M.A. GEOGRAPHY

SEMESTER III (CBCS)

GEOGRAPHY PAPER - 302

GEOGRAPHY OF CLIMATE CHANGE WITH SPECIAL REFERENCE TO INDIA

SUBJECT CODE:99134

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1

AFTER GOING THROUGH THIS CHAPTER, YOU WILL BE ABLE TO UNDERSTAND THE FOLLOWING FEATURES

Unit Structure :

1.1 OBJECTIVES

By the end of this unit, you will be able to

- Understand the changes that happened in climate over geological time
- Factors beyond Earth that contributed to climate change
- Factors within the Earth processes that made climate change happen
- Know the evidences available about climate change

1.2 INTRODUCTION

The climatic change, thus, is defined as variations and shifts in weather conditions over space and time of different scales and magnitude resulting into change of climatic type for example, from warm and moist climate to warm and dry climate, from warm and moist climate to cool and moist climate (as happened during Carboniferous period in India) etc.

In fact, climatic change refers to drastic or secular changes in heat balance of the earth-atmosphere system, moisture, cloudiness and precipitation caused by either external factors such as variations in orbital characteristics of the earth, solar variability (fluctuations in radiation from the photosphere of the sun), tectonic processes (mainly plate tectonics and displacement of continents and ocean basins), vulcanicity, changes in atmospheric composition in terms of concentration of atmospheric aerosols and carbon dioxide contents etc. or by internal factors such as exchanges of energy between the atmosphere, hydrosphere, lithosphere and cryosphere (ice covered surfaces of both lithosphere and hydrosphere) or by both, at local, regional and global levels.

1.3 SUBJECT DISCUSSION

In this chapter you will get acquainted with the historical background of climate change. Also the variety of factors that are responsible for bringing change in climate. Lastly the evidences and indicators of climate change that happened in past are discussed.

1.4 CLIMATIC CHANGE THROUGH GEOLOGICAL TIME

Climatic Changes Through Geological Periods The geological history of the earth or the 'geological clock ' refers to the reconstruction of evolutionary sequences of the geological events involving the information of various zones (crust, mantle and core) of the earth, formation and evolution of geomaterials (rocks), formation and development of mountains and faults, evolution of different lives etc. The whole geological history right from the origin of the earth to its present form has been divided into major and minor periods on the basis of forms of life (organic remains), characteristic rock deposits, places of rock formation, major tectonic events etc. The whole geological history of the earth has been divided into five eras (the largest time division of the earth's history has been termed Era).Based on five major groups of deposits as follows:

Major Groups of Eras Deposits (from youngest to oldest)

- Neozoic - Neozoic Group (era of present life)
- Cenozoic -Cenozoic group (era of recent life)
- Mesozoic - (era of medieval life)
- Proterozoic - Proterozoic (era of earlier life)
- Archeozoic- Archaeozoic (era of primeval life)

Each era is numbered in sequence as first (primary), second (secondary), third (tertiary) and fourth (quaternary) epoch.

Table 1.1 : Geological Time Table (from youngest to oldest)

After Going Through This Chapter, You Will Be Able To Understand The Following Features

Eras	**Epochs**	**Periods**	**Duration (Million Years)**	**Ice Age**	**Starting Time (MYBP)**
Neozoic	Quaternary	2. Holocene or Post-glacial			
		1. Pleistocene	0.990	Ice age 4	1
Cenozoic	Tertiary	4. Pliocene	10.000		11
		3. Miocene	14.000		25
		2. Oligocene	15.000		40
		1. Eocene	30.000		70
Mesozoic	Secondary	3. Cretaceous	65.000		135
		2. Jurassic	45.000		180
		1. Triassic	45.000		225
Paleozoic	Primary	6. Permian	45.000		270
		5.Carboniferous	80.000	Ice age 3	350
		4. Devonian	50.000		400
		3. Silurian	40.000		440
		2. Ordovician	60.000	Ice age 2	500
		1. Cambrian	100.000		0. 6 00
1. Pre - paleozoic	2.	3. Pre-Cambrian - or Algonican	4.	5. Ice age 1	6. 7 00
7. Az oic	8.	9. Archaean	0.	1.	2. 8 00

Pre-Palaeozoic Era

Very few geological evidences are available to reconstruct the climatic history of early pre Palaeozoic era. Inferences have been drawn on the basis of Iithological evolution and evidences thereof, numerical models and deductions. It is assumed that the earliest climatic phase of the earth's atmosphere was warm with average (assummed) atmospheric temperature of 37°C about 4250 M Y B P (million years before present) which is supposed to have dropped to 25°C about 2500 M Y B P . Such assumptions and calculations are based on the estimate that the concentration of carbon dioxide (CO 2) might have been much higher in the earliest atmosphere than at present and thus the prePalaeozoic climate might have been very warm due to greenhouse effect of the early atmosphere. Indicators reveal the existence of probably the first ice age, known as Huronian Glaciation (on the basis of Lake Huron of Canada and USA) which is supposed to have occurred about 2700 MYBP and might have continued up to 1800 MYBP. The earth again experienced warm climatic phase which continued upto 950 MYBP.

Palaeozoic Era (650-600 to 250 MYBP)

The early Cambrian period is supposed to have been in cold climatic phase leading to ice age during which the glaciation was more widespread than pre-Cambrian ice age. The evidences denote warm tropical climate of most of the northern hemisphere including North America, Europe and China, characterized by warm and semi-arid climate. On the other hand, most of the southern hemisphere, say Gondwanaland, was under cool climatic phase leading to widespread glaciation known as Carboniferous Ice Age which is supposed to have continued from middle and late Carboniferous period to early Permian period. By the end of Permian period the southern hemisphere recovered from Carboniferous glaciation due to retreat and ablation of ice sheets.

Mesozoic Era (225-70 MYBP)

The climatic condition during Triassic period was warm and dry but it became wet by the end of this period. Cretaceous period was marked by warming of high altitudes which made the growth of vegetation possible upto Greenland. 'This time of earth history saw the world in its greenhouse mode, when climate was predominantly warm , polar ice caps nonexistent, and sea level high. The change from this to an eventual ice house mode may not have been smooth, but rather episodic ' (Oliver and Hidore, 2003).

Cenozoic Era

The early Tertiary witnessed drop in temperatures but still the climate remained warm. During Miocene period (25-11 M Y B P) the earth's surface was characterized by varying climatic conditions as these varied from dry and desert climatic conditions to wet and cold climate. The Pliocene period (11-1 MYBP) witnessed wide range of fluctuations in temperatures i.e. repetition of warm and cold phases. The glaciers began to form over Antarctica. The continued lowering oftemperature culminated into the formation of continental glaciation and onset of ice age in Pleistocene period of Quaternary epoch.

Quaternary Climate Changes

The Quaternary epoch of Cenozoic era started about one million years before present and continues at present. This epoch comprises Pleistocene and Holocene (post-glacial period) periods. The pleistocene witnessed most pronounced climatic changes for which much authentic data derived through different techniques such as pollen analysis, isotope analysis, carbon dating, potassium argon dating etc. are available and thesequences of events are well documented.

Climate in the Post-Glacial Period

The final retreat and withdrawal of recent ice sheets started about 18,000 YBP and continued upto 10-12,000 YBP. The period ranging from 18,000 to 5,500 YBP is considered as a period of deglaciation denoting rapid

changes in climate and rise in temperature. 'All evidence points to this being a time when the mean atmospheric temperature of the mid-latitudes was 2.5°C (4.5°F) above that of the present. This time has been described as the Climatic Optimum a term originally applied to Scandinavia when temperatures were warm enough to favour more varied flora and fauna ' (Oliver and Hidore, 2003).

After Going Through This Chapter, You Will Be Able To Understand The Following Features

1.5 CAUSES OF CLIMATE CHANGE – EXTERNAL AND INTERNAL CAUSES

Climatic changes arc effected by changes in atmospheric circulation and interactions among five components of the earth atmosphere system, namely atmosphere, hydrosphere, lithosphere, biosphere, and cryosphere (frozen surface of the earth) wherein the amount of received solar energy , and the process of distribution. Redistribution and absorption of solar radiant energy at the earth surface are important considerations of the state of climate of an area in specific time period. The causes for such interactions leading to climatic changes are related to (l) outside sources, say extraterrestrial sources, and (2) inside sources, say earth -atmosphere system or terrestrial sources The significant causes and related theories of climatic changes may be stated as follows:

(1) Solar irradiance (variation in solar radiation) -

Almost all of the energy that affects the climate on Earth originates from the Sun. The Sun's energy passes through space until it hits the Earth's atmosphere. Only some of the solar energy intercepted at the top of the atmosphere passes through to the Earth's surface; some of it is reflected back into space and some is absorbed by the atmosphere.

The energy output of the Sun is not constant: it varies over time and this has an impact on our climate.

(2) Astronomical theories-

(eccentricity of earth's orbit, obliquity of the ecliptic, precession of the equinoxes, earth-Sun relationship) etc.,

The three changes in the Earth's orbit around the Sun — eccentricity, axial tilt, and precession — are collectively called 'Milankovitch cycles'.

According to Milankovitch's theory, these three cycles combine to affect the amount of solar heat that reaches the Earth's surface and subsequently influences climatic patterns, including periods of glaciation (ice ages). The time period between these changes can be tens of thousands of years (precession and axial tilt) or more than hundreds of thousands of years (eccentricity).

(3) Atmospheric dust hypothesis (mainly volcanic eruptions and dusts thereof)*

Volcanoes affect the climate through the gases and particles (tephra/ash) thrown into the atmosphere during eruptions. The effect of volcanic gasses and dust may warm or cool the Earth's surface, depending on how sunlight interacts with the volcanic material. During major explosive volcanic erruptions, large amounts of volcanic gas, aerosol droplets and ash are released.

(4) Carbon dioxide hypothesis

Greenhouse Gasses include carbon dioxide (CO2), Methane (CH4) and water vapour. Water vapour is the most abundant grennhouse gas in atmosphere, but it stays in the atmosphere for about nine years until it is removed by oxidation into CO2 and water. CO2 stays in the atmosphere much longer, from years to centuries, contributing to longer periods of warming. These gasses trap solar radiation in the Earth's atmosphere, making the climate warmer.

(5) Continental drift and pole wandering

Over very long periods of time, plate tectonic processes cause continents to move to different positions on the Earth. For example, Britain was near to the equator during the Carboniferous Period, around 300 million years ago, and the climate was warmer than it is today. The movement of the plates also causes volcanoes and mountains to form and these can also contribute to a change in climate. Large mountain chains can influence the circulation of air around the globe, and consequently influence the climate. For example, warm air may be deflected to cooler regions by mountains.

(6) Tectonic and topographic control theory

On a global scale, patterns of vegetation and climate are closely correlated. Vegetation absorbs CO_2 and this can buffer some of the effects of global warming. On the other hand, desertification amplifies global warming through the release of CO_2 because of the decrease in vegetation cover.

A decrease in vegetation cover, via deforestation for example, tends to increase local albedo, leading to surface cooling. Albedo refers to how much light a surface reflects rather than absorbs. Generally, dark surfaces have a low albedo and light surfaces have a high albedo. Ice with snow has a high albedo and reflects around 90 per cent of incoming solar radiation. Land covered with dark-coloured vegetation is likely to have a low albedo and will absorb most of the radiation.

(7) Oceanic variation hypothesis

Ocean currents carry heat around the Earth. As the oceans absorb more heat from the atmosphere, sea surface temperature increases and the ocean circulation patterns that transport warm and cold water around the globe change. The direction of these currents can shift so that different areas become warmer or cooler. As oceans store a large amount of heat, even

small changes in ocean currents can have large effect on global climate. In particular, increases in sea surface temperature can increase the amount of atmospheric water vapor over the oceans, increasing the quantity of greenhouse gasses. If the oceans are warmer they can't absorb as much carbon dioxide from the atmosphere.

(8) Extra-terrestrial bodies collision theory

Nowadays, most of what is on the Earth stays on the Earth; very little material is added by meteorites and cosmic dust. However, meteorite impacts have contributed to climate change in the geological past; a good example is the Chicxulub crater, Yucatán Peninsula in Mexico.

Large impacts like Chicxulub can cause a range of effects that include dust and aerosols being ejected high into the atmosphere that prevents sunlight from reaching the Earth. These materials insulate the Earth from solar radiation and cause global temperatures to fall; the effects can last for a few years. After the dust and aerosols fall back to Earth, the greenhouse gases (CO_2, water and CH_4) caused by the interaction of the impactor and its 'target rocks' remain in the atmosphere and can cause global temperatures to increase; these effects can last decades.

1.7 EVIDENCES AND INDICATORS OF CLIMATE CHANGE

1. Global Temperature Rise –

The planet's average surface temperature has risen about 2 degrees Fahrenheit (1 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide emissions into the atmosphere and other human activities.[4] Most of the warming occurred in the past 40 years, with the seven most recent years being the warmest. The years 2016 and 2020 are tied for the warmest year on record.

2. Warming Ocean –

The Ocean has absorbed much of this increased heat, with the top 100 meters (about 328 feet) of ocean showing warming of more than 0.6 degrees Fahrenheit (0.33 degrees Celsius) since 1969.Earth stores 90% of the extra energy in the oceans.

3. Shrinking Ice Sheets –

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019, while Antarctica lost about 148 billion tons of ice per year.

4. Glacial Retreat –

Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska, and Africa.

5. Decreased Snow Cover –

Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and the snow is melting earlier.

6. Sea Level Rise –

Global sea level rose about 8 inches (20 Centimeters) in the last century. The rate in the last two decades, however, is nearly double that of the last century and accelerating slightly every year.

7. Declining Arctic Ice Sheet –

Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades.

8. Extreme Events –

The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.

9. Ocean Acidification –

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30%. This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the ocean. The ocean has absorbed between 20% and 30% of total anthropogenic carbon dioxide emissions in recent decades (7.2 to 10.8 billion metric tons per year).

1.8 SUMMARY

Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems.

1.9 CHECK YOUR PROGRESS/EXERCISE

A) Multiple Choice Questions -

1. Consider the following statements with regard to Ecological succession –

1. Ecological succession is the process of change in the species structure of an ecological community over time.
2. Ecological succession leads to a stable, self-perpetuating community, called the seral stage.

3. Secondary succession is faster than primary succession

Which of the above statements are true?

