of water on ocean basins. The most common reason for the tsunami formation is the high magnitude earthquake rocking the ocean floor. The waves generated can be as high as 100 feet and can cause massive destruction in the coastal regions.

### 15.2.5 Floods and Drought

**Floods** are caused by overflowing of a large amount of water over normally dry land for days together. Floods are caused due to abnormal swelling of water levels in the rivers, creeks, lakes. When the water crosses the danger limit and overflows into the villages and cities, it causes destruction to crops, houses, humans and environment.

#### Types of floods

Now let us discuss the types of flood.

**Areal:** Areal floods take place in low flat land areas due to immoderate rainfall or due to abnormal snowmelt down or continuum of storms. Water accumulation results in inundation of large land areas with water. This causes interruption and problems in normal living conditions.

- i. Riverine/Channel:** When water slowly rises in levels due to continuous rainfall, snow meltdown or tropical cyclones in the rivers and streams close to inhabited or uninhabited areas, flash floods are likely to occur.
- ii. Estuarine and Coastal:** Flooding caused by powerful forward or upward movement of sea tides is coastal flooding. Storms in seas and oceans with huge intensity cause the coastal flooding. Tsunami or tropical cyclones are the examples of such flooding.

- iii. **Urban Flooding:** As the name suggests urban flooding is flooding of populated and inhabited property. This happens due to incessant rainfall and results in the malfunctioning of drainage system in the city. This causes flooding of filthy water on the roads, entering the residential buildings and offices. Water levels can go upto several feet to cause inconvenience and discomfort to normal lifestyle of people. Aftermath of such floods can be outbreak of diseases.
- iv. **Catastrophic Flooding:** When due to an engineering fault, an earthquake, a volcanic activity or any other natural disaster, a rift is caused in the dam wall and that causes water to gush out at an uncontrollable speed a flood situation arises. The catastrophic flooding can result in huge loss of human lives, property and cattle if it occurs near a highly populated area.

**Drought** arises as a result of scanty, below average rainfall for a given region. This scanty or no rainfall also known as dry spell results in shortages of surface water (rivers, lakes, ponds) and ground water.

**Types of Droughts**

Places with scanty rainfall and prolonged dry season are prone to droughts. The changing climatic conditions and global warming also play a role in deficiency of rainfall in areas where the existing water bodies are majorly used for day to day life chores but not replenished as speedily.

1. **Meteorological drought** is one where the climate in the area is dry, with less moisture in the air and the ground water level also not too great to sustain life of plants, cattle or humans.
2. **Agricultural drought** is one where the the land is used heavily for cultivation and the soil erosion takes place with speed. The methods used for irrigation are poorly managed and where farmers mainly depend on rainfall for a good crop.
3. **Hydrological drought** is caused when the water bodies available in an area are used to the point of saturation with no measures of replenishing them. Good amount of rain could prove helpful in filling these water bodies and reservoirs. In the absence of a good monsoon, excessive exploitation of the water bodies in the region results in drying of these water bodies.

**Check Your Progress 1**

**Note:** a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1. Name the different types of tropical cyclones.

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2. Give one example of destructive tsunami.

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3. Give account of different types of floods.

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4. Discuss the most devastating tropical cyclones.

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### 15.3 CAUSES OF HYDROLOGICAL HAZARDS

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We just read about the different types of cyclones and found out that even though they form over different areas (i.e. coastal land and ocean water) they form and operate around the same principle and revolve around the low-pressure eye. The tropical storms such as **tropical cyclone, hurricane** and **typhoons** originate in the tropical oceans/seas which generally lie between 8° and 20° latitude in both northern and southern hemisphere. These are the regions which are hot and humid with light winds. The ocean surface temperatures for formation of these storms are ideally warm i.e. 26°C or higher than this. Such conditions are met during summers or early fall i.e. in the months of June to November in the tropical oceans. The tropical cyclone, hurricane and typhoon development starts in the tropical oceans in the zones where the trade winds converge. Gradually a cluster of thunderstorms form in the convergence zones over the tropical ocean. Based on convection the warm air rises and becomes cool on rising and the convective currents form. When the warm air rises quickly it forms an updraft and upon cooling on the top the moisture forms clouds and come back to the ground as rainwater and cool air as downdraft. When the downdraft and updraft work together with intensity the cloud formation is huge and gives rise to thunderstorm cloud. Thunderstorm cloud takes the shape of **cyclone, hurricane** and **typhoon**(depending on its geographical region of origin)when the air is spinning horizontally with great speed.

