MODULE 1

SYSTEMS OF EARTH

LITHOSPEHRE

- Earth has four concentric zones.
- The innermost zone is the 'Inner core'. This zone is a solid mass of iron which has a radius of about 1,216 km.
- Covering the inner core is the outer core. This is a layer of molten liquid containing nickel and iron. It is about 2,270 km thick.
- The outer core is covered by solid 'Mantle', which is about 2,900 km thick.
- The outermost hardened exterior zone is known as 'Crust. The crust varies in thickness from about 5 km to 50 km.
- The crust and the mantle which is hard and brittle is lithosphere.
- Lithosphere is the outer layer of the earth that includes the crust and solid part of mantle
- Lithosphere interacts with atmosphere, hydrosphere and biosphere and forms **Pedosphere**.
- • Pedosphere has both biotic and abiotic components.

- • There are two types of lithosphere:
- – The oceanic lithosphere which is about 5 km to 8 km thick composed of basalt
- – The continental lithosphere which is 30 km to 40 km thick.

- • Earth has seven major plates, which includes Africa, Antarctica, Australia, Eurasia, North America, South America and Pacifica; and a number of minor ones.
- These plates are composed of oceanic and continental lithosphere.
- • They move independently over the mantle relative one another, below the outer rigid lithosphere. This area known as **asthenosphere** is about 100 km to 200 km thick.
- • They move with a restricted independence from the seven large plates.
- • The plates periodically reorganise themselves with new plate boundaries being formed, while certain others closing up. In addition to these movements, the plates also change in shape.

- The plates have three different motions. They are:
  1. Moving apart, thereby creating divergent boundaries,
  2. Gliding horizontally along each other, thereby creating wrench and transform boundaries, and
  3. Moving towards one another, and creating convergent boundaries.
- These movements may also combine:
  1. oblique convergence of plates could produce a 'transpressive deformation'
  2. An oblique divergence could result in the production of 'transtension'
  3. A convergence could be the effect of the descent of one plate beneath the other

Composition:

The lithosphere contains rocks, minerals and soil. It has more than 100 chemical elements, but most of them are rare.

Table 2.1 Elements of Earth's Crust

S. No.	*Elements*	*Per cent*
1	Oxygen	46.6
2	Silicon	27.7
3	Aluminum	8.1
4	Iron	5.0
5	Calcium	3.6
6	Sodium	2.8
7	Potassium	2.6
8	Magnesium	2.1

- Only a few elements are present in pure forms in the earth's crust.
- Called native elements, they include copper, gold, lead, mercury, nickel, platinum, and silver.
- These elements contained in ores are found in different combinations as minerals.

- Certain minerals are composed of single element. For instance, diamond and graphite are composed of only carbon

Rocks:

• Lithosphere has various types of rocks.

• Rocks are naturally occurring hard and consolidated inorganic materials, composed of one or a large number of minerals

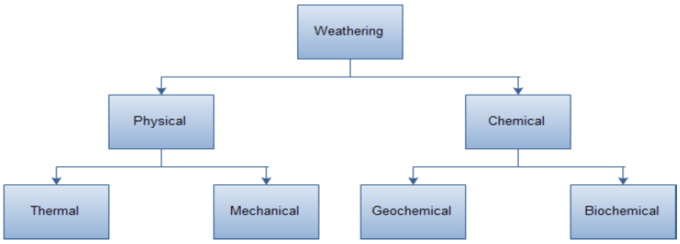
1. Igneous: These rocks are formed by solidification of magma in the interior, or lava on the surface of earth. Igneous rocks are composed of primary minerals, which are predominantly silicates. Igneous rocks sometimes overlap with sedimentary and metamorphic rocks

2. Sedimentary: Sedimentary rocks are formed by the precipitation from solutions, and consolidation of remnants of biotic components like plants and animals. These rocks contain both original primary minerals and altered as well as newly synthesised secondary minerals

3. Metamorphic: Also known as Thermal rocks they are formed from pre existing rocks (igneous or sedimentary) due to change in the temperature and pressure These rocks are formed when magma intrudes through pre existing igneous or sedimentary rocks. Further, igneous and metamorphic rocks get weathered and form sediments. These sediments get deposited and `lithified' into sedimentary rocks.

Weathering:

Weathering is the process of disintegration and decomposition of rocks and minerals. Disintegration can takes place due to fragmentation, splitting, detachment etc. decomposition could occur as a result of chemical changes that could lead to formation of simpler products. Weathering could occur as a result of natural forces like heat, water, wind, micro organisms, action of glaciers etc. the resulting changes would be physical chemical or even both. Based on the occurrence weathering can be classified as follows:



Physical weathering

• Changes occurring only to the physical form of the rocks are known as physical weathering.

Thermal weathering:

- This weathering is caused by the expansion (when heated due to solar radiation at day time) and contraction (when cooled at night) of rocks as a result of fluctuation in temperature. Expansion of rock is more in summer than in winter.
- Pressure is created within the rocks when they expand or contract, due to which the rock on the surface is fragmented.
- Another weathering process, known as exfoliation, occurs in layered rocks. In such rocks the outer part expands and contracts at higher rates. Due to this, a thin layer of rock gets detached and form smaller parts.

Mechanical weathering:

- Many types of rocks absorb water and swell when wetted, and shrink when dried. This expansion and contraction of rocks due to alternate wetting and drying break the rocks into pieces.

- Water also gets accumulated in fractures and joints of rocks. When the temperature goes below the freezing point, this water becomes ice. Ice increases in volume and exerts tremendous lateral pressure on the surrounding rocks. Due to this pressure, the rocks get broken. This is known as **'frost wedging'**.