1. i only

2. iii only

3. Both i and ii

4. Both i and iii

2.Arrange the following greenhouse gases in decreasing order of their Global Warming Potential (GWP).

1. Carbon dioxide

2. Sulphur hexafluoride

3. Nitrous oxide

4. Methane

1. i ii iii iv

2. iv iii i ii

3. ii iii iv i

4. ii I iv iii

3. The Kigali agreement was an amendment to which of the following international conventions aimed at conserving the environment?

1. Montreal Protocol

2. Stockholm Convention

3. Bonn Convention

4. Kyoto Protocol

4. Which of the following cause is related to high ash content in atmosphere?

1. Volcanism

2. Air pollution

3. Tectonic causes

4. Lithospheric causes

5. Which sea ice is major indicator of Global Climate Change?

1. North Sea

2. Hudson bay
3. Arctic sea
4. Ross sea

1.10 ANSWERS TO THE SELF-LEARNING QUESTIONS

A) Multiple Choice Questions –

1. 4
2. 2
3. 2
4. 1
5. 3

1.11 TECHNICAL WORDS AND THEIR MEANING

Atmospheric black clouds (ABC): simply means formation of layers of pollutants in the atmosphere due to burning of fossil fuels (coal, petroleum, natural gas etc.).

Climochronology:Climochronology may be defined as a systematic description of climatic conditions and climatic changes in geological history of the earth.

Climaticprecession: ‘Climatic precession is a complex variable with principal periods of 23,000 and 19,000 years. Climatic precessional parameter refers to the time of year when the earth is at perihelion or closet to the sun, which is now in early January (more precisely January, 3) '(A .L. Bloom, 2002).

Duricrusts: Duricrusts are indurated hardened surfaces of different kinds such as Iaterites, silcretes, calcrete s, alcretes, ferricretes etc.

Eccentricity: Of the earth’s elliptical orbit simply means deviation of its elliptical orbital path from true circular path.

Evaporites: Evaporites are the deposits represented by salt deposits in warm and arid climatic conditions when evaporation exceeds precipitation.

Glaciology: The science dealing with glaciers and glaciation is called glaciology.

Greenhouse effect: Greenhouse effect means ‘progressive warming - up of the earth ’s surface due to blanketing effect of carbon dioxide in the atmosphere.’

Greenhouse phase : Greenhouse phase means increase in earth's temperature by the absorption of outgoing terrestrial infrared radiation by certain gases i.e. greenhouse gases, mainly carbon di-oxide. Icehouse phase: The ice house phase refers to lowering of earth's temperature leading to beginning of glacial period.

After Going Through This Chapter, You Will Be Able To Understand The Following Features

1.12 TASK

Identify the indicators of climate change that you see around in your region and relate them to the local, regional, global causes.

1.13 REFERENCES

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2

GLOBAL WARMING

Unit Structure :

2.1 OBJECTIVES

a. To provide the students with conceptual clarity about climate change, global warming and the associated weather patterns so that they can gain an insight into the ongoing global changes and become aware of the unprecedented climatic phenomena occurring periodically.

b. To familiarize the students with the important aspects of Global warming, its causes and relevance in the present day scenario. An understanding of these aspects will generate in them sensitivity towards the environment so that they may be prompted to adopt environment friendly measures.

c. To acquaint the students with the diverse consequences of global warming, which differently impact the natural systems as well as the anthropogenic activities. This may sound an alarm bell in the young minds, thereby presenting the harsh reality that, the future generations will be exposed to, if timely and prudent actions are not taken up in order to preserve the natural environment.

2.2 INTRODUCTION

The term Global warming has been in use for quite some time now and we have started using it commonly in our conversations, discussions and writings. We all know that global warming is a product of climate change, which has been triggered mainly by the Industrial Revolution. Also wars, nuclear radiation and population explosion are responsible for this. The combined effects of these events have taken a heavy toll on the health of the environment, thus, making the Earth sick. It is high time that we understand the significance of climate change and the tremendously risky situation into which we are putting ourselves as well as our future generations. A few scientists are of the belief that global warming as a whole is, wholly ascribed to the non-prudent human activities. Both the phenomena of climate change and global warming are inter-connected. There are several talks, documentaries, movies and news articles bringing to surface the ill effects of such a phenomenon as the global warming which has engulfed the entire earth, while burdening the world's population with the burning question of 'how to deal with it'. For this purpose, quite a few summits and protocols have also been observed in order to redress the environment and bring the warming down to a reasonable limit for the benefit of one and all. For gaining an understanding of the term Global Warming, it is rather imperative that we fill our minds with the knowledge of 'Climate Change'.

When we say that the climate is changing, we basically mean that, there has been a drastic shift in the climate and weather patterns that have been observed over hundreds of years over the different countries of the world. These are inclusive of temperature and precipitation conditions, inducing untimely rains, severe spells of droughts in the already water scarce areas and floods in areas of heavy rains as well as increase in the intensity and velocity of cyclonic storms. The episodes of flash floods, cloud bursts and torrential rains in western Rajasthan, Uttarakhand and in the Northern Plains of India are a direct result of climate change. Unprecedented challenges with respect to temperature, are surfacing all over the world and in India, especially in the northern states, which have started experiencing scorching summers and severe winters wherein the deviation from the normal is significantly high. Even the incidents of El-Nino and La-Nina have become more frequent over the past 100 years especially in

the post-industrial era. The climatologists associated with the Inter-governmental Panel on Climate Change (IPCC) have, on the basis of their calculations, experiments and future projections hinted towards a substantial rise in the average surface temperature of the whole world in the near future. This is more alarming since such type of an event has not taken place in the last 10,000 years. The temperatures are predicted to soar between 1.4° to 5.8°C. The interior continental areas and places in the higher latitudes will have a tougher time combating the issue of climate change and the accompanying issue of global warming. The disastrous impact of such a change will show up on all living phenomena equally, thus leading to an unprecedented evil influence on nature, its resources and anthropogenic activities.

2.3 MEANING AND HISTORICAL PERSPECTIVE ON GLOBAL WARMING

2.3.1 Meaning of Global Warming:

The term Global warming has been in use for quite some time now and we have started using it commonly in our conversations, discussions and writings. We all know that global warming is a product of climate change, which has been triggered by the industrial revolution, wars, nuclear radiation and population explosion. The combined effects of these events have taken a heavy toll on the health of the environment, thus, making the Earth sick. It is high time that we understand the significance of climate change and the tremendously risky situation into which we are putting ourselves as well as our future generations. A few scientists are of the belief that global warming as a whole is cent per cent attributed to non-prudent human activities. Both the phenomena of climate change and global warming are inter-connected. There are several talks, documentaries, movies and news articles bringing to surface the ill effects of such a phenomenon as the global warming which has engulfed the entire earth in its fold, while facing the world's population with the burning question of 'how to deal with it'. For this purpose, quite a few summits and protocols have also been observed in order to redress the environment and bring the warming down to a reasonable limit for the benefit of one and all. For gaining an understanding of the term Global Warming, it is rather imperative that we fill our minds with the knowledge of 'Climate Change'.

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experiencing scorching summers and severe winters wherein the deviation from the normal is significantly high. Even the incidents of El-Nino have become more frequent over the past 100 years especially in the post-industrial era. The climatologists associated with the Inter-governmental Panel on Climate Change (IPCC) have, on the basis of their calculations, experiments and future projections hinted towards a substantial rise in the average surface temperature of the whole world in the near future. This is more alarming since such type of an event has not taken place in the last 10,000 years. The temperatures are predicted to soar between 1.4° to 5.8°C. The interior continental areas and places in the higher latitudes will have a tougher time combating the issue of climate change and the accompanying issue of global warming. The disastrous impact of such a change will show up on all living phenomena equally, thus leading to an unprecedented evil influence on nature, its resources and anthropogenic activities.

In simple words 'Global Warming' means, the heating up of the Earth and its atmosphere, much beyond the current levels, raising the intensity of hotness to several degrees above the normal limit. This eventuality will reduce the number of cold days, leading to extended summers and the associated heat waves while, escalating the intensity and frequency of storms. We call it as global warming for the simple reason that, this phenomenon is not restricted to just a few countries, rather it has a global influence. All the countries of the globe, especially the developed countries are acting in the most irresponsible and unsustainable manner, because they are giving more importance to- development, economic growth and advancement and all this is being done at the cost of the environment. Now the environment has stopped being passive and started to show resistance towards the reckless nature of the humans.

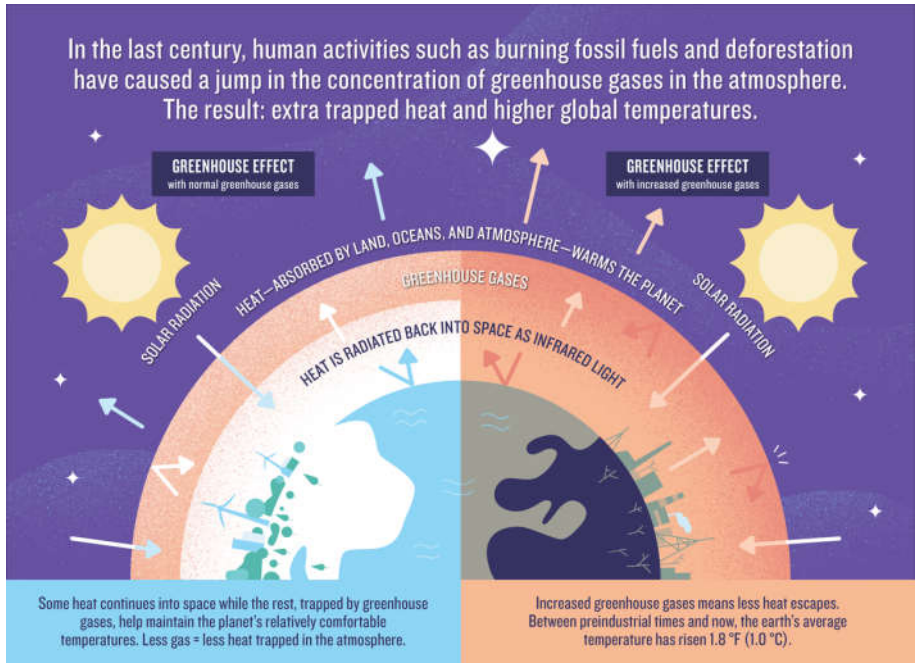

Fig. 2.1: Greenhouse Effect
Source: nrdc.org

2.3.2 Historical Perspectives:

The climate in past geological eras- Climate surveys in past geological periods illustrate that important climate change has occurred in the past. Important events of climate change in the past are briefly Earth's climate is constantly changing. Evidence suggests that for most of Earth's history, the climate has been much warmer than today.

The last glacial period (or ice age) began about 2.5 million years ago. Glacial periods are interrupted by warmer periods called interglacial periods. In North America, continental glaciers reached their maximum thickness and range from about 26,000 to 20,000 years and disappeared completely from North America about 6000 years ago.

The glacial event called young 'dryas' about 12,000 years ago caused the glaciers to return to north-east America and northern Europe.

From 1880 to 2012, the earth's surface temperature increased by about 0.85°C. This trend of global warming accelerated in the 1980s and 1990s, then declined in the 2000s. (Mozaffari, G.A., 2022)

2.3.3 Green House Gases:

Warming of the earth happens due to the release of greenhouse gases (GHGs) into the atmosphere. These gases majorly comprise of:

- ✓ Water vapor
- ✓ Carbon-di-oxide
- ✓ Methane
- ✓ Carbon mono oxide
- ✓ Nitrous oxide
- ✓ Chloro-fluoro-carbons (CFCs)
- ✓ Sulphur-di-oxide
- ✓ Ozone.

These gases act as a blanket cover in the atmosphere which is transparent to the short wave solar radiation and allows it to enter and heat up the earth but they are opaque towards the long wave terrestrial radiation. This means- during the evening time, when the Earth radiates the heat it received from the sun during the day, back into space, these GHGs present in the atmosphere, prevent this from happening, because they trap the long wave terrestrial rays and thus are responsible for retaining the heat. The more is the concentration of the GHGs in the atmosphere, higher is the level of heating caused by them. Among these, the most potent and abundant greenhouse gases are water vapor and Carbon-di-oxide. Their concentration is much more as compared to the other gases. Having mentioned all this, it is worth noting the fact that – had it not been for

these gases, the Earth would have experienced a never ending 'ice-age'. Moreover, they play a role in ending combustion by cutting off the oxygen supply, which allows the fire to burn continuously. The capacity of these gases to trap heat energy, indirectly proves beneficial for the human kind and all other life forms as well. But it is in the best interest of the humans and the environment as a whole that the most intelligent specie acts in the most prudent and benevolent manner.

The levels of CO_2 have enormously increased in the atmosphere. Apart from the plant community which releases this gas during respiration, it is mainly emitted from thermal power stations, vehicles, industries/factories, brick kilns, burning of fossil fuels, wood or solid waste, deforestation (forests are also known as carbon sinks due to their capacity to store carbon in different forms), mining, oil drilling (it releases 30 per cent of methane and 8 per cent of carbon), dairy farming (cattle and other dairy animals release lot of methane) & agriculture.

Note: It should be well noted that the Global Warming Potential (GWP) of Methane (25 times), Nitrous oxide (300 times) and CFCs (1000 to 10000 times) is much higher than carbon-di-oxide. There are three criteria that must be considered while understanding the role of GHGs that cause global warming. Firstly, the quantity of the gas in the atmosphere. Secondly, the duration of time that gas remains in the atmosphere (i.e. lifetime of the gas which may extend up to 100 years or more). Thirdly, the capacity of that gas to store the terrestrial heat rays. This is also known as the GWP of that particular gas.