**Hurricanes** mostly originate in a convergence zone which lies in the tropical Atlantic Ocean on the western coast of Africa. The tropical cyclones called hurricanes mostly impact the south eastern coast of North America and Mexico.

**Typhoon** originate when the following conditions are met i.e. warm ocean surface water, humid conditions, low pressure centre. Typhoon is identical to hurricane forming in the Atlantic ocean and a cyclone forming in eastern Pacific and Indian ocean. The typhoons geographically originate in the western north Pacific ocean and they usually travel with speed greater than 74 miles per hour. They strike places like Philippines, China and Japan. Typhoons and hurricanes are types of tropical cyclones which are quite similar in terms of their mechanism of formation.

“*Trade winds, Coriolis effect, Doldrums and westerlies*: In the Northern Hemisphere, warm air around the equator rises and flows north toward the pole. As the air moves away from the equator, the *Coriolis effect* deflects it toward the right. It cools and descends near 30 degrees North latitude. The descending air blows from the northeast to the southwest, back toward the equator (Ross, 1995). A similar wind pattern occurs in the Southern Hemisphere; these winds blow from the southeast toward the northwest and descend near 30 degrees South latitude. These prevailing winds, known as the *trade winds*, meet at the Intertropical Convergence Zone (also called the *doldrums*) between 5 degrees North and 5 degrees South latitude, where the winds are calm. The remaining air (air that does not descend at 30 degrees North or South latitude) continues toward the poles and is known as the westerly winds, or *westerlies*.”

**Tsunamis** are experienced along coastal areas and can form due to various reasons viz: high magnitude earthquake on ocean floor, volcanic eruptions, glacier calving, underwater explosions during nuclear material testing, landslides, meteorite impacts etc. The most common reason for a trigger of tsunami is high magnitude earthquake in the ocean basin at plate margins.

**Floods** commonly occur due to non-stop heavy downpour, dam leaks, water bursts, glacial lake bursts, technical failure of water storage bodies or ocean disturbances caused due to cyclonic rains, storm surges, hurricanes, typhoons and tsunamis. **Drought can occur majorly due to natural factors and can also get aggravated by anthropogenic activities like deforestation i.e. felling trees for various reasons such as cooking, furniture, medicinal purposes, industrial and agricultural goods.** Global warming is causing a change in climate. There is a drastic change in temperatures worldwide. All these changes are causing either excessive rainfall that result in floods or there is dearth of rainfall that cause droughts in certain areas.

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## 15.4 GEOGRAPHICAL DISTRIBUTION OF HYDROLOGICAL HAZARDS (CYCLONES, HURRICANES, TYPHOONS, TSUNAMIS, FLOODS AND DROUGHTS)

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The world distribution of cyclones, hurricanes and typhoons, mostly limited to six regions over tropical and subtropical oceans is given below:

- (1) West Indies, Gulf of Mexico, and Caribbean Sea (**Hurricanes**);
- (2) Western North Pacific, including the Philippine Islands, China Sea, and Japanese Islands (**Typhoons**);
- (3) Arabian Sea and Bay of Bengal (**Tropical Cyclones**);
- (4) Eastern Pacific coastal region off Mexico and Central America (**Hurricanes**);
- (5) South Indian Ocean, off Madagascar (**Tropical Cyclones**); and
- (6) Western South Pacific, in the region of Samoa and Fiji Islands and the east coast of Australia (**Tropical Cyclones**).

Tsunamis occur in seismically and tectonically active areas.

**Floods** can be attributed to multiple reasons such as heavy deluge, glacial lake outburst (GLOF), seawater level rise due to glacier melting, tsunamis, tropical cyclones i.e. hurricanes and typhoons.