- **'frost heaving‘**: Rock fragments contained in flowing water disintegrate while colliding with each and while rolling on the bed of rocks. The 'cutting action' of water and the suspended materials accelerate this disintegration

- Another form of weathering happens in glaciers. Glaciers are large bodies of ice that slowly move along the mountain slopes. When the glaciers flow down the slope, the rocks contained in it smash and shatter against one another. As the overlying rock gets removed, the underlying rocks expand and split due to the release of pressure.
- Certain other weathering agents include wind, gravity, plants, etc. Suspended particles in the wind have abrasive power, and over a period of time it could weather rock surfaces.
- When large masses of rocks get detached and fall down due to gravity, they get broken into pieces at the foothills.
- The roots of plants enter the rock fractures exerting lateral pressure and get broken in course of time.

Chemical weathering

- Alterations to the chemical or mineralogical composition of rocks are known as chemical weathering.
- During chemical weathering, minerals are decomposed into soluble and insoluble products. Due to this weathering different minerals may occur

Geochemical weathering

- This weathering occurs as a result of reaction with water, acids, bases, salts, etc.
- Eg) dissolution, hydration, hydrolysis, oxidation, reduction, carbonation, and other acid reactions.
- Minerals are not ordinarily soluble in water. However, due to hundreds of years of wetting in the presence of certain natural acids in water, the process of dissolution is accelerated
- Hydration is the binding of water to the molecules of minerals like iron and aluminium oxides
- Oxidation and reduction are other process wherein certain minerals are weathered.
- Hydrolysis is a process in which minerals get decomposed effectively. During hydrolysis, water molecule gets splits into hydrogen and hydroxyl ions. The hydrogen then replaces a cation from the mineral structure, whereby the particular mineral becomes easily susceptible to decomposition by further hydrolysis or other reactions.

Biochemical weathering

- This weathering occurs due to the action of organisms.
- Carbonation: In this process, carbonic acid is produced by the dissolution of CO2 in water. For this the CO2 available in the atmosphere, or from microbial or root respiration process is made use of
- The carbonic acid so produced has the property of dissolving many minerals.
- Further, certain plants and their associated micro-biota also cause weathering by modifying surrounding pH through the production of CO2 and organic acids.
- • Different minerals weather at different speeds. Complex minerals weather easily.
- • The climatic conditions also influence weathering process. Chemical weathering is usually low in areas having low water and temperature, as against warmer and moister areas.
- • In humid tropical areas the rate of weathering is high with weathered products lost quickly by leaching. This is a continuous process and occurs even after formation of the parent material.

Soil:

- Soil is the surface layer of the land. It is a natural body that contains a variable mixture of broken and weathered materials and decaying organic matter.
  - It takes long period of time for the soil to form through the natural process. The formation takes place from the weathering and decomposition of rocks and minerals.
  - Soil is a dynamic layer of earth's crust which is constantly changing and developing.

- The upper limit of soil is air or water and its lateral margins grade to deep water or barren areas of rock or even ice.
- The lower limit is thought to be the lower limit of the common rooting depth of respective native perennial plants.
- Soil develops from rocks and minerals, which can be considered as parent materials.
- Soil is a natural resource that is renewable in nature.
- It serves as a natural medium, wherein microbial activity happens.
- Soil provides nutrients for the growth of plants.
- Properties, like texture, structure, permeability, water porosity, soil pH, nutrient (organic and inorganic) contents, microbial property, etc. determines the fertility and the resultant productivity of the soil.
- In addition to this, the topography, climate, biotic factors, etc. too contribute to the fertility. Soil fertility is the quality of a soil that enables it to provide nutrients in adequate amounts and balance, for the growth of plants.

Table 2.2 Different Types of Soil

S. No.	*Soil*	*Details*
1	Volcanic ash	Volcanic ash is fine grained, and has the property of weathering relatively easily. Plants invade a new deposit of volcanic ash quickly and colonise it very fast. This could happen even within a few years' time. The soils that result from volcanic ash, known as Andisols, are fine textured. It is fertile and normally rich in organic matter and plant nutrients. These soils are likely to be found in places where there are active and recently extinct volcanoes. It is estimated that these soils cover approximately 124 million ha of land (0.84 per cent of earth's surface).
2	Granite	Granite is a coarse-grained rock. It has about 25 per cent quartz and 65 per cent orthoclase. It may also have small amounts of mica and hornblende. Soils that develop from granite are usually sandy in nature. They are normally low in nutrient content, with characteristics like being friable, permeable, acidic, and low in base status. This soil has very little cohesion or consolidation, and is highly susceptible to erosion.
3	Limestone	Limestone rocks mainly contain calcite. They also have considerable quantities of impurities of other carbonates, silt, clay, quartz, iron, and so on. Soils that result from limestone are clayey. It could also be in the form of clay loams and sandy loams.
4	Sandstone	Sandstone mostly consists of sand sized quartz. It could also have impurities such as feldspar and mica, and other agents, like silica, iron, and lime. Soils that are formed from sandstone are not fertile, usually coarse textured and acidic in nature. However, the characteristics of sandstone soils are dependent on the particular type of sandstone—whether grain size or mineralogical composition.
5	Basalt	Basalt is fine textured in nature. It is rich in ferromagnesian and calcic plagioclase minerals. Basalt gets weathered relatively easily to form fine-grained clay minerals. The soils that originate from Basalt are fine textured in nature. It has good amount of the minerals and has a high base status.

Functions of Soil

1. It provides mechanical support to the plant.
2. It has the ability of holding water as it has the property of porosity. This ability makes soil a reservoir of water.
3. Soil provides micro and macro nutrients, as well as ideal pH required for the growth of the micro-organisms, plants and animals.
4. Soil prevents excessive leaching of nutrients.
5. Soil houses bacteria that fix nitrogen and other elements; fungi, protozoa and other micro-organisms. These organisms aids in the decomposition of organic matter.