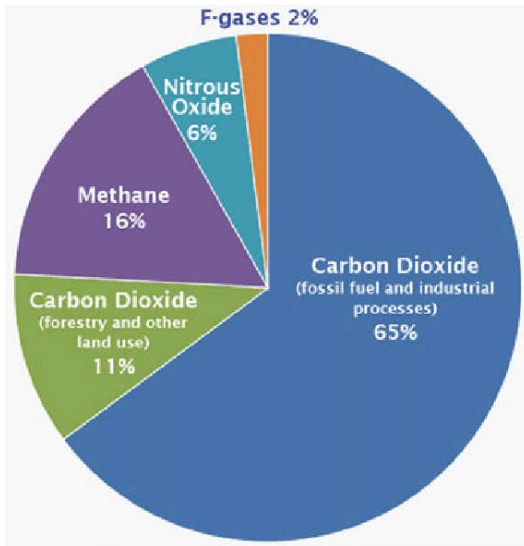

Fig. 2.2: Concentration of Greenhouse Gases in the Atmosphere
Source: researchgate.net

2.3.4 Sources of the Green House Gases:

There are many sources that emit these gases which occupy a prominent space in the lower atmosphere. There are natural sources like flora and fauna, soil surfaces (addition of fertilizers) and human and animal waste that release gases like carbon-di-oxide, methane, nitrous oxide etc. into the

air but the environment is able to balance such releases in a sustainable manner. The problem arises when there is an overload of the GHGs due to human interference through anthropogenic activities. Some of the 'human induced gas emissions' are listed below:

- **Power Stations-**

The burning of fossil fuels like coal, gas and oil in the power stations helps generate electricity but also produces heat and releases carbon-di-oxide in large quantities plus methane and nitrous oxide in small quantities into the air. Moreover the exhaust gases released from the automobiles as a result of combustion of petrol/diesel are GHGs.

- **Agriculture and allied activities-**

The changes in land use and land cover are also responsible for release or the absorption of GHGs especially carbon-di-oxide into the atmosphere. In case of floral decomposition, deforestation or slash and burn agriculture ('Jhum' cultivation in practiced in North Eastern States of India), carbon stored in the trees/vegetation is released. Whereas, when afforestation or reforestation is practiced then the plants tend to absorb the atmospheric carbon-di-oxide. The land covered with thick soil layers is beneficial for reducing the concentration of carbon-di-oxide since the carbon sticks to the microbes present in the soil. The nitrogenous fertilizers added to the soil release nitrous oxide which also increases the GHG load in the atmosphere. Practices like dairy farming release large amounts of methane gas.

Industrialization-

The industrial sector is a major contributor to the GHG emissions. Nearly one-fifth of these emissions are a direct result of industrial activity. Carbon-di-oxide occupies a major share among the gases discharged (methane, nitrous oxide, and fluorinated gases) from the industries/factories.

- **Transport Sector-**

This sector accounts for around 14 percent of the emissions from all over the world. The gases released from airplanes, ships, vehicles/automobiles etc. are mainly produced due to combustion of petroleum based fuels and the exhaust fumes comprise of carbon-di-oxide, carbon-mono-oxide, methane, nitrous oxide and CFCs, which are released as a result of air conditioning/ refrigeration. Nearly 80 per cent of the carbon emissions of this sector come from automobiles.

- **Buildings-**

These may serve as office, commercial or residential constructions, but these too play a role in adding to the existing burden of the GHGs through air conditioning and refrigeration, burning of natural gas/LPG and disposal of kitchen and other waste plus waste water.

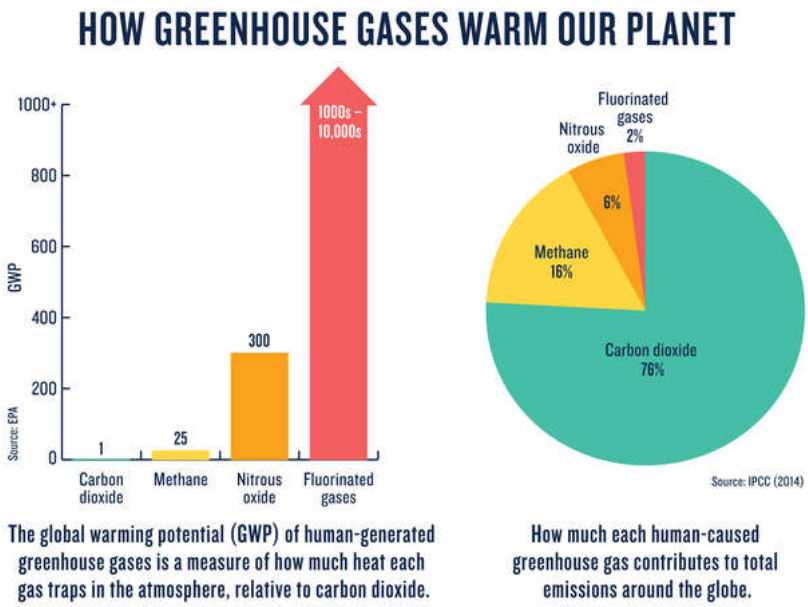

Fig. 2.3 GHG induced warming of the Earth
Source: nrdc.org

Note: Since the start of the Industrial Revolution, more than 2,000 billion tons of carbon dioxide have been released into the atmosphere by human activities, according to the Global Carbon Project. North America and Europe are responsible for approximately half of that total, while the emerging economies of China and India have contributed another 14 percent. For the remainder, 150-plus countries share responsibility.

An analysis of carbon dioxide emissions by country today shows that China now leads the pack, responsible for 27 percent of all emissions. Next comes the United States (15 percent), the European Union's 28 member states including the United Kingdom (10 percent), and India (7 percent) next. Together, these global powers account for almost 60 percent of all emissions. (NRDC. Org, 2022)

2.3.5 Summits and Agreements:

To support the belief that global warming is real and is on the rise, there are certain summits, agreements and premises that have been presented here for the sake of better understanding and accepting the truth about the current state of our environment, that has been bestowing several benefits in the form of resources on us thus making our lives comfortable and worthwhile. We as the wisest race among all biota, are morally obligated towards our environment so as to preserve and restore it while it preserves and supports the existence of all living organisms. United Nations has instituted a convention for the purpose of keeping a check on climate change and its associated phenomena called- 'United Nations Framework Convention on Climate Change' (UNFCCC). It became effective on 21.3.1994 and since then there have been several summits and conferences

that have been taking place under its purview, i.e. COP 1 to COP 26, Earth Summit, Kyoto Protocol, Bali Action Plan, Copenhagen Accord, the Cancún Agreements and Durban Platform for Enhanced Action The objective of all these summits/agreements between nations has been to control climate change, curb global warming, reduce GHG emissions and design action plans to mitigate the harmful impacts of these human induced environmental influences and to make sure that the action plans are adhered to by the member nations. Besides this, there is the Montreal Protocol which aims at protecting the Ozone Layer by reducing the emission of CFCs.

Kyoto Protocol -

This took place in the third COP of UNFCCC at Kyoto in Japan on 11.12.1997. This protocol especially targeted the developed nations i.e. 37 industrialized countries on the principle of 'Common But Differentiated Responsibilities' to significantly reduce their GHG emissions and bring them down to the 1990 levels in order to deal with the issue of climate change. It was binding on the nations and was based on commitment from the member nations. It became effective from 16.2.2005. Total of 192 countries were able to ratify their commitment of reducing their emissions by an average of 5 per cent against the 1990 GHG levels by 2011. The time frame given to the members was 5 years i.e. 2008-2012 (Both years included). Also, the protocol allowed certain amount of flexibility to the members by allowing them to make use of 3 important mechanisms to first of all reduce their domestic emission rate. These mechanisms were innovative and market based. They are as follows:-

1. Emissions trading or the Carbon Market
2. Clean Development Mechanism (CDM)
3. Joint Implementation

The protocol was designed such that the member countries are provided with due assistance which may be required by them for adapting to the inevitable effects of climate change, while facilitating the development of such mechanisms that may prove to be helpful in becoming more resilient to the effects of climate change.

A second amendment to this protocol was made at Doha in Qatar in December 2012. This extended the previous time frame decided at Kyoto and extended it from January 2013 to December 2020.

Note: India validated its commitment to the aim of Kyoto protocol by reaffirming the fact that possible measures will be adopted in order to fulfil the objectives laid down in the second commitment period, till 2020.

Montreal Protocol-

This is an internationally accepted agreement which became effective from 1.1.1989. The protocol was held in Montreal, Canada. It was signed by 197 countries. The basic objective behind this agreement was to make the nations aware about the ongoing depletion of the Ozone, which is a serious issue as the ozone layer acts as a protective shield from the harmful rays of the sun, especially the Ultra Violet radiation (UV Rays) for all the living existence on Earth. This was happening because of the enormous release of certain man-made chemicals like the chloro-fluoro-carbons (CFCs) and aerosols into the atmosphere which was destroying the ozone layer due to chemical reactions happening between the chlorine and oxygen molecules. The protocol emphasized on a step-wise schedule for the member countries to adopt in order to reduce and then altogether cease, the production and consumption of the ozone depleting substances (ODS). This schedule included the adoption of 3 approaches namely; production and consumption control, trading control and choosing of ozone friendly substances and technology for the benefit of all humanity. The ozone depleting substances were identified as:

CFCs

Halons

Methyl Bromide

Carbon-tetra-chloride

Methyl Chloroform

Hydrochloro-fluoro-carbons

Hydro-bromo-fluoro-carbons

Bromo-chloro-methane

This agreement significantly brought down the levels of ODS thus making possible the recovery of the ozone layer and subsequently benefitting the climate by limiting the negative climate change phenomenon. This was seen to be more successful than the Kyoto Protocol, in its mission since, the emission rate of the ozone destroying substances was drastically reduced.

Note: India became a Party to the Montreal Protocol on Substances that Deplete the Ozone Layer on 19 June, 1992 and since then has ratified the amendments to the Montreal Protocol. The Kigali Amendment to the Montreal Protocol for phase down of Hydrofluorocarbons was endorsed by India and the phase out targets of all the ODS have been successfully met, as per the schedule set by the Montreal agreement. India will complete its phase down of HFCs in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047.

Paris Climate Agreement-

It is an action oriented global plan, designed to combat the burning issue of climate change and hence, mitigate global warming. This agreement is like a new chapter in the ongoing struggles to deal with the fast changing patterns of the climate, taking place worldwide. It has persuaded around 197 countries to join hands and make stricter commitments and adhere to them. The Paris Climate Accord, as it is commonly known, was adopted in 2015 (12.12.2015 at COP 21 i.e. 21st Conference of the Parties in Paris, France) but it became effective from 4.11.2016. The challenges of climate change mitigation, adaptation, and finance which face us today were covered in this accord. This agreement is a 32 pages long document which acts as an outline for global climate action.

The aim of this accord is to restrict the emission of the green-house gases which is causing large scale rise in the global temperature. It is understood that the temperatures are rapidly rising in both the hemispheres and there is an urgent need to curb this. A meaningful and logical attempt by all member nations will be to- take quick decisions and implement mechanisms which considerably bring down the emission rate. As a matter of fact, even if all the nations take a united stand and reduce the GHG emission drastically, in the next 5 years, still the climate will continue to heat up due to the long life of these gases in the atmosphere. A rise of 1.5 to 2 degree Celsius is predicted by the IPCC in the next 15-20 years. Such a rise in temperature can have far reaching effects on the earth systems and the humans by inducing problems of extreme heat, habitat loss, wild fires, water scarcity, drought, food insecurity, diseases, malnutrition, poverty and subsequent wars. Secondly, the accord aims at establishing a framework to be followed by all member nations to act with transparency, accountability to achieve the ambitious targets.

2.4 CAUSES OF GLOBAL WARMING

It should be well understood that global warming is a consequence of a variety of changes that keep taking place in the Earth's climate from time to time. This has happened earlier as well, in the geologic history of the Earth. The climate changes occur as a result of both natural as well as man-made interferences. There are several evidences and theories put forth by climatologists and experts to support this notion. There theories are presented here:

- **Earth's Orbital Theory-**

There is a cycle of 90,000 to 100,000 years that the Earth follows. It has been observed that, in this cycle, the shape of the Earth's orbit undergoes changes such that the shape becomes more circular or it stretches into a larger oval over a period of time and returns to the shape it currently has. When such orbital alterations occur, the amount of heat received at the earth's surface also changes during the phases of aphelion and perihelion, where it becomes 20-30 times more or less, depending upon the orbit's shape.

Another phenomenon is the change in the tilt of the Earth's axis, which occurs within a cycle of 41,000 years. The Earth is currently inclined at 23.5 degrees angle, which it forms with its orbit. But the tilt keeps varying between the angles of 22 degrees to 24.5 degrees. When such changes in the tilt occur, then there is a marked change in the amount of solar radiation received by the Earth, indicating the presence of more warm periods.

- **Continental Drift and Sea Floor Spread Theory-**

These two theories were put forth by Alfred Wegener and H.H. Hess respectively. Both these theories suggest that there the continents and ocean bodies are present over tectonic plates which keep floating over the magma. There is construction and destruction of the plate boundaries when they collide with each other or when they drift away. This causes changes to take place in the position of the continents and oceans. This disturbs the flow direction of the ocean currents, which in turn affects the temperature and precipitation pattern brought about by the changes in ocean currents. Thus, the amount of heat received in different parts of the Earth changes altogether.

- **Theory of Alteration in Atmospheric Composition-**

The atmosphere is composed of several types of gases, water vapor, dust particles and other chemicals. Some of them are naturally present there, but some are artificially introduced by human activities. There are a few gases which fall in the category of GHGs and the amounts of these gases have crossed the permissible limits, courtesy the rampant rise in the developmental activities introduced by man, in order to lead a comfortable lifestyle. One of the most prominent and indefinitely increasing GHG is Carbon-di-oxide. This is attributable to heavy dependence of humans on fossil fuels. On burning/combustion, these fuels produce large quantities of smoke, ash, Sulphur and Carbon-di-oxide and Carbon-mono-oxide.

The theory that Carbon-di-oxide causes climate change was put forth by T.C. Chamberlain. He knew that this gas has a role to play in the heating of the Earth and its atmosphere due to its tendency of allowing the short wave solar rays to pass and reach the earth and stopping the infrared long wave terrestrial rays from escaping into space. The more is the concentration of Carbon-di-oxide in the atmosphere, higher is the amount of heat trapped. It is estimated that if the rate of increase of this gas continues at the present rate, then the amount will double by the year 2050. Besides this, the concentration of this gas will reach 500 ppm (parts per million) by the end of this century. The result of this will be- an estimated rise of 1.5 to 2.0 degrees Celsius in the temperature of the Earth.

Note: 60% of the global warming caused in the lower atmosphere, can be safely attributed to the enormous increase in the quantity of carbon-di-oxide, which is released into the atmosphere at the rate of 8-10 billion metric tons per annum. The industries are responsible for releasing 46% of the GHG emissions all over the world.