The condition for **droughts** can arise anywhere in the world but there are specific regions on the world map where some very severe droughts have taken place and are still prone to such harsh living conditions. Our country, India, is water stressed and needs immediate remedial measures to check current levels of water stress.

**Check Your Progress 2**

**Note:** a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1. Where are hurricanes common.

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2. Which countries get affected by Typhoons.

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3. Describe the causes of drought?

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4. Why do tsunamis form? Detail the World distribution of tsunami.

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**15.5 IMPACT ON LIFE, PROPERTY AND ENVIRONMENT DUE TO VARIOUS HYDROLOGICAL HAZARDS**

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Hydrological hazards discussed in the preceding sections cause great loss of life and property. These hazards also impact the environment adversely. If evacuation of the affected area is not pre planned, great loss of human and animal lives becomes common during these disasters. Due to dead bodies all around chances of spread of diseases is not uncommon in affected areas. The financial situation becomes grim and people are devoid of means to fulfill their basic needs. Grave shortage of water and food supplies is commonly observed during such hazards. People all stay together in camps due to loss of houses. They are emotionally devastated and traumatised. They try to support and help each other to get over the trauma caused by the catastrophe. Water and food served in the relief camps are of poor quality and contaminated at times.

The huge loss of property in terms of homes and infrastructure brings life to a standstill mode. People are not able to meet their basic needs and suffer hardships in terms of transportation due to destruction of roads. Water borne diseases spread due to stagnation of water for long periods. Economy of the country and the affected area suffers due to the devastation caused by various hydrological hazards. It takes serious manpower and money to put things back to normal functioning. Huge capital is lost to reinstate the infrastructure. Such hazards take a toll on the tourism sector. Business takes a hit and it takes lot of effort to put things back to normal. The income from exports suffers and the economy of the area takes a dip. It takes several years to bring the pace to normal. With businesses closed there is lot of unemployment in the area and people try to migrate to different places in the hope of getting employment to survive. Transport and communication means come to a halt. Severe droughts could cause fire in the dry regions due to scorching heat and soaring temperatures. This also leads to loss of life and increase in air pollutants which are harmful for environment and living beings. Droughts can cause loss of crops and thus negligible grain productivity. It can also initiate famine if not managed in time. Floods and droughts can damage top soil and organisms dwelling in them. Flood and drought can also spoil the crops and lead to agrarian crisis.

Hydrological hazards cause extreme damage to the environment in terms of removal of top soil during floods in any region. The tsunamis for example can lead to fires and oil spills. The fire can cause intense large scale burning thus polluting the atmosphere. The oil spill in oceans can be huge threat to the aquatic life. The cyclones, hurricanes and typhoons can also harm the environment if they reach the land and cause flooding. The flooding can cause oil spills, mixing of sewage water with other sources of water. The droughts create extreme dry conditions. The scorching heat in areas prone to drought can lead to massive fires and cause extensive pollution of the air.

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## 15.6 CASE STUDIES PERTAINING TO HYDROLOGICAL HAZARDS

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In this section we will discuss some case studies pertaining to hydrological hazards.

### 15.6.1 Cyclone

**Phailin** is also known as a ' **Super Cyclone**'. It devastated the eastern coast of India on October 12, 2013. It was a category five storm. The two badly affected states were Orissa and Andhra Pradesh on the eastern coast of India. It was termed the size of hurricane Katrina that claimed many lives in U.S. in 2005. More than 400,000 people were forced to flee to safer locations like built in storm shelters. Phailin known as the country's largest cyclone, devastated the farmlands and fishing colonies. The tidal waves rose up to 3 to 5 meters. The storm lasted for 6 to 7 hours. The winds travelled at the speed of 220 km/hr. The cyclone devastated the local environment, killed animals in great numbers and took lives of 10,000 humans at least in Orissa. The National Disaster Management Authority estimated that more than 4,40,000 people were evacuated. The economy in the states hit by Phailin came to a standstill; there was a total shutdown of businesses, offices and schools. None of the transport options were plying. Food became scarce and there was shortage of drinking water. The electricity and communication system did not work. People were stranded in adverse circumstances and were completely dependent on the rescue operations carried out by military and naval services.