ATMOSPHERE

- Based on the temperature, the atmosphere is divided into four parts: (1). Troposphere (2). Stratosphere (3). Mesosphere (4). Thermosphere

1. *Troposphere:*

- The bottom dense part, containing 70 per cent of the mass, close to the ground is troposphere. It reaches up to 11 km from the ground.
- Clouds, storms, fog and haze are found only in troposphere.
- The temperature in this layer decreases at about - 6.4°C/km with height. This decrease of temperature with altitude is called lapse rate.
- The boarder of troposphere is called Tropopause. Tropopause acts like a lid over troposphere. Temperature stops decreasing with height from tropopause.

2. *Stratosphere:*

- This layer extends to a height of about 50 km from earth's surface.
- Ozonosphere is an important layer found within stratosphere. Ozone (03) is found in this layer.
- The temperature increases with height in stratosphere. Due to this, vertical winds seldom occur and only horizontal winds parallel to earth's surface are seen.
- This property leads to absence of turbulence in this layer. This absence of turbulence and clouds ensures good visibility and smooth travel for jet planes

• It is often said that the flying of jet planes in this layer is partly responsible for the destruction of sizable quantities of ozone.

• Above the stratosphere, there is a small layer called Stratopause where temperature neither decreases nor increases with height.

3. *Mesosphere:*

- The portion of the atmosphere above stratosphere, between 50 km and 80 km is known as mesosphere.
- Though the temperature in mesosphere near stratosphere is higher by about 10°, it falls to -75°C at 80 km.
- The density of air at this height is about 1/1000 as that of sea level.
- Mesosphere plays a crucial role in radio communication as ionisation occurs here. The sunlight passing through this layer converts individual molecules to charged ions.
- These ionised particles are concentrated as a zone in this layer, which is named D-layer. The D-layer reflects radio waves transmitted from earth.
- Just above the mesosphere is a small layer called Mesopause, where temperature is stable.

4. *Thermosphere:*

- Thermosphere extends from 80 km to about 60,000 km from earth. Here the temperature increases to about 2000°C.
- Ions are abundant in thermosphere. It is in thermosphere that most of the approaching meteoroids burn up before reaching earth.
- Ionisation takes place in this layer also. Ionisation produces two ionised layers—E and F layers. These layers also have an influence over ratio communication as it reflects radio waves.
- In the upper thermosphere, due to higher concentration of ions, it is called Magnetosphere. Thermosphere has no definable upper boundary and it gradually blends with the outer space.

OZONE LAYER DEPLETION

- Due to human activities ozone layer is becoming thin. The thinning of this layer is called ozone depletion.
- Ozone-oxygen Cycle
- The ozone layer is located in the lower part of the stratosphere between 15 km and 35 km.

- Concentration of ozone is the maximum at about 25-30 km. At this altitude, it is 10 ppm. Beyond this, it ranges between two to eight ppm.
- The level of ozone is maintained at this level by Ozone- Oxygen Cycle.
- When ultra-violet radiation that emanates from the sun strikes the oxygen molecule (02), it splits the molecule into two individual oxygen atoms (0 + 0).
- The oxygen atoms, thus produced, combines with 02 molecule and produce ozone molecule (03). This reaction is aided by either Nitrogen (N2) or Oxygen, which absorbs the excess energy that is liberated.
- Ozone thus formed will be split by ultra-violet rays into a molecule of oxygen (02) and an atom of oxygen (0). It is through this repeated circular ozone and oxygen formation that the concentration of ozone is maintained in the stratosphere.
- Due to severe depletion of ozone in the atmosphere 'ozone holes' are created.
- Ozone holes, which were discovered in 1985, are overhead areas having less than 220 Dobson Units (DU).

Depletion by CFCs and BFCs
- CFCs and BFCs are stable compounds in the atmosphere that have the property of living longer (50 to 100 years).
- Due to their long life, they rise up to the stratosphere.
- Through the action of UV radiation from the Sun on these compounds, Chlorine (Cl) and Bromine (Br) radicals are released. These radicals act as catalysts, and initiate breaking down of ozone molecules.
- It is estimated that a single such radical of either Cl or Br is capable of breaking down over a lakh of ozone molecules.
- Due to this action, Ozone concentration is decreasing at a drastic rate of four per cent per decade.
- Realising the seriousness of the problems created by CFCs and BFCs, countries initiated steps to either completely ban or phase out their use. Sweden was the first country to ban aerosol sprays that contained CFCs, as early as in 1978.
- On discovering the Ozone hole in 1985, countries came together and signed an international treaty at Montreal, in 1987. This treaty, known as Montreal Protocol, decided to completely phase out CFCs by the year 1996.
- The Montreal Protocol was followed up by Copenhagen Protocol. Representatives of large number of countries met in 1992 at Copenhagen in Denmark, and agreed to phase out ozone depleting chemicals.
- Because of these efforts scientists could announce on August 2, 2003 that the depletion of ozone layer has slowed down considerably.

Depletion by Nitric Oxide
- One molecule of nitric oxide (NO) combines with ozone (03); it gets oxidised to nitrogen dioxide (NO2) and Oxygen (02).
- This NO2 combines with another 03 molecule to become NO3 (Nitrate) and 02.
- The NO2 and NO3 then combine to form N205 (Dinitrogen pentoxide).
- Thus, due to this series of actions and reactions ozone is completely utilised, and thereby depleted.
- Large quantities of nitrogen are emitted by aircrafts that fly near stratosphere.
- Realising the seriousness of the issue, the international community decided to withdraw the operation of jet aircrafts that emit oxides of nitrogen. This step has also helped in reducing the depletion of ozone.

GREEN HOUSE EFFECTS

Incoming Solar Radiation

Atmosphere behaves like a complex mega heat engine. A large number of processes like air movements (storms and cyclones), evaporation and formation of clouds, precipitation, etc. take place in the atmosphere.