Apart from Carbon-di-oxide, the concentration of methane, nitrous oxide, Carbon-mono-oxide, Sulphur di oxide and CFCs is also continuously growing. All these gases are collectively causing the climate to undergo unprecedented changes including the depletion of ozone due to CFCs.

- **Theory of Sunspots-**

Experts have pointed out that, the Sun has 'Spots' (dark/black portions on the surface which are cooler than the remaining areas). The number of these spots grows or declines in a cyclic fashion which, on an average takes place after every 11 years. This phenomenon leads to a change in the solar constant which in turn affects the climate, thereby causing the weather patterns to change.

- **Greenhouse Effect Theory-**

The greenhouse effect is set forth/caused by the presence of GHGs in the atmosphere. These gases have a peculiar quality of absorbing the terrestrial heat released by the Earth, thereby preventing it from entering into the ice age. The fact that, on an average the global temperatures remain around 15°C, is due to the presence of GHGs in the lower atmosphere. The issue of climate change arises when there is a drastic rise in these gases. This leads to heavy concentration of heat energy, which gets trapped between the earth's surface and the lower troposphere. This heat energy does not find any outlet to outer space therefore, it becomes the reason for high temperatures, altering of weather patterns, melting of glaciers, rise in the sea level, submergence of low-lying areas, droughts and floods etc. According to the heat budget, the earth receives heat energy from the sun during the day, which warms up the surface and after the sun sets, this energy is balanced by an equal amount of outgoing long wave infrared terrestrial radiation. This heat energy is supposed to escape into the space but the GHGs do not allow that to happen. Thus the problem of global warming arises, causing the entire planet to heat up.

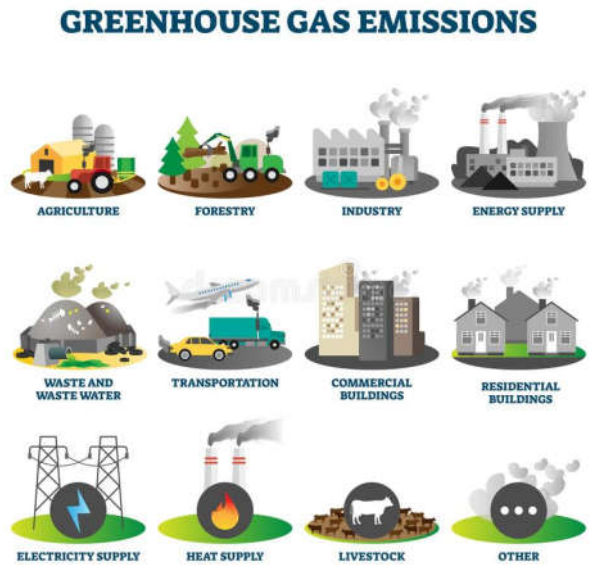

Fig. 2.4: Human Induced Causes of Global Warming

2.5 CONSEQUENCES OF GLOBAL WARMING

2.5.1 Factors suggesting climate change:

It is not difficult to assess that the impact of climate change has already started, and it can be clearly noticed if we pay attention to our surroundings. These impacts may become very serious in the near future if the human race allows these changes to go unnoticed. Following are a few factors which are suggestive of climate change and particularly global warming:-

a. Temperate areas are facing cases of diseases like- malaria, chikungunya, dengue, yellow fever, Egyptian fever etc. which are generally found in the tropical areas. These diseases are caused by insects, viruses or bacteria which can easily thrive in the hot/humid climates but not in the cold climates.

b. Severe Heat Waves in the Northern Plains belt of the Indian Subcontinent. Here the temperature has started rising above the 45 degree mark during the peak of summer season, thus creating survival problems for the flora, fauna and humans alike.

c. Shift in the rainfall patterns, there is an abnormal change in the monsoon that strikes India, wherein it has become more unpredictable. The arrival and departure of monsoon winds has seemingly changed.

d. Shorter winters- India has of late started experiencing shorter winter months which means that the number of cold days has reduced and the summers have become longer, suggesting the obvious impact of global warming.

e. In 2021, Delhi witnessed heavy rainfall in the autumn month of October. This kind of a downpour in Delhi was very unusual. This indicates that the weather patterns are getting altered.

f. The last 30-40 years have seen a prominent decline (almost 40%) in the numbers of Antarctic Penguins.

g. Coral bleaching and widespread destruction of corals has been seen in the oceans due to rise in the temperature of the ocean waters. Around 27% of the global coral reefs have been destroyed due to global warming.

h. Alaska and Siberia are known for their severe cold type of climate and permafrost. But the melting of ice in these regions, testifies that global warming is real.

i. In the opinion of Fredrick Njau, an activist in the Kenyan Green Belt Movement, there has been large scale deforestation in and around Mt. Kilimanjaro and Mt. Kenya. Both these peaks have lost considerable amounts of ice due to snow melt, i.e. 82% and 92% respectively.

2.5.2 Consequences of Global Warming on Natural Systems:

These have been enlisted below-

a. Rise in the level of the sea/ocean water all over the world, leading to the submergence of the low lying and coastal areas under sea water.

b. Northward shift of the ITCZ (Inter Tropical Convergence Zone)

c. Significant upsurge in the frequency and intensity of the stormy weather and tropical cyclones. These cyclones generally form in the Bay of Bengal and Arabian Sea and make a landfall on the eastern and Western coast of India respectively.

d. Alteration in the observed patterns of rainfall and snowfall throughout the Indian subcontinent and other parts of the world as well. Monsoon winds begin their onset early over the Indian landmass and recede later than their expected retreat. The previous three years have clearly exemplified this phenomena. The Indian Institute of Tropical Meteorology (IITM) has pointed out that the number of rainy days during the monsoon season may decrease in future whereas, the intensity and amount of rainfall received over a short duration may increase i.e. the incidence of torrential downpour is likely.

e. Intensification of the process of desertification wherein, the area under deserts will expand in the near future. This can be seen in case of widening of the Thar Desert towards its neighboring areas and also in the case of the Sahara Desert in Africa.

f. Drying up of wells and other sources of underground water. Besides this, visible drop in the soil moisture content thereby affecting the vegetation and crop growth. Severely affected are those areas of India which receive negligible amount of rainfall like Bundelkhand, Baghelkhand, Kalahandi, Marathwada etc. Parts of India which are dependent on well irrigation and well water consumption will start facing a tough time if this drying up continues.

g. It is predicted that the natural reserves and national parks will also undergo unprecedented changes if global warming continues at the current rate.

h. Corals that survive in the oceans are undergoing bleaching, deterioration and slow death. This may become intensified if the current levels of global warming continue to persist.

Note: A report released by IPCC with the title- 'Climate Change 2021: The Physical Science Basis' has clearly pointed towards a conspicuous rise in the temperatures and intensity and frequency of heat stress, humidity conditions especially over South Asia in the 21st century.

In the event of 1.5 to 2.0 degree C rise in the global temperatures, the temperature of the Indian Ocean is likely to increase by 1.0^{o} to 2.0^{o} C.

The IPCC has also indicated that glacial retreat in the Hindu Kush Himalayas, compounding effects of sea-level rise and intense tropical cyclones leading to flooding, an erratic monsoon, and intense heat stress are inevitable if the warming continues. India has recently suffered a spate of flooding and landslide disasters in high mountains of Uttarakhand and Himachal Pradesh. A glacier breach on February 7 in Uttarakhand triggered flash floods in the Rishiganga and Dhauliganga valleys, sweeping away the Rishiganga hydel project and National Thermal Power Corporation's Tapovan Vishnugad project. The disaster is feared to have killed over 200 people. (Hindustan Times, 2021)

2.5.3 Consequences of Global Warming on Anthropogenic Activities:

The rate of global warming is growing at an alarming rate, which is much higher than the estimated rate put forth by the climatologists. At this rate it is understood that there could be a temperature rise of more than 3.5^{o} C on earth in the 21st century. These temperature changes will be accompanied by vagaries/fluctuation in rainfall which in turn will lead to flood and drought situation and even India will bear the brunt of this eventuality. The only logical and viable mechanism to curb the warming scenario would be that humans start making conscious and widespread efforts in this regard.

The consequences can be listed as under-

a. Visible changes in the cropping patterns and yields. Due to global warming, there can be changes in the growing and harvesting seasons of various crops like oats, wheat, barley, beet-root etc. The farming and cultivable lands may shift further northward due to higher temperatures there.

b. Acidification of soil- (change in the pH balance) due to less water supply heavy dependence on chemical fertilizers to meet the growing demand for food.

c. Negative impact on international trade.

d. Impact on water demand and supply due to changes in rainfall pattern and drying up of oasis and diminishing of mountain springs. The underground water may become polluted due to high levels of industrialization and also limited due to over use as well as high levels of urbanization, construction of metaled roads, railway tracks, airports, runways, buildings etc. causing runoff rather than infiltration of water to underground sources.

e. Forestry and lumbering activities are also predicted to see a change, since the forests will shift towards the interior of the continents. Water and food shortages will directly impact the human populations especially in the tropical countries and diseases like malaria, chikungunya, dengue, several deficiencies, malnutrition etc. will predominate in the countries of higher latitudes as well.

f. Acid Rain- this is a phenomenon where the chemicals released from the industries/ factories, kilns, fossil fuel combustion, forest fires, oil refining, metal smelting and automobile exhaust fumes spread in the atmosphere and interact with water content and other atmospheric gases. During this interaction and reaction, sulphates, nitrites, sulphuric and nitric acid and other dangerous pollutants are formed. These then spread and are carried upward into the atmosphere by currents of air and wind. During cloud formation and rain showers, these pollutants mix with the falling drops of water and strike the ground as acid rain. This type of rain is thoroughly detrimental to the health of the farmlands, soil, vegetation, forests, standing crops, surface and underground water sources as well as buildings, concrete structures, monuments of national heritage etc. this type of rain is more pronounced in North America, Europe, Japan, China and Southeast Asia, incurring huge national losses.

g. Destruction and depletion of the ozone layer (O_3) - this layer is naturally formed in the stratosphere by the action of the sun rays when they hit the oxygen molecules present there. It is a slow process but the ozone layer is known to renew itself if the damage is less. But in case of ozone holes which are created in this layer the repair mechanism is extremely slow. This destruction happens when the chlorine from the CFCs interact with oxygen present in the chemical structure of ozone and destabilizes the structure. This destabilized structure is incapable of absorbing the harmful UV radiation of the sun and this in turn causes skin problems, irritation, cataracts and harmful chronic diseases in humans and animals alike. Moreover certain types of crops and plankton are also damaged due to excess of UV rays. The influx of so much solar radiation which makes its way towards the earth causes the increase in the level of heat received thus accelerating the warming.

Note: The leaves of the trees in the forests are deeply and negatively impacted by acid rain because, the polluted rain drops carve out holes when they fall on the waxy coating of the leaves. These look like dead brown spots, which interfere with the process of photosynthesis of the plant. This makes the trees more vulnerable to conditions of drought, cold and insect infestation. The Fir and Spruce trees which grow at higher elevations are at a greater risk of the damaging effect of acid rain.

The water in the lakes ponds reservoirs etc. becomes acidic when acid rain falls in them. This destroys the aquatic ecosystem. Due to this, fishing activities can be hampered and making the aquatic life sick, increasing the chemical load in the water as well as in the bodies of the fish and other organisms. The consumption of such fish will cause diseases in the humans as well.

Industrial compounds and chemicals such as bromine, halocarbons and nitrous oxides from fertilizers are also potent enough to destroy the ozone layer, even though the release of CFCs has been restricted or banned in several countries.

Solution:

-Manufacturing and using Battery operated vehicles

-Reducing the dependence on fossil fuels

-Conducting Research and development on eco-friendly fuels (bio-fuels)

-Reduction of the overall carbon footprint, especially for industries/factories

-Earning of carbon credits

-Paying more attention to the catalysts of forest fires and subsequently eliminating them

-Introducing eco-friendly technology for homes, offices, commercial and manufacturing sector

-Increasing dependence on renewable resources for energy generation

-Reclamation of wastelands and practicing agriculture, agro-forestry or forestry related activities will serve as a wonderful alternative to mitigate climate change as this will improve the vegetation cover, help retaining the soil moisture, keep the soil bound together and prevent soil erosion, improve the oxygen level, reduce the carbon-di-oxide level, enhance the food chain and food web of that area by attracting birds which will feed on pests/insects, increase groundwater recharge rate, generate employment, and promote environment friendly living standards.

2.6 EXERCISES

a) Fill Ups.

1. _____ is a greenhouse gas but also helps in plant photosynthesis.

2. CFCs are responsible for the destruction of the _____ layer.

3. _____ trees are at a higher risk of damage from acid rain.

4. Acidification means change in the _____ of the soil.

5. The theory of sea floor spreading was put forth by _____.

b) Multiple Choice Questions (MCQs).

1. India signed the Montreal Protocol on:

a. 19.6.1990

b. 19.6.1991

c. 19.6.1992

d. 19.6.1993

2. One of these is not a greenhouse gas. Identify.

a. Water vapor

b. Ozone

c. Carbon-di-oxide

d. Argon

3. One of these is not an ozone depleting substance. Identify.

a. Neon

b. Methyl Bromide

c. Carbon-tetra-chloride

d. Methyl Chloroform

4. The sun spots grows or declines in a cyclic fashion which repeats after every-

a. 10 years

b. 11 years

c. 12 years

d. None of the above

5. The Paris Climate Agreement is also known as:

a. COP 20

b. COP 21

c. COP 22

d. COP 23

2.6.1 Answers to Exercises:

a) Fill ups.

1. Carbon-di-oxide

2. Ozone

3. Spruce/Fir

4. pH balance

5. H.H. Hess

b) MCQs

1. 19.6.1992

2. Argon

3. Neon

4. 11 years

5. COP 21

2.6.2 Task: Long Answer Questions

Try to attempt the questions given below.

a) Explain the meaning of the term Global Warming and discuss the causes that lead to the intensification of this phenomenon

b) How is the Paris Climate Agreement significant from the Climate change point of view? Also throw some light on the consequences of global warming with special reference to the natural systems. State a few examples from India.