### 15.6.2 Hurricanes

'**Harvey**' developed in the Atlantic ocean and had a devastating landfall in the southern United States in August, 2017. It lasted for four-days with heavy deluge. More than 100 cm of rain was recorded in the eastern Texas with unruly winds. The heavy landfall and deluge led to massive flooding of the region with thousands of homes drowned in water. This hurricane landfall along with heavy rain displaced approximately 30,000 people in the region. Harvey caused a death toll of confirmed 74 people in US. The loss of infrastructure and property was enormous to the tune of approximately \$200 billion.

### 15.6.3 Typhoons

**Haiyan** was a '**Super Typhoon**' which struck Philippines in November, 2013. It is recorded as one of the most devastating (category 5 on Saffir-Simpson scale) tropical cyclone of the western Pacific. Although the typhoon severely affected parts of southeast Asia but the landfall was most drastic in Philippines. It killed approximately 6,500 people in Philippines alone. The survivors suffered from pangs of trauma and lot of them suffered multiple fractures and severe health problems. This typhoon caused loss of \$225 million in agricultural sector alone. It was a big blow to the fisheries of the country. Many provinces were declared under a state of national calamity. The prices of all necessary commodities shot up. People became homeless and relief camps setup were insufficient to cope up with the huge number of people who became homeless. Infrastructure was badly affected, the roads got damaged and aid flown in was unable to reach the people for days. Dearth of water and food made the lives of survivors miserable. There was feeling of anger and despair amongst the local people. Thousands of people were evacuated from the affected areas in cargo planes. Electricity in the severely hit areas was great hindrance in the relief work. Looting and hooliganism became rampant.

### 15.6.5 Tsunamis

The **Tohoku earthquake** (magnitude-9) rocked Japan on 11<sup>th</sup> March, 2011 which generated a huge tsunami on the north eastern coast of Japan killing approximately 18,000 people. The water rose 40 meters high in the form of wall of ocean water which broke on the coastal regions making half a million people homeless. The tsunami devastated many towns and villages in north eastern coast of Japan. The tsunami was responsible for nuclear reactors at the Fukushima Daiichi power station to spill radioactive materials causing environmental pollution and causing enormous damage to the power station. The tsunami and earthquake together caused losses to the tune of approximately \$210bn!! People who survived this tsunami were traumatised and feeling of anxiety prevailed for long times. Even today people who witnessed the deadliest tsunami could not come to terms with life and dread this devastating phenomenon.

### 15.6.5 Floods

**Floods in Bihar in 2008**, the most destructive in nature was caused by breach of the Kosi embankment near Indo-Nepal border due to excessive rains on 18<sup>th</sup> August, 2008. The river that flows through Bihar was forced to change its course and flooded the densely inhabited areas in Bihar. The flood devastated over 2.3 million population of north Bihar. Loss of life and cattle was rampant during the flooding. The floods made millions of people homeless. The infrastructure suffered a big blow. Many parts of

Bihar were plunged in the darkness as the electric poles got damaged. The transportation system got completely paralysed. The then chief minister of Bihar and the Prime Minister declared it a catastrophe and sent financial help to the people of Bihar to deal with the situation. It was recorded as the worst floods in 50 years.

### 15.6.6 Droughts

The western Plateau of India experiences three different seasons and while some states are lined up on the coast receive a rainfall of 2000 mm in the monsoon season some regions of Maharashtra state receive scanty rainfall of up to an average of 600 to 700 mm and are termed as semi arid regions. The Marathwada region of Maharashtra largely covers the Aurangabad division of the state. The region is made up of 8 districts and the district picked for case study is Jalna as it is in the dryland region. Jalna is not very densely populated due to the unfavorable climatic conditions. **Due to severe drought the farmer's in Marathwada committed suicide. They make several attempts at the crop production but, given to poor monsoon in the region their effort are lost. There are reports of farmer's suicide every year from this region. Besides people, cattle also suffer due to drought and poor monsoon.** Farmers are incapable of arranging for food and fodder for their cattle and in the absence of monsoon there are no pastures left for cattle grazing. These are the common vagaries of drought in this region and such conditions are met almost every year in this region.