- The incoming solar radiation (insolation) supplies the required energy and drives these processes.
- Only two-billionth of the solar energy reaches Earth, of which only a small portion is responsible for the physical and biological processes. Sun also emits solar winds consisting of charged particles like plasma, magnetic fields, etc.
- Insolation contains X-rays, gamma rays, ultraviolet (UV) rays, visible light, infrared rays, microwaves, radio waves, and the like.
- Of all the energy received by earth; UV, visible and infrared portions constitute over 95 percent.
- The harmful UV radiation is prevented from reaching earth by the ozone layer. Parts of the long waves within the solar radiation are absorbed in the troposphere.
- The solar radiation which ultimately reaches the earth comprises mainly of visible light, which is composed of seven colours.
- While travelling through the atmosphere, a portion of the radiation energy is reflected by clouds, and some are scattered and absorbed by gases and particles.
- The scattered radiation that reaches earth is called diffuse radiation.
- Of the diffuse radiation that finally reaches earth's surface, based on the surface characteristics, substantial quantity is reflected back. The solar radiation that is reflected back is called albedo.
- As stated earlier, the albedo is based on the surface characteristics. For instance, the albedos of a water body, land area, forest area, desert area, etc. vary significantly.

Outgoing Radiation

- If the entire energy that is received by earth is retained in its surface, the planet would be very hot and would become an inhabitable place.
- The earth, after heating up of its surface, reflects a certain amount of energy. Some of this heat energy is transmitted to the upper layers of air through conduction.
- The conduction will in turn initiate convection in the air above the earth's surface. The heat energy so emitted from the earth's surface is in the form of long wave radiation, and is called outgoing radiation.
- A portion of the outgoing radiation is absorbed by certain gases in the atmosphere. Gases capable of absorbing outgoing radiation are CO2, CO, water vapour, etc. They are called Green House Gases (GHG).
- The amount of radiation absorbed is in direct proportion to the concentration of gases.
- Due to the effect of GHGs Earth is prevented from cooling down drastically. GHGs thus act like a blanket and provide earth with an ideal climate for life to flourish. This process is known as Green house effect.
- The intensity of Green house effect varies from place to place depending upon the concentration of GHGs.

GLOBAL WARMING

- Earth receives solar energy in abundance, heating its surface.
- Some quantities of heat is radiated back into the space.
- Certain gases, known as Green House Gases (GHG), that include carbon dioxide, methane, nitrous oxide, ozone, etc., and water vapour prevent the heat from escaping the earth's atmosphere.

- This leads to an increase in the atmospheric temperature, known as greenhouse effect. The greenhouse effect has its own positive effect. Without greenhouse effect the temperature of earth would have been much cooler and covered with ice.
- Recently, due to certain human activities the quantity of GHGs has increased manifold.
- The burning of large quantities of fossil fuels, deforestation, mining activities, agricultural activities, overall
- concentration industrial activities, etc. has increased the of GHGs around the globe.
- This is aggravated by the reduction in green coverage. Certain natural processes, like volcanic eruptions also contributes to GHG emissions. Chlorofluorocarbons (CFCs) like methane released from human and animal waste, garbage dumps, rice fields, etc. have caused large scale depletion of the ozone layer.

Per cent of Contribution of CHGs to Global Warming

S. No.	*GHG*	*% contribution*
1	Carbon dioxide	61
2	Methane	15
3	Chlorofluorocarbons	11
4	Nitrous oxide	4
5	Other gases	9

- The abnormal increase in the concentration of GHGs has led to the global temperature has become warmer. The average temperature of the globe has become warmer over the last century.
- This warming is however not uniform all over the globe. While the temperature is high in some places, it gets cooler in certain other places.
- Over the last century the overall temperature of earth's atmosphere has become warmer by about 0.6 degrees Celsius (1.3 degrees Fahrenheit).
- Evidences show that the warming is happening much faster than they have in the past.
- Further, there is new and stronger evidence suggesting that most of the observed warming over the last 50 years is attributable to anthropogenic reasons.
- If GHG emissions continue at this rate, by 2030 the temperature will rise by 1.5°C to 4.5°C.
- The Intergovernmental Panel on Climate Change (IPCC) states that the human induced change in atmospheric chemistry will increase temperatures by 1.4°C to 5.8°C by the year 2100 (IPCC, 2001).
- There has been large number of apparent signs of global warming in many parts of the globe. A few of them include melting of ice caps in the poles, shrinking of glaciers in mountain ranges, like Alps, Andes, Himalayas, Mount Kilimanjaro, etc.
- Some other signs include arrival of spring earlier than normal, and autumn arriving later in many parts of the globe.
- Continued global warming would result in melting of massive quantities of ice from the Polar Regions and glaciers, leading to rise in the sea level.
- It is estimated that if the glaciers continue to rise at the current rates, the sea level is expected to rise over 1.5 m in the next few decades.
- Rising sea levels are expected to inundate low lying areas leading to mass exodus of people and creation of climate refugees, intrusion of saline waters into arable lands thereby affecting food security, etc.

WEATHER

- When radiation from insolation strikes earth, its top layer gets heated. The heat energy so created is transferred to the overlying areas through activities like conduction and convection.
- Due to this, as well as the movement of earth, air moves in all directions—both horizontally and vertically. This movement of air is the basis of weather.

- Weather is the atmospheric conditions that exist for a short duration. Weather conditions can fluctuate very often. The average weather or atmospheric conditions over a fairly long period of time like months, years or even decades; in a particular area is called climate.

Temperature

- Temperature is the index of heat that is sensible. It indicates the kinetic energy of molecules, or the speed at which the molecules moves.
- In air and water, molecules keep on moving but in solids the molecules involve in a vibration movement in their place. The speed at which this vibration takes place is described as temperature. A body having higher temperature transmit it to another one having lower temperature.
- Temperature is measured using thermometer, and is reported in either Celsius, Kelvin or Fahrenheit scales.

1. Altitudinal variation: In the troposphere, temperature decreases with height at a rate of -6.4°C/km. This rate is called lapse rate. The lapse rate is not uniform and it varies due to different conditions like pollution in the atmosphere.