2.7 SUMMARY

After gaining a thorough understanding of this unit, the students will now become fluent with the concepts that have been systematically elaborated under the various headings of this study material and will be able to reflect upon the meaning, causes and consequences of Global warming. Besides this, they will learn the imperativeness of their role in the society as responsible citizens of the country and the immediate requirement of reduction of the sources and causes that promote climate change and subsequently accelerate the warming. They will also get an insight into the various natural and man induced warming scenarios while getting to learn about the various summits and agreements held from time to time in different countries of the world, so as to mitigate the warming processes, their significance and relevance. The factors that suggest climate change and warming effects as mentioned in the text will surely enlighten the students about the fact that this eventuality is real and if not taken care of or handled judiciously will lead to deleterious outcomes for all living entities both existing on land as well as water, in the near future, thus disrupting ecosystems on a large scale.

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3

ISSUES AND MEASURES RELATED TO CLIMATE CHANGE

Unit Structure :

3.1 INITIATIVES AT GLOBAL LEVEL

This section of the chapter deals with various issues of global climate change and also global level initiatives to combat with the climate change.

3.1.1 Issues of Global climate change

For many, a warming climatic system is expected to impact the availability of basic necessities like freshwater, food security, and energy, while efforts to redress climate change, both through adaptation and mitigation, will similarly inform and shape the global development agenda. The links between climate change and sustainable development

are strong. Poor and developing countries, particularly least developed countries, will be among those most adversely affected and least able to cope with the anticipated shocks to their social, economic and natural systems.

The international political response to climate change began at the Rio Earth Summit in 1992, where the 'Rio Convention' included the adoption of the UN Framework on Climate Change (UNFCCC). This convention set out a framework for action aimed at stabilizing atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system." The UNFCCC which entered into force on 21 March 1994, now has a near-universal membership of 197 parties. In December 2015, the 21st Session of the Conference of the Parties (COP21/CMP1) convened in Paris, France, and adopted the Paris Agreement, a universal agreement which aims to keep a global temperature rise for this century well below 2 degrees Celsius, with the goal of driving efforts to limit the temperature rise to 1.5 degrees Celsius above pre-industrial levels.

In the 2030 Agenda for Sustainable Development, Member States express their commitment to protect the planet from degradation and take urgent action on climate change. The Agenda also identifies, in its paragraph 14, climate change as "one of the greatest challenges of our time" and worries about "its adverse impacts undermine the ability of all countries to achieve sustainable development. Increases in global temperature, sea level rise, ocean acidification and other climate change impacts are seriously affecting coastal areas and low-lying coastal countries, including many least developed countries and Small Island Developing States. The survival of many societies, and of the biological support systems of the planet, is at risk".

Sustainable Development Goal 13 aims to "take urgent action to combat climate change and its impact", while acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

More specifically, the associated targets of SDG 13 focus on the integration of climate change measures into national policies, the improvement of education, awareness-raising and institutional capacity on climate change mitigation, adaptation, impact reduction and early warnings. SDG 13's alphabetical targets also call for the implementation of the commitment undertaken at the UNFCCC and for the promotion of mechanisms able to increase capacity for effective climate –change related planning and management in least developed countries and Small Island Developing States.

The outcome document of the Rio+20 Conference, the Future We Want, underscores climate change as "an inevitable and urgent global challenge with long-term implications for the sustainable development of all countries". Through the document, Member States express their concern

about the continuous rising of emissions of greenhouse gases and the vulnerability of all countries, particularly developing countries, to the adverse impacts of climate change. Given these concerns, Member States have called for the widest cooperation and participation of all countries in an effective and appropriate international response to climate change.

3.1.2 Global Climate Change initiatives

Following are some of the important International Climate Change Initiatives:

- U.S. Department of State - Office of Global Climate Change
- United Nations Framework Convention on Climate Change (UNFCCC)
- The Paris Agreement (Accord de Paris)
- UNFCCC Background and Timeline of Significant Events
- International Carbon Action Partnership (ICAP)
- Intergovernmental Panel On Climate Change (IPCC)
- ICLEI - Local Governments for Sustainability
- New England Governors and Eastern Canadian Premiers (NEG-ECP)
- 2017 Update of the Regional Climate Change Action Plan: Building on Solid Foundations
- AR6 Synthesis Report (SYR)

U.S. Department of State - Office of Global Climate Change

The Office of Global Change is responsible for implementing and managing U.S. international policy on climate change. It represents the U.S. in negotiations under the United Nations Framework Convention on Climate Change, and several other international climate change forums.

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC commits signatories' governments to reduce atmospheric concentrations of greenhouse gases (GHGs) with the goal of preventing dangerous anthropogenic interference with Earth's climate system. There are over 190 parties to this treaty, including the U.S.

The Paris Agreement (Accord de Paris)

Adopted by consensus in December 2015, the Paris Agreement is an agreement within the UNFCCC that deals with GHG emissions mitigation, adaptation and finance beginning in 2020. It aims to respond to the global climate change threat by keeping a global temperature rise well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

The Paris Agreement is a **legally binding international treaty on climate change**. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016.

Its goal is to **limit global warming** to well below 2, **preferably to 1.5 degrees Celsius**, compared to pre-industrial levels.

To achieve this long-term temperature goal, countries aim to **reach global peaking of greenhouse gas emissions as soon as possible** to achieve a climate neutral world by mid-century.

The Paris Agreement is **a landmark** in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.

How does the Paris Agreement work?

Implementation of the Paris Agreement requires **economic and social transformation**, based on the best available science. The Paris Agreement works on a **5- year cycle** of increasingly ambitious climate action carried out by countries. By 2020, countries submit their plans for climate action known as **nationally determined contributions (NDCs)**.

In their NDCs, countries communicate actions they will take to **reduce their Greenhouse Gas emissions** in order to reach the goals of the Paris Agreement. Countries also communicate in the NDCs actions they will take to **build resilience to adapt** to the impacts of rising temperatures.

Long-Term Strategies

To better frame the efforts towards the long-term goal, the Paris Agreement invites countries to formulate and submit by 2020 **long-term low greenhouse gas emission development strategies** (LT-LEDS).

LT-LEDS provide the **long-term horizon to the NDCs**. Unlike NDCs, they are not mandatory. Nevertheless, they place the NDCs into the context of countries' long-term planning and development priorities, providing a vision and direction for future development.

The Paris Agreement provides a framework for **financial, technical and capacity building support** to those countries who need it.

The Paris Agreement reaffirms that developed countries should take the lead in **providing financial assistance** to countries that are less endowed and more vulnerable, while for the first time also encouraging voluntary contributions by other Parties. Climate finance is needed **for mitigation**, because large-scale investments are required to significantly reduce emissions. Climate finance is equally important **for adaptation**, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate.

The Paris Agreement speaks of the vision of **fully realizing technology development and transfer** for both improving resilience to climate change and reducing GHG emissions. It establishes **a technology framework** to provide overarching guidance to the well-functioning

Technology Mechanism. The mechanism is accelerating technology development and transfer through it's policy and implementation arms.

Not all developing countries have sufficient capacities to deal with many of the challenges brought by climate change. As a result, the Paris Agreement places **great emphasis on climate-related capacity-building** for developing countries and requests all developed countries to enhance support for capacity-building actions in developing countries.

With the Paris Agreement, countries established an **enhanced transparency framework (ETF)**. Under ETF, starting in 2024, countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures and support provided or received. It also provides for international procedures for the review of the submitted reports.

The information gathered through the ETF will feed into the **Global stocktake** which will assess the collective progress towards the long-term climate goals.

This will lead to recommendations for countries to set more ambitious plans in the next round.

Although climate change action needs to be massively increased to achieve the goals of the Paris Agreement, the years since its entry into force have already sparked **low-carbon solutions and new markets**. More and more countries, regions, cities and companies are establishing **carbon neutrality targets. Zero-carbon solutions** are becoming competitive across economic sectors representing 25% of emissions. This trend is most noticeable in the **power and transport sectors** and has created many new business opportunities for early movers.**By 2030, zero-carbon solutions** could be competitive in sectors representing over **70% of global emissions**.

UNFCCC Background and Timeline of Significant Events

This resource provides helpful information on international climate change negotiations to date.

International Carbon Action Partnership (ICAP)

Founded in 2007, ICAP functions as a multilateral forum of governments and public authorities focusing exclusively on cap and trade systems for GHG mitigation, to share best practices and discuss emission trading scheme design elements. It aims to contribute to the global effort to create a global carbon market. ICAP includes members from the European Union Emission Trading Scheme, **Western Climate Initiative**, **Regional Greenhouse Gas Initiative**, Australia, New Zealand, Norway, and the Tokyo Metropolitan Government.

Intergovernmental Panel On Climate Change (IPCC)

Established in 1988, the IPCC is the premier international scientific body for climate change reporting. Working under the United Nations, the IPCC is made up of thousands of scientists that publish assessment reports on a regular basis.

ICLEI - Local Governments for Sustainability

ICLEI originally stood for International Council for Local Environmental Initiatives. In 2003, the organization dropped the full phrase to become "ICLEI - Local Governments for Sustainability." Established in 1990, this global network promotes local action for global sustainability and supports cities in becoming "sustainable, low-carbon, resilient, ecomobile, biodiverse, resource-efficient and productive, healthy and happy, with a green economy and smart infrastructure." Its membership includes more than 1,500 cities, towns and regions in more than 86 countries.

New England Governors and Eastern Canadian Premiers (NEG-ECP)

The 11 member jurisdictions of NEG-ECP are the six New England states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont, and the five eastern Canadian provinces of Quebec, Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador. The member jurisdictions meet annually in a collaborative effort to tackle climate change and to present a long-term vision on the issue.

2017 Update of the Regional Climate Change Action Plan: Building on Solid Foundations

The 2017 Update presents achievements since the NEG-ECP's adoption of regional Climate Change Action Plan in 2001, outlines a framework of possible joint actions to reduce regional GHG emissions, and highlights the need for regional collaboration on adaptation to climate change.

3.2 ROLE OF GLOBAL PLAYERS IPCC, UNFCCC KYOTO PROTOCOL

3.2.1 IPCC

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for assessment of climate change. It is a key source of scientific information and technical guidance to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and Paris Agreement. The IPCC provides governments at all levels with scientific information they can use to develop climate policies.

The IPCC is an organisation of governments that are members of the United Nations or the World Meteorological Organization (WMO). The IPCC currently has 195 members.

IPCC's main activities are to prepare:

- comprehensive assessment reports on climate change, its causes, impacts and response options
- methodology reports, which provide practical guidance to Parties to help them prepare national greenhouse gas inventories
- special reports on topics that inform the assessment reports.

The IPCC does not undertake new research but synthesises published and peer-reviewed literature to develop a comprehensive assessment of scientific understanding, published in IPCC assessment reports.

The IPCC's work is guided by a set of principles and procedures that govern all the main activities of the organisation. IPCC member governments and observer organisations nominate experts and the IPCC Bureau selects authors and editors with expertise in a range of scientific, technical and socio-economic fields. IPCC reports are the product of multiple drafting and review processes to promote an objective, comprehensive and transparent assessment of current knowledge.

Assessment Reports consist of contributions from each Working Group and a Synthesis Report integrating these contributions and any Special Reports prepared in that assessment cycle. The IPCC also produces Special Reports on specific issues agreed by its member governments and Methodology Reports that provide practical guidelines for the preparation of greenhouse gas inventories. Each IPCC report starts with a scoping meeting to develop a draft outline. Experts nominated by member governments, Observer Organizations and the Bureau and selected by the relevant Bureau prepare a draft outline of the report for the Panel. Based on the report of the scoping meeting, the Panel decides whether work should continue on preparing the report and agrees on its scope, outline and work plan including schedule and budget. Member governments, Observer Organizations and the Bureau (Co-Chairs and Vice-Chairs) of the Working Group or Task Force producing the report then draw up lists of experts, from which the relevant Bureau or Bureaux select the authors of the report. The Bureau may consider other experts known through their publications and work. Scientists who are nominated but not selected as authorsare invited to register as expert reviewers for the report. The selection of authors is a careful process that aims to reflect the range of scientific, technical and socio-economic expertise and to strike a good balance in terms of gender, geographical representation, and representation of experts from developing countries, developed countries and those with economies in transition. It is also important to have a mixture of authors with and without previous experience in the IPCC.

AR6 Synthesis Report (SYR)

The IPCC is currently in its Sixth Assessment cycle, during which the IPCC will produce the Assessment reports of its three Working Groups, three Special Reports, a refinement to the methodology report and the

Synthesis Report. The Synthesis Report will be the last of the AR6 products, due for release in late 2022 or early 2023.

According to IPCC procedures the Synthesis Report (SYR) should "synthesise and integrate materials contained within the Assessment Reports and Special Reports" and "should be written in a non-technical style suitable for policymakers and address a broad range of policy-relevant but policy-neutral questions approved by the Panel". It is composed of two parts, a Summary for Policymakers (SPM) of 5 to 10 pages and a Longer Report of 30 to 50 pages.

The AR6 SYR is based on the content of the three Working Groups Assessment Reports: WGI – The Physical Science Basis, WGII – Impacts, Adaptation and Vulnerability, WGIII – Mitigation of Climate Change, and the three Special Reports: Global Warming of 1.5°C, Climate Change and Land, The Ocean and Cryosphere in a Changing Climate.

Synthesis Report Outline

The SYR outline agreed at the 52nd Panel Session of the IPCC consists of an introduction and three main sections arranged by timeframes.

The first section, 'Current Status and Trends', covers the historical and present period. The second section, 'Long-term Climate and Development Futures', addresses projected futures up to 2100 and beyond. The final section is 'Near-term Responses in a Changing Climate', considers current international policy timeframes, and the time interval between now and 2030-2040.

This structure, substantially different to what was adopted for AR5 SYR, enables a holistic framing that integrates across the Working Groups, better enabling the SYR to cover different aspects of climate change.

3.2.2 UNFCC Kyoto protocol

The UNFCCC entered into force on 21 March 1994. Today, it has near-universal membership. The 197 countries that have ratified the Convention are called Parties to the Convention. Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC. The Convention:

Recognized that there was a problem.

This was remarkable for its time. Remember, in 1994, when the UNFCCC took effect, there was less scientific evidence than there is now. The UNFCCC borrowed a very important line from one of the most successful multilateral environmental treaties in history (the Montreal Protocol, in 1987): it bound member states to act in the interests of human safety even in the face of scientific uncertainty.