#### Check Your Progress 3

**Note:** a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1. Which region in the state of Maharashtra is prone to droughts.

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2. Which super typhoon devastated the coastal parts of Philippines.

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3. Give one case study of floods in India.

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4. What effects hydrological hazards have on life and property.

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## 15.6 LET US SUM UP

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The hydrological hazards such as cyclones, hurricane and typhoon are unique names given to strong regional storm systems which require warm tropical ocean surface water for their initiation. All the three spin around a central eye and first form on the oceans and then with great speed progress landwards along the coastal areas. They are accompanied with strong winds and heavy rainfall. Depending on their energy, they are capable of giving rise to storm surges in the coastal regions. Storm surges, together with strong, fast winds and heavy deluge can cause catastrophic effects on the coasts and land inwards. The tsunami is also a unique hydrological hazard caused by large sea wave created by intense earthquake of high magnitude, volcanism, glacier breaking etc. The inundation of coastal waters by large sea waves (tsunami) which can form an intense wall of sea water as high as 40 mts can be very devastating. Floods, the most common hydrological hazards which can be created by heavy deluge, glacial lake bursting, glacier melting, storm surges during cyclones, hurricanes, typhoons and tsunamis. Drought is a peculiar condition caused by paucity of water which can lead to a condition of famine. All these hydrological hazards can be extensively catastrophic as have been discussed in the above sections with case studies pertaining to each.

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## 15.7 KEYWORDS

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**Whirlwind**

: It is a strong wind that moves in a spiral, swirling motion and has the potential to cause damage to the buildings, trees, and environment.

**Convection**

: It takes place when the movement hotter fluids begin to rise and cold and dense fluid begins to dip due to gravity. In the process the transfer of heat is experienced.

**Super Typhoon**

: It is a term 'Super Typhoon' is used in context of a typhoon which is equivalent to a devastating category 4/ 5 hurricane.

**Tropical**

: Refers to tropical climate i.e. warm to hot and moist year-round. Tropics encompass region of the Earth surrounding the Equator. The tropical regions are confined between the Tropic of Cancer in the Northern Hemisphere (23°26'21.3" N) and the Tropic of Capricorn in the Southern Hemisphere (23°26'21.3" S).

**GLOF**

: A glacial lake outburst flood (GLOF) is a catastrophic phenomena where type of outburst flood that occurs when the dam containing a glacial lake fails.

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## 15.8 REFERENCES AND SUGGESTED FURTHER READINGS

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Grotzinger, J.P. and Jordan, T. H., 2014: Understanding earth. W. H. Freeman and company, New York. 672p.

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## 15.9 ANSWERS TO CHECK YOUR PROGRESS

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### Answers to Check Your Progress 1

Your answers should include the following points.

1. Hurricane, typhoon, and cyclone
2. Harvey.
3. “A cyclone is a large-scale air mass that rotates around a strong center of low atmospheric pressure. Cyclones are characterized by inward spiraling winds that rotate about a zone of low pressure.”

The types are as follows

The Tropical Cyclone – as the name suggest these cyclones occur in tropical areas. Now hurricanes and typhoons are also considered as cyclones, but they are named differently and there is reason to it. Actually the names help us understand the area, where these winds are rising. Atlantic ocean and Northeast Pacific ocean see the rise of hurricanes, whereas Northwest Pacific sees the occurrence of Typhoons. The tropical cyclones occur in Indian Ocean or South Pacific.

#### 4. Types of floods

##### i. Areal

Areal floods take place in low flat land areas due to immoderate rainfall or due to abnormal snowmelt down or continuum of storms. Water hoarding results in to cause huge interruption and problems in normal living conditions.

##### ii. Riverine/Channel

When water slowly rises in levels due to continuous rainfall, snow meltdown or tropical cyclones in the rivers and streams close to inhabited or uninhabited areas, flash floods are likely to occur. This phenomena is true in small rivers, or the ones that flow through steep valleys.