2. Horizontal temperature variation: Temperature varies at different times of the day and also at different months and seasons of the year.

a) *The hour of the day:* More solar energy is received during the noon, when sun's rays strike vertically overhead; than hours in the morning hours, when the rays strike at angles.

b) *Insolation:* The amount of insolation or incoming solar radiation is based on rotation and revolution of earth. The temperature of any given area is based on the insolation of that area. The length of daylight and the angle at which the rays fall on earth also determines the temperature.

c) *Distance from the equator*: The sun rays strike in perpendicularly on the equator. Near to the poles it strikes at an angle. Due to this, areas farther away from equator will experience lesser temperature.

d) *The tilt of the axis*: The earth's axis is tilted at angle of 66.5 degrees to the plane of the ecliptic. This tilt is maintained throughout its orbit. This tilting of the axis leads to seasonal variations. The northern hemisphere tilts maximum towards the sun on June 22. Due to this, the months closer to June are summer months in this hemisphere. On December 22, the reverse occurs, and southern hemisphere will receive maximum amount of solar energy.

e) *The surface:* The heating of earth's surface differs according to the type of the surface in an area. For instance, rocky surfaces get heated rapidly, while water takes considerably long time to get heated up. In the same way, rocky surfaces loose heat rapidly as against water which loose heat slowly.

<u>Cyclones</u>

- The atmospheric pressure in a given area has an important role to play with respect to the formation of a cyclone. Whena flow of air moves along curved isobars which is a net centripetal acceleration pulls it toward the centre of a curvature, making the air to rotate. Such wind (called gradient wind) is called **cyclone**
- If the movement of the gradient wind is in the anticlockwisedirection in the northern hemisphere. it is called cyclone and anticyclone in southern hemisphere.
- In the southern hemisphere, the clockwise motion of gradient wind is called cyclone and anticyclone in

northern hemisphere.

- During a cyclone, the surface air moves towards the centre having low pressure and hence converges. The converged airhas the property of ascending in the centre within the lowpressure area.
- The reverse happens in a high pressure area. Air tends to sinkin the centre of a high pressure area during anticyclones.

Atmospheric Circulation

- When Earth rotates on its axis, the rotation causes the deflection in the wind flow due to Coriolis force.
- Coriolis force is a force which is produced due to the rotation of the earth.
- In addition to this, a low pressure belt is formed over the tropical regions, since the equatorial region is heated throughout the year. This belt is called the Inter-Tropical Convergent Zone (ITCZ). This zone is also known as doldrums.
- This is not a conspicuous belt, but a discontinuous one that fluctuates in its position and intensity.
- Even with disruptions like weather fronts and storms, there is a consistent pattern to how air moves around our planet's atmosphere. This pattern, called atmospheric circulation.
- This is caused because the Sun heats the Earth more at the equator than at the poles. It's also affected by the spin of the Earth.
- In the tropics, near the equator, warm air rises. When it gets about 10-15 km (6-9 miles) above the Earth surface it starts to flow away from the equator and towards the poles.
- Air that rose just north of the equator flows north. Air that rose just south of the equator flows south.
- When the air cools, it drops back to the ground, flows back towards the Equator, and warm again. Now the warmed air rises again, and the pattern repeats. This pattern, known as convection, happens on a global scale. It also happens on a small scale within individual storms

Indian Monsoon

Monsoon is a regional wind that blows towards land at a certain season and blow from the landmasses during other season. These wind blows in the opposite direction in summer and winter.
Though monsoon winds blow over all parts of the world, it is well-developed over India and the South-east Asian regions. The Indian subcontinent has two types of winds. 1.South-West Monsoon 2.North-East Monsoon

South West Monsoon:

- The south-east trade winds originate from the southern hemisphere in the Indian Ocean. When these winds cross the equator, they get deflected towards the right by the Coriolis force, becoming the south-west trade winds. These winds gather large quantities of moisture as they pass over the Indian Ocean.
- As the SW monsoon winds approaches the Indian Peninsula, they are diverted into two-the Arabian Sea Branch and the Bay of Bengal Branch.
- When the moisture laden Arabian Sea branch reaches the south-western side of India, they are blocked by the Western Ghats.
- When the mountain range blocks the horizontal flow, the wind ascends along the slope of the mountain range, gets cooled down and form clouds. These clouds then results in precipitation.
- Kerala gets the south-west monsoon mostly during early June every year.
- These winds then take a west turn and continue their journey, and spread over the northern parts of India bringing in rains to these areas.
- Monsoon winds normally reach Delhi in the first week of July and could last till end September/early October.

North East Monsoon

- The Inter-Tropical Convergent Zone (ITCZ) moves to the south of the equator, when the position of the sun shifts to the southern hemisphere. This leads to the reversal of winds, and the winds start blowing from the north-eastern direction towards the ITCZ. These winds are known as the north-east monsoon winds or the north-east trade winds.
- Since North-East winds originate mainly from the land masses of the north-east region of India, they are relatively dry.
- When these winds pass over the Bay Bengal towards south, they gather moisture and cause rainfalls over parts of Odisha, Andhra Pradesh and Tamil Nadu.
- Cyclone formation is common over Bay of Bengal during the north-east monsoon season. The cyclones also bring in abundant rainfall over Odisha, Andhra Pradesh, Telangana and Tamil Nadu.

HYDROSPHERE

- Hydrosphere forms over 70 per cent of the earth's surface . In terms of area, it comes to 3,62,000 km2. Water is found in the oceans as well as on land. Life is made possible on earth due to the availability of water.
- The hydrosphere has a direct influence on weather and climate conditions on Earth. This occurs due to the important role played by the worldwide oceanic circulations.
- The average depth of oceans is around 3.7 km. The floor of the oceans has mountain ranges and valleys, isolated volcanic peaks, and vast plains. Many of these mountain ranges and valleys exceed in size of their counterparts on land.
- As on date, less than 10 per cent of the ocean floor has been surveyed.
- Water has a number of unique properties like high heat capacity, dissolving capacity, etc. These properties are made possible due to its molecular structure. A water molecule consists of two atoms of Hydrogen that are bound to an oxygen atom.