Related reading: Science

Sets a lofty but specific goal.

The ultimate objective of the Convention is to stabilize greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." It states that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."How do we know what is "dangerous anthropogenic interference"?

The idea is that, as they are the source of most past and current greenhouse gas emissions, industrialized countries are expected to do the most to cut emissions on home ground. They are called Annex I countries and belong to the Organization for Economic Cooperation and Development (OECD). They include 12 countries with "economies in transition" from Central and Eastern Europe. Annex I countries were expected by the year 2000 to reduce emissions to 1990 levels. Many of them have taken strong action to do so, and some have already succeeded.

Industrialized nations agree under the Convention to support climate change activities in developing countries by providing financial support for action on climate change-- above and beyond any financial assistance they already provide to these countries. A system of grants and loans has been set up through the Convention and is managed by the Global Environment Facility. Industrialized countries also agree to share technology with less-advanced nations.

Keeps tabs on the problem and what's being done about it.

- Industrialized countries (Annex I) have to report regularly on their climate change policies and measures, including issues governed by the Kyoto Protocol (for countries which have ratified it).
- They must also submit an annual inventory of their greenhouse gas emissions, including data for their base year (1990)and all the years since.
- Developing countries (Non-Annex I Parties) report in more general terms on their actions both to address climate change and to adapt to its impacts - but less regularly than Annex I Parties do, and their reporting is contingent on their getting funding for the preparation of the reports, particularly in the case of the Least Developed Countries.

Charts the beginnings of a path to strike a delicate balance.

Economic development is particularly vital to the world's poorer countries. Such progress is difficult to achieve even without the complications added by climate change. The Convention takes this into consideration by accepting that the share of greenhouse gas emissions produced by developing nations will grow in the coming years. Nonetheless, in the interests of fulfilling its ultimate goal, it seeks to help such countries limit emissions in ways that will not hinder their economic progress. One such

win-win solution was to emerge later, when the Kyoto Protocol to the Convention was conceived.

Kicks off formal consideration of adaptation to climate change.

The Convention acknowledges the vulnerability of all countries to the effects of climate change and calls for special efforts to ease the consequences, especially in developing countries which lack the resources to do so on their own. In the early years of the Convention, adaptation received less attention than mitigation, as Parties wanted more certainty on impacts of and vulnerability to climate change. When IPCC's Third Assessment Report was released, adaptation gained traction, and Parties agreed on a process to address adverse effects and to establish funding arrangements for adaptation. Currently, work on adaptation takes place under different Convention bodies. The Adaptation Committee, which Parties agreed to set up under the Cancun Adaptation Framework as part of the Cancun Agreements, is a major step towards a cohesive, Convention-based approach to adaptation.

Related reading: Adaptation

UNFCCC and the Rio Convention

The UNFCCC is a “Rio Convention”, one of two opened for signature at the “Rio Earth Summit” in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to boost cooperation among the three Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern.

3.3 CARBON CREDITS DEFINITION, CARBON MARKETS, CLEAN DEVELOPMENT MECHANISM

3.3.1 Background

It is universally accepted fact that carbon is one of the most important green housegas contributing to global warming and subsequently climate change since last few decades. Hence the world has now realised that we need to reduce carbo emission to maximum possible extent so that further damage to the natural environment can be reduced. The need for global policy towards climate change and related natural disasters was felt to be most important for combating with global climate change and related issues. Carbon bank and carbon credits are two of the important concepts in this context.

3.3.2 Carbon credits

A carbon credit is a tradable permit or certificate that provides the holder of the credit the right to emit one ton of carbon dioxide or an equivalent of another greenhouse gas – it’s essentially an offset for producers of such gases. The main goal for the creation of carbon credits is the reduction of

emissions of carbon dioxide and other greenhouse gases from industrial activities to reduce the effects of global warming.

Carbon credits are market mechanisms for the minimization of greenhouse gases emission. Governments or regulatory authorities set the caps on greenhouse gas emissions. For some companies, the immediate reduction of the emission is not economically viable. Therefore, they can purchase carbon credits to comply with the emission cap.

Companies that achieve the carbon offsets (reducing the emissions of greenhouse gases) are usually rewarded with additional carbon credits. The sale of credit surpluses may be used to subsidize future projects for the reduction of emissions.

The introduction of such credits was ratified in the Kyoto Protocol. The Paris Agreement validates the application of carbon credits and sets the provisions for the further facilitation of the carbon credits markets.

Types of Carbon Credits

There are two types of credits:

- **Voluntary emissions reduction (VER):** A carbon offset that is exchanged in the over-the-counter or voluntary market for credits.
- **Certified emissions reduction (CER):** Emission units (or credits) created through a regulatory framework with the purpose of offsetting a project's emissions. The main difference between the two is that there is a third-party certifying body that regulates the CER as opposed to the VER.

Trading Credits

Carbon credits can be traded on both private and public markets. Current rules of trading allow the international transfer of credits.The prices of credits are primarily driven by the levels of supply and demand in the markets. Due to the differences in the supply and demand in different countries, the prices of the credits fluctuate.

Although carbon credits are beneficial to society, it is not easy for an average investor to start using them as investment vehicles. The certified emissions reductions (CERs) are the only product that can be used as investments in the credits. However, CERs are sold by special carbon funds established by large financial institutions. The carbon funds provide small investors with the opportunity to enter the market.

There are special exchanges that specialize in the trading of the credits, including the European Climate Exchange, the NASDAQ OMX Commodities Europe exchange, and the European Energy Exchange.

3.3.3 Carbon market

As the first meetings of the contact groups got under way today, UNFCCC Executive Secretary, Yvo de Boer, spoke of "a good mood in the air " and said the meetings were "going well."

The work of the special group on the future, which began yesterday and continued today, is generating "a huge amount of interest, " he said. Brazil (on behalf of the G77), China, the United States, Japan and the European Union have all come forward with suggestions on what the Bali roadmap should look like and what needs to be included in a long-term climate change policy. He described the fact that many countries have come prepared with their own proposals on how the process should move forward as "encouraging."

On the recurring subject of emissions targets, Mr. de Boer emphasized that "what is clear to everyone is that industrialized countries must continue to take the lead and must reduce their emissions by 25-40% by 2020. That is the agreed range for industrialized countries."

He explained that in order to reach these ambitious targets, it is important in future negotiations to focus on the toolbox required to forge international cooperation and create the necessary market mechanisms. The Kyoto Protocol, by putting a price on carbon, has created a "unique environmental commodity on the international market," he said. The Protocol has developed three innovative mechanisms which give Parties a certain degree of flexibility in meeting their emission reduction targets.

Emissions trading - known as the carbon market - is "truly global and growing," he said, amounting to 30 billion USD in 2006 and expected to be much higher this year. The International Transaction Log (ITL), the computer trading system which allows Parties to trade emission reduction rights among each other, was launched recently by the UNFCCC Secretariat, thereby rendering the market internationally operational from a technical point of view.

The Clean Development Mechanism (CDM) and Joint Implementation (JI) are the two project-based mechanisms of the Kyoto Protocol. All three mechanisms, said Mr. de Boer, play an important role in the international response to climate change by stimulating investments in innovative technology and encouraging public-private partnerships in efforts to achieve clean energy growth in developing countries.

Of particular interest to developing countries are the ongoing discussions on technology transfer. Mr. de Boer explained that he was encouraged to see not only governments, but also the private sector engaging in the technology debate and offering solutions on the way forward. He referred to a new publication by the World Business Council for Sustainable Development (WBCSD) which discusses technological solutions for a clean future and the action governments need to take to enable the private sector "to go that extra green mile."

In connection with the recent reports by the Intergovernmental Panel on Climate change (IPCC), which have been crucial in setting the scene for this conference, Mr. de Boer mentioned a suggestion that the IPCC should be asked to update these reports in 2009, coinciding with the time negotiations on the future are expected to be completed.

Mr. de Boer described information received earlier from Washington that the US Senate and Environment and Public Works Committee had approved America's Climate Security Act setting mandatory cuts on power plants, industry and transportation as "encouraging news."

3.3.4 Clean Development Mechanism

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

The mechanism is seen by many as a trailblazer. It is the first global, environmental investment and credit scheme of its kind, providing a standardized emissions offset instrument, CERs.A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers.The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

Operating details of the CDM

A CDM project must provide emission reductions that are additional to what would otherwise have occurred. The projects must qualify through a rigorous and public registration and issuance process. Approval is given by the Designated National Authorities. Public funding for CDM project activities must not result in the diversion of official development assistance.

The mechanism is overseen by the CDM Executive Board, answerable ultimately to the countries that have ratified the Kyoto Protocol.

Operational since the beginning of 2006, the mechanism has already registered more than 1,650 projects and is anticipated to produce CERs amounting to more than 2.9 billion tonnes of CO2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012.

3.4 CARBON FOOTPRINT METHODS OF CALCULATING AND REDUCTION

3.4.1 Concept of carbon footprint

A carbon footprint corresponds to the whole amount of **greenhouse gases (GHG)** produced to, directly and indirectly, support a person's lifestyle and activities. Carbon footprints are usually measured in equivalent tons of CO2, during the period of a year, and they can be associated with an individual, an organization, a product or an event, among others.

The GHGs whose sum results in a carbon footprint can come from the production and consumption of fossil fuels, food, manufactured goods, materials, roads or transportation. And despite its importance, carbon footprints are difficult to calculate exactly due to poor knowledge and short data regarding the complex interactions between contributing processes – including the influence of natural processes that store or release carbon dioxide.

According to WHO, a carbon footprint is a measure of the impact your activities have on the amount of carbon dioxide (CO2) produced through the burning of fossil fuels and is expressed as a weight of CO2 emissions produced in tonnes.

Carbon footprint, amount of carbon dioxide (CO_2) emissions associated with all the activities of a person or other entity (e.g., building, corporation, country, etc.). It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, the carbon footprint concept also often includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs).

3.4.2 Methods of Calculating carbon footprints

Carbon footprints are different from a country's reported per capita emissions (for example, those reported under the United Nations Framework Convention on Climate Change). Rather than the greenhouse gas emissions associated with production, carbon footprints focus on the greenhouse gas emissions associated with consumption. They include the emissions associated with goods that are imported into a country but are produced elsewhere and generally take into account emissions associated with international transport and shipping, which is not accounted for in standard national inventories. As a result, a country's carbon footprint can increase even as carbon emissions within its borders decrease.

The per capita carbon footprint is highest in the United States. According to the Carbon Dioxide Information Analysis Center and the United Nations Development Programme, in 2004 the average resident of the United States had a per capita carbon footprint of 20.6 metric tons (22.7 short tons) of CO_2 equivalent, some five to seven times the global average.

Averages vary greatly around the world, with higher footprints generally found in residents of developed countries. For example, that same year France had a per capita carbon footprint of 6.0 metric tons (6.6 short tons), whereas Brazil and Tanzania had carbon footprints of 1.8 metric tons (about 2 short tons) and 0.1 metric ton (0.1 short ton) of CO_2 equivalent, respectively.

In developed countries, transportation and household energy use make up the largest component of an individual's carbon footprint. For example, approximately 40 percent of total emissions in the United States during the first decade of the 21st century were from those sources. Such emissions are included as part of an individual's "primary" carbon footprint, representing the emissions over which an individual has direct control. The remainder of an individual's carbon footprint is called the "secondary" carbon footprint, representing carbon emissions associated with the consumption of goods and services. The secondary footprint includes carbon emissions emitted by food production. It can be used to account for diets that contain higher proportions of meat, which requires a greater amount of energy and nutrients to produce than vegetables and grains, and foods that have been transported long distances. The manufacturing and transportation of consumer goods are additional contributors to the secondary carbon footprint. For example, the carbon footprint of a bottle of water includes the CO_2 or CO_2 equivalent emitted during the manufacture of the bottle itself plus the amount emitted during the transportation of the bottle to the consumer.

A variety of different tools exist for calculating the carbon footprints for individuals, businesses, and other organizations. Commonly used methodologies for calculating organizational carbon footprints include the Greenhouse Gas Protocol, from the World Resources Institute and the World Business Council for Sustainable Development, and ISO 14064, a standard developed by the International Organization for Standardization dealing specifically with greenhouse gas emissions. Several organizations, such as the U.S. Environmental Protection Agency, the Nature Conservancy, and British Petroleum, created carbon calculators on the Internet for individuals. Such calculators allow people to compare their own estimated carbon footprints with the national and world averages.

Measurement of Carbon Footprint

The carbon footprint is a very important means to understand the impact of a person's behavior on **global warming**. This is why someone who effectively wants to contribute to stopping global warming, at least on an individual scale, needs to measure and keep track of their personal carbon footprint.

And here is where online calculators come in. For instance, by using the carbon footprint calculators from **WWF**, **TerraPass** (includes calculator for companies and events) or the **UN** you'll be asked to provide pieces of information such as: how you commute to work, what your usual diet is,

how much you drive or fly, the size of your household, or what type of electricity the grid provides you.

The result you'll get won't be perfect or very much accurate – and there are several reasons why. First, because carbon footprint calculators use standard values that aren't always right for a multiple of possible situations. For instance, when you type how many miles you drive on average, a certain reference value for the CO2/emissions/mile will be multiplied by your miles and then by 12 months. However, both numbers are estimations: sometimes you drive more than you actually told the calculator, and perhaps you drive a 4×4 truck and not an SUV as the calculator is expecting.

The same can happen for how much impact your diet has: eating meat is on average very carbon polluting, but it also depends on where you buy it (if it's local it has fewer emissions from transportation) or how caws are fed. Another reason is also that these estimations usually forget (because it's very hard to find numbers) to account for goods and services purchased.

In the end, the truth is that an exact number is hard to find. Still, these calculators are the best there is and there's no excuse for not getting your carbon footprint and working on how to improve it.

3.4.3 Measures to reduce carbon footprint

Individuals and corporations can take a number of steps to reduce their carbon footprints and thus contribute to global climate mitigation. They can purchase carbon offsets (broadly stated, an investment in a carbon-reducing activity or technology) to compensate for part or all of their carbon footprint. If they purchase enough to offset their carbon footprint, they become effectively carbon neutral.