##### iii. Estuarine and Coastal

Flooding caused by powerful forward or upward movement of sea tides is coastal flooding. Storms with huge intensity cause the coastal flooding. Tsunami or tropical cyclones are the examples of such flooding.

##### iv. Urban Flooding

As the name suggests urban flooding is flooding of populated and inhabited property. This happens due to incessant rainfall and results in the malfunctioning of drainage system in the city. This causes flooding of filthy water on the roads, entering the residential buildings and offices. Water levels can go upto several feet to cause inconvenience and discomfort to normal lifestyle of people.

##### v. Catastrophic Flooding

When due to an engineering fault, an earthquake, a volcanic activity or any other

natural disaster a rift is caused in the dam wall, that causes water to gush out at an uncontrollable speed. This result in castastrophic flooding and such a phenomena causes huge loss of human lives, property and cattle if situated close to the inhabited area.

### Answers to Check Your Progress 2

Your answers should include the following points.

1. West Indies, Gulf of Mexico, and Caribbean Sea (Hurricanes)
2. China, Japan, Phillipines.
3. **Drought can occur majorly due to natural factors and can also get aggravated by anthropogenic activities like deforestation i.e. felling trees for various reasons such as cooking, furniture, medicinal purposes, demand for wood as a natural resource because of population rise, demand for industrial and agricultural goods.** Global warming is causing a change in climate. There is a drastic change in temperatures worldwide. All these changes are causing either excessive rainfall that result in floods or there is dearth of rainfall that cause droughts in certain areas.
4. Tsunamis are experienced along coastal areas and can from due to high magnitude earthquake on ocean floor, volcanic eruptions, glacier calving, underwater explosions during nuclear material testing, landslides, meteorite impacts etc. the most common reason for a trigger of tsunami is high magnitude earthquake in the ocean basin at plate margins.

### Answers to Check Your Progress 3

Your answers should include the following points.

1. Marathwada
2. Typhoon Haiyan
3. Floods in Bihar in 2008 was one of the most destructive floods in the history of Bihar and was caused when the Kosi embankment near Indo-Nepal border fell apart due to excessive rains on 18<sup>th</sup> August 2008. The river that flows through Bihar was forced to change its course and flooded the densly inhabited areas in Bihar. The flood affected over 2.3 million people in the northern part of Bihar. The then chief minister of Bihar and the Prime Minister declared it a catastrophe and sent financial help to the people of Bihar to deal with the situation. It was recorded as the worst floods in 50 years.
4. Hydrological hazards discussed in the preceding sections cause great loss of life and property. These hazards also impact the environment adversely. If evacuation of the affected area is not pre planned, great loss of human and animal lives becomes common during these disasters. Due to dead bodies all around chances of spread of diseases not uncommon in affected areas. The financial situation becomes grim and people are devoid of means to fulfill their basic needs. Grave shortage of water and food supply commonly observed during such hazards. People all stay together in camps due to loss of houses. They are emotionally devastated and traumatised. They try to support and help each other to get over the trauma caused

by the catastrophe. Water and food served in the relief camps are of poor quality and contaminated at times.

The huge loss of property in terms of homes and infrastructure brings life to a standstill mode. People are not able to meet their basic needs and suffer hardships in terms of transportation due to destruction of roads. Water borne diseases spread due to stagnation of water for long periods Economy of the country and the affected area suffers due to the devastation caused by various hydrological hazards. It takes serious manpower and money to put things back to normal functioning. Huge capital is lost to reinstate the infrastructure. Such hazards take a toll on the tourism sector. Business takes a hit and it takes lot of effort to put things back to normal. The income from exports suffers and the economy of the area takes a dip. It takes several years to bring the pace to normal. With businesses closed there is lot of unemployment in the area and people try to migrate to different places in the hope of getting employment to survive. Transport and communication means come to a halt. Severe droughts could cause fire in the dry regions due to scorching heat and soaring temperatures. This also leads to loss of life and increase in air pollutants which are harmful for environment and living beings. Droughts can cause loss of crops and thus negligible grain productivity. It can also initiate famine if not managed in time. Excess water during floods and droughts can damage top soil and organisms dwelling in them. Floods and drought can also spoil the crops and lead to agrarian crisis.