OCEANS

- Water in oceans is saline in nature. This salinity occurs due tothe dissolved materials (mainly salts) contained in it. The mean salinity of sea water is around 34.7 g/kg. The lowest value being 33 and highest being 36 g/kg .
- Though sea water contains a mixture of several dissociated salts, NaCl is the most important one. Additional salts arealways added to the oceans through various processes.
- However, seawater salinity is stable due to various mechanismsthat remove salt from the oceans. Salt is spreaded to the atmosphere when wind blows sprays of sea water.
- The salt particles in the atmosphere enable water molecules tostick to it, and this falls on the land with rain and snow.

Oceanic Circulations

- Oceanic Circulations Water in oceans is constantly in movement in regular patterns due to the activity of winds. These movements of water in oceans are called ocean circulations or ocean currents.
- These currents arise due to the interplay of wind and water.
- The speed of ocean currents is much slower than air currents (the maximum speed that a current can reach is about 10 km/h).
- Most of the wind-driven surface currents occur parallel to the major wind systems. For instance, the northeast and southeast trade winds drive water westward along the equator. This is known as the equatorial current. In the Atlantic Ocean, the equatorial current flows into South America.

- In the Pacific Ocean this current flows into the East Indies. On reaching these places both these currents divide into two parts, with one flowing south and the other north.
- These currents move away from the equator through the continental edges. These currents are then influenced by the westerlies, and due to this they flow eastward across the oceans.
- Due to this movement gigantic whirlpools occur in the Atlantic and Pacific Oceans on both sides of the equator. These whirlpools are influenced by aspects, like the presence of islands, continental projections, undersea mountains and valleys.
- The pace and direction of the circulations are determined by various factors.
- They include the structure and strength of the wind systems, the regional distribution of precipitation patterns, the heat exchange with the atmosphere and the shape of the sea floor.
- These factors are instrumental in the stratification, circulation and the formation of global water masses.
- Stratification and circulation in the upper areas are crucial for the penetration of heat into the ocean.
- Formation of water mass in the higher latitudes works to control the oceanic uptake of CO_2 through the sea surface.
- This process directly influences the radiative forcing in the atmosphere.
- Globally, ocean currents can be divided into large horizontal gyres, circulating in the ocean basins, and an overturning vertical circulation in the meridional realm.
- A combination of these circulations act like a huge conveyor belt that constantly distributes heat, nutrients, sediments and traces of chemicals around the world ocean.

Ocean as Moderator of Climate

- Oceans as Moderator of Climate Oceanic circulations have a profound and significant influence in heating up the globe, and hence, its climate.
- When water moves up from the colder and deeper parts of the ocean to the warmer surface, the heat is carried with it.
- Due to the interplay of various factors, the ocean water moves around the globe, and with it the heat or cold is transferred.
- This heat transfer plays a major role in impacting earth's climate. When extremes of incidents, like rainfall or droughts occur, the normal path of the ocean current can be disturbed and climate change could occur.
- The phenomenon of El Niño is a classic example of the impact of changes in the path of ocean currents.
- The oceans play a multifold role in the Earth's climate system. It plays both short- and long-term roles on the climate system.
- The short-term role is evident in the close correspondence that oceans have between the surface temperature and the air temperature close to the ground. The so called thermal inertia' of the great water masses also works to slow down climatic changes.
- The long-term role played by the oceans is evident from the heat distributions around the globe. Oceans determine climates through absorbing solar energy and transferring it around the world through the surface currents.

Oceans as Heat Reservoir

- Oceans as Heat Reservoir Oceans play a role of a heat reservoir, moderating extreme temperatures. This occurs through a complex process.
- The water in the upper portion of oceans store higher heat than in the entire atmosphere.

- During spring and summer seasons, the oceans are cooler than the nearby lands.
- During winters oceans are warmer than the land masses.
- Due to this temperature difference in sea and land there is heat energy transfer from land to water and vice-versa. This energy transfer could exceed the solar energy that arrives at earth.
- Since the interiors of continents are lacking such a heat reservoir, they have lower temperature in winters and higher temperatures in summers than coastal areas.
- The heat transfer processes in the oceans occurs on a broad range of time scales. The interactive processes in the upper layer of the ocean takes place in shorter periods—may be a few days, weeks or months.
- The major heat redistribution processes between the massive warm equatorial water masses and the cold water of the deep ocean in the Polar Regions occurs over decades or even centuries.

Oceans as Reservoir for carbon

- The oceans are the largest carbon reservoirs of Earth.
- Periodically, it gives off large amounts of carbon into the atmosphere.
- Through certain biological and chemical exchange processes it plays an important role in carbon cycle.
- For instance, certain amount of carbon is deposited routinely on the sea bed through dead organisms and their calcified shells.
- The large surface area of oceans also has a major role to play with respect to carbon cycle.
- Though the water near the surface of the oceans has a quasi-equilibrium with the atmosphere, the ocean is normally inert to the increase in atmospheric CO_2.
- The oceans withdraw CO_2 permanently only when the carbon chemically or biologically bound in the surface water, sinks to lower levels in the ocean and gets buried in the sediments.