Carbon footprints can be reduced through improving energy efficiency and changing lifestyles and purchasing habits. Switching one's energy and transportation use can have an impact on primary carbon footprints. For example, using public transportation, such as buses and trains, reduces an individual's carbon footprint when compared with driving. Individuals and corporations can reduce their respective carbon footprints by installing energy-efficient lighting, adding insulation in buildings, or using renewable energy sources to generate the electricity they require. For example, electricity generation from wind power produces no direct carbon emissions. Additional lifestyle choices that can lower an individual's secondary carbon footprint include reducing one's consumption of meat and switching one's purchasing habits to products that require fewer carbon emissions to produce and transport.

As we can tell from above, it's hard to get someone's exact carbon footprint. Besides this, in order to accurately reduce CO2 emissions, it's also important to use numbers that approximately mirror someone's local reality.

If you think about it, the calculator is likely to assume that whether you have an American SUV from brand A being driven in New Zealand or a light Japanese car from brand B driven in Japan – they both have the same emissions.

However, at least for now, estimations like these need to be made so we can get to something specific to work on. And the fact is that even though there is the chance that your car pollutes less than the average value used, or that the beef you buy is less polluting than the average: they're still great sources of CO2 emissions, which means general guidelines still apply. In this way, and in compliance with the World Health Organization suggestions, there are 5 main areas you can work on to improve your carbon footprint:

1. TRANSPORTATION – EXAMPLES OF GOOD & SUSTAINABLE BEHAVIORS

- Avoid polluting car journeys (each liter of fuel burnt in a car engine emits over 2.5 kg of CO2) and favor walking, cycling or using public transport, especially trains;
- If you are driving, share the ride with others and don't speed as it uses more petrol and therefore, emits more CO2;
- Avoid flying, the world's fastest-growing source of CO2 emissions. If you do it, consider offsetting your emissions.

2. FOOD – EXAMPLES OF GOOD & SUSTAINABLE BEHAVIORS

- Reduce the number of animal products consumed;
- Eat local and seasonal produced food: short trips mean less pollution from transportation;
- Recycle/ compost organic waste. Otherwise, methane will be released by the decomposing biodegradable waste in landfills. In the EU, these emissions account for ~3% of GHG emissions.

3. WATER USE – EXAMPLES OF GOOD & SUSTAINABLE BEHAVIORS

- Use the washing machine and dishwasher only when they are full;
- Boil only the water you will need and cover your pots while you cook: you'll save plenty of energy and the process will be faster;
- Collect the cold water from the first seconds of your shower to water your garden or plants;
- Harvest rainwater if you have access to a rooftop as an alternative to groundwater;

- Raise hand pumps to protect drinking-water from flood contamination.

4. ENERGY USE – EXAMPLES OF GOOD & SUSTAINABLE BEHAVIORS

- Be mindful of the temperature of your house: just 1ºC less reduce emissions (and your energy bill) by 5-10%;
- Turn down air-con for the cold – they are super energy expensive. Use a fan instead;
- Program your energy devices so that they're on only while you are (about to get) home;
- Improve your house's insulation so that less heat gets out when its cold and less heat comes in when it's warm, reducing the need to use other devices;
- Mind the settings you choose: maybe your fridge doesn't have to be in the coolest setting and your water cylinder thermostat doesn't have to be set higher than 50ºC;
- Unplug your cellphone's charger as it still drains electricity even when it is not connected to the cellphone;
- Switch off the lights when you don't need them and use energy-saving lights such as LED;
- Change your electricity supplier for a greener one that provides more green (renewable) energy so help low carbon energy sources are strengthened.

5. WASTE MANAGEMENT – EXAMPLES OF GOOD & SUSTAINABLE BEHAVIORS

- Refuse what you don't need, reduce what you need; reuse it as many times as you can, re-purpose if you're not using it anymore and recycle or compost it and something reaches the end of its lifecycle;
- Avoid buying new bags to transport your shopping back home by reusing your shopping bag;
- Choose products with little/no packaging: this ultimately cuts down production costs.

3.5 REFERENCES

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3.6 CHECK YOUR PROGRESS

1. Explain major issues of global climate change.
2. Discuss the Initiatives at global level to combat with global climate change.
3. Explain the initiatives of IPCC with respect to global climate chang.
4. Write a note on UNFCCC (Kyoto Protocol)
5. Elaborate the concepts; Carbon credits definition, carbon markets, Clean Development Mechanism.
6. Write a note on Clean Development Mechanism.
7. Define carbon footprint. Explain methods of calculating Carbon footprint.
8. What are the measures to reduce carbon footprint?

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4

INDIA: IMPACTS OF CLIMATE CHANGE

Unit Structure :

4.1 OBJECTIVES

By the end of this unit you will be able to derive answers to the following questions:

- What is climate change? How is anthropogenic climate change different from natural climate change?
- What are the global, regional and local impacts of climate change? What are the effects of climate change on the human societies, with reference to India?
- What is the necessity of controlling the triggers of climate change?

- What are the various measures that are being adopted by the Government of India to combat climate change and its impacts?

4.2 CLIMATE CHANGE- AN OVERVIEW

Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil, and gas), which produces heat-trapping gases.

Anthropogenic climate change is defined by the human impact on Earth's climate while natural climate change are the natural climate cycles that have been and continue to occur throughout Earth's history.

Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.

Examples of greenhouse gas emissions that are causing climate change include carbon dioxide and methane. These come from using gasoline for driving a car or coal for heating a building, for example. Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main emitters.

And emissions continue to rise. As a result, the Earth is now about 1.1°C warmer than it was in the late 1800s. The last decade (2011-2020) was the warmest on record.

Many people think climate change mainly means warmer temperatures. But temperature rise is only the beginning of the story. Because the Earth is a system, where everything is connected, changes in one area can influence changes in all others.

The consequences of climate change now include, among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.

Climate change can affect our health, ability to grow food, housing, safety and work. Some of us are already more vulnerable to climate impacts, such as people living in small island nations and other developing countries. Conditions like sea-level rise and saltwater intrusion have advanced to the point where whole communities have had to relocate, and protracted droughts are putting people at risk of famine. In the future, the number of "climate refugees" is expected to rise.

4.3 UNDERSTANDING THE IMPACTS OF CLIMATE CHANGE

Predicting the consequences of global warming is one of the most difficult tasks for the world's climate researchers. The natural processes that cause rain, hail and snow storms, increases in sea level and other expected

effects of global warming are dependent on many different factors. It is also difficult to predict the size of the emissions of greenhouse gases in the coming decades as this can be influenced by political decisions and technological advancements.

Many of the effects of global warming have been well documented and observations from real life are consistent with predictions.

What will be affected by temperature rise?

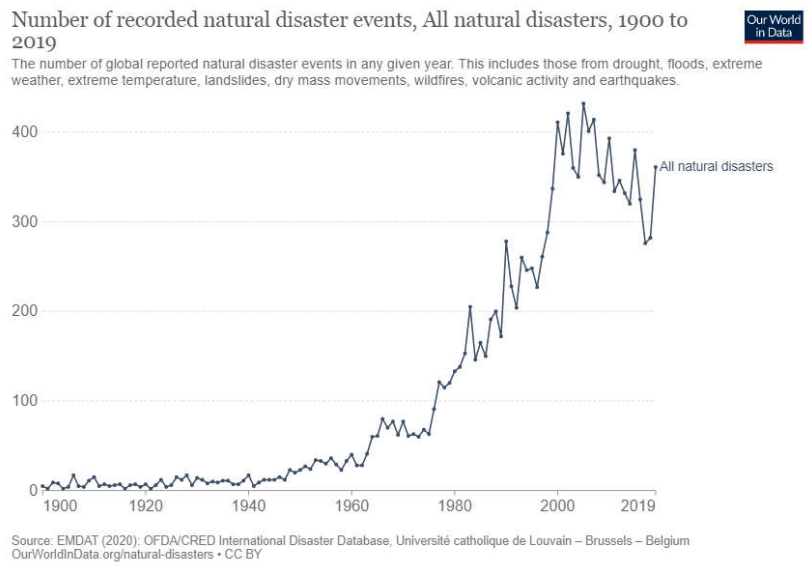
- **Agriculture**

Different crops demand different conditions to grow. Even within a country like Britain, crops such as apples grow better in some places than in others. This regional variation is often down to different local conditions, including climate. If temperatures rise, some crops may become harder to cultivate and may have to be replaced with ones more suited to the new environment

- **Frequency of Extreme Weather Events**

In the future, a warmer climate may cause more heatwaves, increase rainfall and increase the frequency and strength of storms. Over the past 35 years, there has been an almost fivefold increase in the recorded number of disasters caused by natural hazards, although not all were influenced by extreme weather events

The number of global reported disasters caused by natural hazards since 1900. This includes those from drought, floods, extreme weather, extreme temperature, landslides, dry mass movements, wildfires, volcanic activity and earthquakes. Overall, deaths from natural hazards have seen a large decline over the past century, but meteorological, hydrological and climatological events have increased since 1980. Source: Our World in Data



As the Earth warms up, interactions between the oceans and atmosphere can amplify the frequency and intensity of weather events. These include hurricanes, floods and droughts. Extra water vapour in the atmosphere falls again as extra rain, which can cause flooding. During hot weather, evaporation from both land and sea increases and can cause droughts in regions where there is low precipitation.

- **Increasing Sea Level**

Increased levels of ice and snow melt cause sea levels to rise, as does thermal expansion (water expands when warmed). Areas that lie just above sea level now, may one day become submerged. For example, some Pacific Island nations are expected to be partially or completely submerged by the end of the 21st century.

A rise in sea levels will also have an impact on coastal and shallow marine plants and animals will be affected, for example mangroves and coral reefs. In countries with large areas of coastal lowland, there will be a dual risk of river floods and coastal flooding, which will reduce the area for living and working. Coastal defences will need strengthening and river levées will require developing.

An increase in standing water may potentially increase populations of insects like mosquitoes, and therefore malaria, and other diseases that are associated with standing water, such as Lyme's disease.

- **Threats to Wildlife**

Wildlife will respond to climatic changes in different ways. Certain species might be able to adapt or migrate to habitats with more suitable conditions. Where species are unable to adapt and conditions become inhospitable, populations are likely to become threatened and, in extreme cases, species may face extinction.

In 2019, a UN Report suggested that around one million animal and plant species would be threatened with extinction, many within decades, and more than ever before in human history.

4.4 IMPACTS OF CLIMATE CHANGE ON INDIA

India will likely face irreversible impacts of climate change, with increasing heat waves, droughts and erratic rainfall events in the coming years if no mitigation measures are put in place, experts warn.

India will suffer more frequent and intense heat waves, extreme rainfall events and erratic monsoons, as well as more cyclonic activity, among other weather-related calamities, in the coming decades, a report of the Intergovernmental Panel on Climate Change (IPCC) has warned.

"Heat extremes have increased while cold extremes have decreased, and these trends will continue over the coming decades," the report said regarding the Indian subcontinent.

Experts say India, and South Asia in general, is particularly vulnerable to climate change.

"The threat of climate change is real — dangers are imminent and the future is catastrophic. This message from the IPCC report confirms what we already know and can see in the world around us," said SunitaNarain, an environmentalist and director of the Delhi-based Center for Science and Environment.

"From wildfires because of extreme heat and moisture loss to devastating floods because of extreme rain events, and tropical cyclones because of the changing temperatures between the sea and land surface, it should worry us," Narain said.

Climate change has already hit India hard, causing huge economic and social losses in recent years.

In 2021, for instance, India has witnessed severe floods, cloudbursts and landslides in several states across the country, causing death and destruction.

4.4.1 Climate Change and Indian Agriculture :

Climate and Agriculture are interrelated processes, both take place on a global scale. Global warming is projected to have significant impact on conditions of affecting agriculture, including temperature, precipitation and glacial run-off. Rising Carbon Dioxide levels would also have effects both detrimental and beneficial, on crop yields. The overall effect of Climate Change on agriculture will depend on the balance of these effects. India is a predominantly agriculture-oriented economy, as 52 per cent of the population directly depends on agriculture either as farmers or agricultural labourers, and their concentration is higher at 76 percent in the villages. Variation in climate will have a direct impact on the majority of the livelihood of the people. Food production in India is sensitive to Climate Change like variations in temperature and monsoon rainfall. Rise in temperature has a direct impact on the Rabi crop and every 10° C rise will reduce wheat production by 4 to 5 Million Tones. Every small change in temperature and rainfall has significant effect on the quality and quantity of fruits, vegetables, tea, coffee, basmati rice and aromatic and medicinal plants.

The impact of Climate Change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Climate Change can affect crop yield (both positively and negatively), as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water, amount of solar radiation that affect plant growth as well as the prevalence of pests.

Despite complex spatial differences in Climate Change, forecasts agree that in many developing countries, climate will become less suitable for agricultural practices that they now undertake because of more warm and

humid atmosphere. Stern Report 2007 by Nicholas Stern, Head of United Kingdom Government Economic Service and Advisor to the Government on the Economics of Climate Change and Development, projected that a 20C increase in average temperature would reduce world gross domestic product by roughly 1 per cent while according to World Development Report of the World Bank (2009), Climate Change will cause a decrease in annual GDP 5 per cent in India.

According to Intergovernmental Panel on Climate Change (IPCC) Report, Climate Change 2014 – Impacts, Adaptation and Vulnerability, rise of global temperature and increasing food demand would pose large risk to food security globally and regionally. It finds that even at just 10C of warming, a negative impact for major crops like wheat, rice and corn would be seen. For India and China, the prediction is that the stress on staple wheat crop would increase negatively, affecting the overall food security of the continent. Post 2030, the overall food production will decrease, but certain region could also see a small rise in food production.

IMPACT ON SOIL: The global Climate Change will have adverse effect on soil processes and properties important for restoring soil fertility and productivity. Increase in temperature, will reduce the soil carbon storage due to increased decomposition of soil organic matter by carbon dioxide emission, and ultimately leading to low water holding and nutrient supplying capacity. All these effects are highly region specific, depending on the magnitude of the Climate Change, soil properties and climate condition.