BIOSPHERE

- Biosphere is an important realm of Earth. The term biosphere' was first coined by the geologist Eduard Suess in 1875. More insights about biosphere were provided in the early 20th century by the ecologists Henry Cowles and Frederic Clements. Kirkham (2007) provided a comprehensive description of biosphere he referred it as: the totality of life on earth and its interdependency on abiotic environmental factors.
- Biosphere consists of the complex interdependency between biotic and abiotic environmental components.
- Basically, biosphere is a thin envelop that encircles most of the earth, and supports life. It is the global sphere in which the biota interacts with lithosphere, atmosphere and hydrosphere.
- It is totally dependent on, and involves complex interactions between the atmosphere, hydrosphere, and lithosphere.
- Biosphere is the spherical terrestrial layer that comprises of the lower part of the atmosphere. the seas and the upper layers of the soil wherein living organisms exist naturally.
- All forms or life including human beings dwell in biosphere. The health of the biosphere is determined by the availability of oxygen, moisture, temperature, air pressure and soil.
- Biosphere is a giant ecosystem that consists of two major ecosystems (a) Terrestrial ecosystem b) Aquatic ecosystem.

Terrestrial ecosystem

- The terrestrial ecosystem consists of plants, animals, microorganisms their dependencies and interdependencies with the non-living items around it on the land. A terrestrial ecosystem is made up of either natural ecosystem or artificial/man-made ecosystem.

- Natural Ecosystem: this consists of mountains, grasslands, forests, semi arid regions, deserts, tundra and islands. When there was no human intervention the ecosystem was sustainable. The ecosystem where capable of taking needs of their organisms. Due to industrial development in past few centuries led to the formation of artificial ecosystems.

- Artificial ecosystem: examples are crop fields and garden ecosystem. In this the land is used intensively and has been modified into irrigatable and pastoral lands. Large areas have been converted into urban and industrial centers. This conversion has increased the food production and raw materials. However, large scale conversion of natural ecosystem and misuse of land have led to degradation of natural environment

Aquatic Ecosystems:

- Aquatic ecosystem consists of marine and fresh water ecosystem. While seas and oceans form the marine ecosystem; the rivers, pond, lakes, and wetlands form fresh water ecosystem. Aquatic ecosystems provide human beings with a wide range of services.
- Some of the services include the availability of water for day to day uses, foods like fish and crustaceans, breaking down: of chemical and organic wastes, recreation, etc. The aquatic ecosystem provides the human beings with a wealth of natural resources.

Natural Aquatic Systems:

- Natural aquatic ecosystem The natural aquatic ecosystem includes the marine and the fresh water ecosystems.
- Marine ecosystem is very vast and saline. It consists of the Ocean ecosystem, Coastal or estuarine ecosystem and the Coral reef ecosystem.
- Aquatic ecosystem can also be classified based on the salinity. According to salinity it is classified as fresh water, brackish water and marine ecosystem.
- Fresh water ecosystem consists of ponds, tanks and lakes (stagnant ecosystem); and streams and rivers (running water ecosystem).
- Brackish water ecosystems mostly consist of expanses of shallow water with peculiar vegetation. This ecosystem is ideal for certain water birds, fish and crustaceans. The water in such ecosystems is saline, but not as saline as that of the marine ecosystem. Brackish water ecosystems in river deltas have vast tracts of mangrove forests, and are considered to be some of the world's most productive ecosystem in terms of biomass production.
- The wetland ecosystem is a special ecosystem wherein water level fluctuates considerably based on the seasons. This ecosystem is highly fragile and is of importance to human beings in various ways.
- The species that thrive in the aquatic ecosystem are adapted to live in the different types of habitats. The natural aquatic ecosystems break down the chemical and organic wastes created by human beings. However, the aquatic ecosystem is incapable of handling wastes beyond a certain limit.

Artificial Aquatic systems: it consists of aquarium ecosystem and sewage ecosystem.

DEFINITION AND MEANING OF KEY TERMS IN DISASTER RISK REDUCTION AND MANAGEMENT

Disaster:

- A serious disruption of the functioning of a community or a society due to hazardous events interacting with conditions of vulnerability and exposure, leading to widespread human, material, economic and environmental losses and impacts.
- The International Federation of the Red Cross and Red Crescent Societies (IFRC) define disaster as *a calamitous event resulting in loss of life, great human suffering and distress, and large-scale material damage.*

Hazard:

- A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation is called hazard.

- A hazard turns into a disaster when there are elements of risk and vulnerability A is said to occur when the hazard impacts on that it exceeds its capacity to cope with it. Hazards vary duration, area of extent, speed of onset.

- Hazards can be single or a combination of many, in origin and effects. It can vary with respect to location, type, intensity, probability frequency

Exposure:

Exposure is the nearness of people, properties or communities to a hazard zone in space and time to suffer potential impacts. Houses and people close to an earthquake zone or at the epicentre are more exposed than those far away. However, a person living at the epicentre, but was away when an earthquake happened, would avoid personal injuries or death as opposed to a visitor who was at the premises.

Vulnerability:

Vulnerability is the degree to which a system, such as a community, is susceptible and exposed to the adverse effects of a given hazard. It is a condition that predisposes individuals, groups, communities or systems to hazard event. Vulnerability depends on the physical, socio-economic and environmental characteristics and circumstances that make the target system or community susceptible.

Categories:

Physical Vulnerability: It considers those aspects that may be damaged or destroyed by a hazard. This vulnerability is based on the physical conditions of a community and elements of risk. Physical conditions include different buildings, structures and infrastructures and their capability to withstand. The proximity and nature of hazard is also considered.

Socio- Economic Vulnerability: The socio economic conditions of a population also have a say on the intensity of impact to which a population is exposed to. For instance, poor people are most vulnerable in the event of cyclone or flood as the houses may not be strong and may be constructed with locally available materials. Further they find difficult to rebuild their houses.

Risk:

- The combination of the probability of a hazardous event and its consequences which result from interaction(s) between natural or man-made hazard(s), vulnerability, exposure and capacity is called risk.

Risk Assessment:

- An approach to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.

- Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability including the physical social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process.

- ISO 31000 defines risk assessment as a process made up of three processes: risk identification, risk analysis, and risk evaluation.

1. Risk identification: process that is used to find, recognize, and describe the risks that could affect the achievement of objectives.
2. Risk analysis: process that is used to understand the nature, sources, and causes of the risks that have been identified and to estimate the level of risk. It is also used to study impacts and consequences and to examine the controls that currently exist.
3. Risk evaluation: process that is used to compare risk analysis results with risk criteria in order to determine whether or not a specified level of risk is acceptable or tolerable.

Risk Mapping:

- Risk mapping is a process of analyzing the hazard, vulnerability and capacity through a scientific methodology.
- The process of risk map preparation includes analysis of several variables and parameters which are sub-sets of base categories; hazard, vulnerability and capacity.
- Hence, preparation of multi hazard risk map is a combination of all risk elements on several hazards.
- This process is important in risk map preparation and obviously in disaster management field for appropriate implementation of disaster risk reduction activities.

Capacity:

- The combination of all the strengths, attributes and resources available within a community, society or organization to manage and reduce the risks and strengthen resilience.
- Capacity may include infrastructure and physical means, institutions, societal coping abilities, as well as human knowledge, skills and collective attributes such as social relationships, leadership and management.
- Capacity assessment is a term for the process by which the capacity of a group is reviewed against desired goals, and the capacity gaps are identified for further action.

Coping Capacity:

- The ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters is called coping capacity. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during crises or adverse conditions. It can be two types:

  Physical Coping capacity: Some members of a community affected by hazards could have the required skills to find employment elsewhere and helps their family to sustain.

  Socio – economic coping capacity: In the event of any disaster maximum losses occurs in physical and material realm. However rich members in a community could quickly and completely recover due to their strength of wealth. This may not be possible for poor people

Resilience:

- The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
- Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to any hazard or event is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need.

Disaster Risk reduction:

- Disaster risk reduction is a systematic and continuous analysis and redressing of the causal factors of disasters.
- It is the first step and key component of disaster (risk) management.
- It should be deliberate and proactive; not episodic (occasional or conveniently) and reactionary.
- Disaster risk reduction efforts and activities are normally specified in a formal document called disaster risk reduction plan prepared by an appropriate entity or authority.
- Disaster risk reduction involves structural and non-structural measures.

- *Structural measures* include the use of physical or engineering solutions (such as ocean wave barriers or earthquake resistant buildings) to avoid disaster or reduce its impacts.
- *Non-structural measures* involve the use of policies, laws, education and awareness creation, and practices to avoid or reduce the impacts of disaster.

Disaster risk management:

- Disaster risk management is the application of disaster risk reduction policies, processes and actions to prevent new risk reduce existing disaster risk and manage residual risk contributing to the strengthening of resilience.

- Disaster risk management includes actions designed to avoid the creation of new risks, such as better land-use planning and disaster resistant water supply systems (prospective disaster risk management), actions designed to address pre-existing risks, such as reduction of health and social vulnerability, retrofitting of critical infrastructure (corrective disaster risk management) and actions taken to address residual risk and reducing impacts on communities and societies, such as preparedness, insurance and social safety nets (compensatory disaster risk management).

Early Warning Systems:

An interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks is called early warning systems.

Effective "end-to-end" and "people-centered" early warning system comprises four interrelated key elements: 1) risk knowledge and risk assessment; 2) detection, monitoring, analysis and forecasting of the hazards and possible scenarios; 3) dissemination and communication of timely, accurate and actionable warnings and associated likelihood and impact information; and 4) preparedness and local capabilities to respond to the warnings received.

Disaster Preparedness:

Disaster preparedness consists of the knowledge and capacities of institutions, communities and individuals to effectively anticipate, respond to, and recover from the impacts of likely, imminent or active hazard events or conditions. Thus, preparedness is incomplete if potentially affected people are not aware of the threat of a hazard. Preparedness is embedded in disaster risk management.

Disaster Prevention:

- Activities and measures to avoid existing and new disaster risks is called prevention.

- Prevention (i.e. disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts of hazards, vulnerability conditions and exposure through action normally taken in advance of a hazardous event. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high risk zones, and seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake.

Disaster Mitigation:

- The lessening or limitation of the adverse impacts of a hazardous event is called mitigation.

- The adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness.

Disaster Response:

- Actions taken during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

- The provision of emergency services and public assistance during or immediate after a disaster in order to save lives, reduce impacts, ensure public safety and meet the basic subsistence needs of the people affected

- Disaster response is predominantly focused on immediate and short-term needs and is sometimes called disaster relief. Effective, efficient and timely response relies on risk-informed preparedness measures, including the development of the response capacities of individuals, communities, organizations, countries and the international community.

- The institutional elements of response often include provision of emergency services and public assistance by public and private sectors and community sectors, as well as community and volunteer participation. The division between this response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage.

Damage Assessment:

Damage assessment is the procedure for determining the magnitude of damage caused by a disaster or emergency event. Damages are normally classified as:

- Severe: the target facility or object cannot be used for its intended purpose. Complete reconstruction is required.
- Moderate: the target facility or object cannot be used effectively for its intended purpose unless major repairs are made.
- Light the target facility or object can be used for intended purpose but minor repairs would be necessary.

Crisis Counseling:

Crisis counselling is the process of alleviating the emotional and psychological disturbances of persons affected by disaster in order to restore a sense of control and mastery and to aid the process of recovery and reconstruction. Normally, disasters overwhelm the physical and psychological capacity of people to cope. This can lead to emotional and psychological disturbances which can affect a person's ability to make right decisions or adopt reasonable responsive actions. Crisis counselling addresses these problems and is a crucial part of recovery and reconstruction.

Needs Assessment:

Needs assessment is a process of estimating (usually based on a damage assessment) the financial, technical, and human resources needed to implement the agreed-upon programmes of recovery, reconstruction, and risk management. *Post-damage needs assessment* is normally a rapid, multi-sectoral assessment that measures the impact of disasters on the society, economy, and environment of the disaster-affected areas.