Estimated Impact of Climate Change on Crop production in South-Asia 2050s

Crops	Crop production (year 2000)	Crop as % of total Production	Projected yield improvement No. Climate Change (% p.a.)	Crop production 2050s, No Climate Change	Crop Production 2050 2050s with Climate Change and No Co2 Fertilization Effect	Average Annual yield change with Climate Change
Rice(mmt)	120	48%	0.9%	169	145	-0.2%
Wheat(mmt)	97	38%	1.6%	191	103	-1.3%
Maize(mmt)	16	6%	0.6%	19	16	0.1%
Millet(mmt)	11	4%	1.5%	12	11	0.0%
Sorghum(mmt)	8	3%	1.2%	10	8	1.4%
Total(mmt)	252			401	282	
Cereal Availability	185			174	122	

Source: World Bank Report, June 2013 'Then Down the Heat; Climate Extremes Regional Impact and the case for Resilience'

[8] Warming Climate in India to Pose Significant Risk to Agriculture, World Bank, Press Release, 19 June, 2013
[9] Climate Change : IPCC Report Warns of Looming Food Crisis, Article by Arnab Pratim Dutta, Down to Earth, 31 March, 2014

4.4.2 Climate Change and Indian Monsoons

A recent study published in Earth System Dynamics estimates that "For every degree Celsius of warming, Indian monsoon rainfalls will likely increase by about 5%". Excessive rainfall is disastrous for Indian economy as more than 50 percentage of population directly depends on agriculture.

Climate change also causes extreme variability in the spatial and timely distribution of the rainfall. Erratic monsoon pattern causes floods, droughts etc. in different places in the country.

Simply put, climate change means we will have more monsoon rain in future, but also more variability in rainfall dispersal over the monsoon period, as witnessed in 2021, and more localised extremely heavy rain in short spans of time, as seen in coastal Maharashtra, west Gujarat and Hyderabad this year.

India Meteorological Department (IMD) has carried out an analysis of observed monsoon rainfall variability and changes of 29 States & Union Territory at State and District levels based on the IMD's observational data of recent 30 years (1989- 2018) during the Southwest monsoon season from June-July-August-September (JJAS). Source: (https://mausam.imd.gov.in/)

The highlights of the report are as follows

- Five states viz., Uttar Pradesh, Bihar, West Bengal, Meghalaya and Nagaland have shown significant decreasing trends in southwest monsoon rainfall during the recent 30 years period(1989-2018).
- The annual rainfall over these five states along with the states of Arunachal Pradesh and Himachal Pradesh also show significant decreasing trends.
- Other states do not show any significant changes in southwest monsoon rainfall during the same period.
- Considering district-wise rainfall, there are many districts in the country, which show significant changes in southwest monsoon and annual rainfall during the recent 30 years period(1989-2018).
- With regard to the frequency of heavy rainfall days, significant increasing trend is observed over Saurashtra& Kutch, South-eastern parts of Rajasthan, Northern parts of Tamil Nadu, Northern parts of Andhra Pradesh and adjoining areas of Southwest Odisha, many parts of Chhattisgarh, Southwest Madhya Pradesh, West Bengal, Manipur & Mizoram, Konkan& Goa and Uttarakhand.

4.4.3 Climate Change and Indian Cities

Climate Change can be devastating for cities for a multiple of reasons.

- Extreme heat: Because of pollution and heat from buildings,cities are usually at a higher temperature than rural areas. Recent studies show that a global increase of 2 degrees can result in a temperature increase of 4-5 degrees in the cities.
- Flooding: When added to the poorly designed infrastructure, heavy rains can cause serious and life threatening floods. Examples of Mumbai –July 2005, Chiplun -2021 are fresh in the minds of people.

- Drought: Because of the higher temperature and pollution, cities are likely to get less frequent rainfall. This can lead to droughts, with long gaps between heavy spells of rains. So future cities can be severely water stressed.

- Disease Outbreaks: Increase in heat can create conditions for growth of bacteria, virus and other parasites. Frequent flooding can help mosquitoes and other insects to breed, increasing probability of disease outbreaks.

4.4.4 Climate Change and Displacement of Population- Climatic Refugees :

Governments of many tropical countries have been faced with the problem of evacuating large populations at the advent of the natural disasters like hurricanes, dust storms, flash floods which are hitting with increasing frequency, which is a clear indicator of climate change.

The term "climate refugees" was first coined to describe the increasing large-scale migration and cross-border mass movements of people that were partly caused by such weather-related disasters.

In April, the United Nations High Commissioner for Refugees (UNHCR) released data showing that the number of people displaced by climate change-related disasters since 2010 has risen to 21.5 million, pointing out that "in addition to sudden disasters, climate change is a complex cause of food and water shortages, as well as difficulties in accessing natural resources."

In 2020 in India, 3,856,000 people were displaced by environmental disasters, 989 times more than the 3,900 persons displaced by conflicts, according to data of the Internal Displacement Monitoring Centre (IDMC.)

UN reports document that India is the seventh most climate-change affected country, and major cities like Mumbai and Kolkata are at risk of drowning by 2050. Along with intensifying storms, floods are becoming common even in areas that never flooded before. Interestingly, flooding is historically a vital function in long cross-country rivers such as the Ganga and Brahmaputra. For centuries, they have flooded periodically, forming unique ecosystems and supporting their own unique biodiversity.

"Floods that seem devastating for us play a part in engineering the landscape. They maintain the grassland-woodland dynamics and maintain biodiversity of floodplains in Brahmaputra and Ganga rivers," says ecologist DrQamarQureshi, professor, Wildlife Institute of India.

The same floods needed to maintain biodiversity, when intensified through human interference and climate change, cause grave human suffering. Recently, the last two inhabited islands in the Sunderbans—Mousuni and Ghoramara—were evacuated. These islands have lost the ability to sustain human life, and most of their 34,000 evacuees left, hoping to make a new

life in mainland India after their home was hit by four cyclones in just 24 months.

4.5 INDIA'S APPROACH TO CLIMATE CHANGE-GLOBAL AND NATIONAL LEVELS

India is both a major greenhouse gas emitter and one of the most vulnerable countries in the world to projected climate change. The country is already experiencing changes in climate and the impacts of climate change, including water stress, heat waves and drought, severe storms and flooding, and associated negative consequences on health and livelihoods. With a 1.2 billion but growing population and dependence on agriculture, India probably will be severely impacted by continuing climate change. Global climate projections, given inherent uncertainties, indicate several changes in India's future climate:

• Global observations of melting glaciers suggest that climate change is well under way in the region, with glaciers receding at an average rate of 10–15 meters per year. If the rate increases, flooding is likely in river valleys fed by these glaciers, followed by diminished flows, resulting in water scarcity for drinking and irrigation.

• All models show a trend of general warming in mean annual temperature as well as decreased range of diurnal temperature and enhanced precipitation over the Indian subcontinent. A warming of 0.5° C is likely over all India by the year 2030 (approximately equal to the warming over the 20th century) and a warming of 2-4°C by the end of this century, with the maximum increase over northern India. Increased warming is likely to lead to higher levels of tropospheric ozone pollution and other air pollution in the major cities.

• Increased precipitation, including monsoonal rains, is likely to come in the form of fewer rainy days but more days of extreme rainfall events, with increasing amounts of rain in each event, leading to significant flooding. Drizzle-type precipitation that replenishes soil moisture is likely to decrease. Most global models suggest that the Indian summer monsoons will intensify. The timing may also shift, causing a drying during the late summer growing season. Climate models also predict an earlier snowmelt, which could have a significant adverse effect on agricultural production. Growing emissions of aerosols from energy production and other sources may suppress rainfall, leading to drier conditions with more dust and smoke from the burning of drier vegetation, affecting both regional and global hydrological cycles and agricultural production. Uncertainties about monsoonal changes will affect farmers' choices about which crops to plant and the timing of planting, reducing productivities. In addition, earlier seasonal snowmelt and depleting glaciers will reduce river flow needed for irrigation. The large segment of poor people (including smallholder farmers and landless agricultural workers) may be hardest hit, requiring government relief programs on a massive scale. Finally, migration, especially from Bangladesh, may strain resources and India-Bangladesh relations.

The most important impacts of climate change will likely include the following:

• Agriculture. High-input, high-output agriculture will be negatively affected even as demands for food and other agricultural products rise because of an increasing population and expectations for an improved standard of living. Millions of subsistence and smallholder farmers will experience hardship and hunger through being less able to predict climate conditions. To a certain extent, trade may compensate for these deficits.

• Water: Glacier melt may yield more runoff in the short term but less in the medium and long terms. More severe storms (especially cyclones) will cause more damage to infrastructure and livelihoods and exacerbate salt water intrusion in storm surges. Changes in the timing and amount of monsoon rains will make the production of food and other agricultural products more uncertain, so that, even in good-weather years, farmers will be more likely to make decisions leading to lower-productivity.

• Exacerbation of Inequality: The welfare of those who are affected by climate change and who have limited means to adapt may act as a force that can change governments, strain public budgets, and foster unrest. About one-third of Indians are extremely poor, and 60 percent depend upon agriculture for their livelihoods.

• Energy: As India searches for additional sources of energy to meet rising demand, climate change mitigation efforts may constrain its use of indigenous and imported coal, oil, and gas, while development of nuclear energy will be slow at best and likely to encounter opposition. Other non-emitting technologies will require technology transfer and capacity-building.

• Migration: India receives immigrants from a number of countries. Under climate change conditions, it may be flooded with many more, particularly from Bangladesh. Such migration may exacerbate tension between the two countries as well as putting a strain on Indian central and state governments. Adaptive capacity in India varies by state, geographical region, and socioeconomic status. Studies point to influential factors such as water availability, food security, human and social capital, and the ability of government (state and national levels) to buffer its people during tough times. Where adaptive capacity is low, the potential is greater for impacts to result in displaced people; deaths and damage from heat, floods, and storms; and conflicts over natural resources and assets.

The Ministry of Earth Sciences (MoES), Government of India has recently published a Climate Change report entitled "Assessment of Climate Change over the Indian Region" which covers all the aspects of regional climate change including the climatic extremes across India. The preparation of this report was led by the Center for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM) Pune.

The report from the MoESis the first of its kind where a comprehensive discussion has been made regarding the impact of human-induced global climate change on the regional climate and monsoon of the Indian subcontinent, adjoining Indian Ocean and the Himalayas. Based on the available climate records, the report documents that, the surface air temperature over India has risen by about 0.7 °C during 1901–2018 which is accompanied with an increase in atmospheric moisture content. The sea surface temperatures in the tropical Indian Ocean have also increased by about 1 °C during 1951–2015. Clear signatures of human-induced changes in climate have emerged over the Indian region on account of anthropogenic greenhouse gases and aerosol forcing, and changes in land use and land cover which have contributed to an increase in the climatic extremes. The complex interactions between the earth system components amidst the warming environment and regional anthropogenic influences have therefore led to a rise in frequency of localized heavy rainfall events, drought and flood occurrences, and increase in the intensity of tropical cyclones etc. in the last few decades. Also, recent studies by Indian Scientists reveal that the trends in sea level rise are estimated to be 1.3mm/year along the Indian coasts during the last 40-50years.

4.6 GOVERNMENT INITIATIVES TO TAKE CLIMATE CHANGE

Climate change is one of the most critical global challenges of our times. Recent events have emphatically demonstrated our growing vulnerability to climate change. Climate change impacts will range from affecting agriculture – further endangering food security – to sea-level rise and the accelerated erosion of coastal zones, increasing intensity of natural disasters, species extinction, and the spread of vector-borne diseases.India released its much-awaited National Action Plan on Climate Change (NAPCC) to mitigate and adapt to climate change on June 30, 2008, almost a year after it was announced.

4.6.1 National Action Plan on Climate Change (NAPCC) :

The action plan outlines a number of steps to simultaneously advance India's development and climate change-related objectives. The National Action Plan on Climate Change (NAPCC) encompasses a range of measures. It focuses on eight missions, which are as follows:

1. National Solar Mission: The NAPCC aims to promote the development and use of solar energy for power generation and other uses, with the ultimate objective of making solar competitive with fossil-based energy options. It also includes the establishment of a solar research center, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, and increased government funding and international support.

2. National Mission for Enhanced Energy Efficiency: The NAPCC recommends mandating specific energy consumption decreases in large energy-consuming industries, with a system for companies to

trade energy-saving certificates, financing for public–private partnerships to reduce energy consumption through demand-side management programs in the municipal, buildings, and agricultural sectors, and energy incentives, including reduced taxes on energy-efficient appliances.

3. National Mission on Sustainable Habitat: The NAPCC also aims at promoting energy efficiency as a core component of urban planning by extending the existing Energy Conservation Building Code, strengthening the enforcement of automotive fuel economy standards, and using pricing measures to encourage the purchase of efficient vehicles and incentives for the use of public transportation. The NAPCC also emphasizes on waste management and recycling.

4. National Water Mission: The NAPCC sets a goal of a 20% improvement in water use efficiency through pricing and other measures to deal with water scarcity as a result of climate change.

5. National Mission for Sustaining the Himalayan Ecosystem: This particular mission sets the goal to prevent melting of the Himalayan glaciers and to protect biodiversity in the Himalayan region.

6. Green India Mission: The NAPCC also aims at afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23 to 33% of India's territory.

7. National Mission for Sustainable Agriculture: The NAPCC aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.

8. National Mission on Strategic Knowledge for Climate Change: To gain a better understanding of climate science, impacts, and challenges, the plan envisions a new Climate Science Research Fund, improved climate modeling, and increased international collaboration. It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

The NAPCC also describes other ongoing initiatives that are as follows:

1. Power generation: The government is mandating the retirement of inefficient coal-fired power plants and supporting the research and development of Integrated Gasification Combined Cycle IGCC and supercritical technologies.

2. Renewable energy: Under the Electricity Act 2003 and the National Tariff Policy 2006, the central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources.

3. Energy efficiency: Under the Energy Conservation Act 2001, large energy-consuming industries are required to undertake energy audits and an energy-labeling program for appliances has been introduced.

4. Proposals for health sector: The proposed program comprises two main components, namely provision of enhanced public health care services and assessment of increased burden of diseases due to climate change.

5. Implementation: Ministries with lead responsibility for each of the missions are directed to develop objectives, implementation strategies, timelines, and monitoring and evaluation criteria to be submitted to the Prime Minister's Council on Climate Change. The Council will also be responsible for periodically reviewing and reporting on each mission's progress. To be able to quantify progress, appropriate indicators and methodologies will be developed to assess both avoided emissions and adaptation benefits.

WWF-India feels that the National Action Plan is fairly comprehensive in its coverage and has cross-sectoral links through the eight National Level Missions. At the center stage of the Action Plan is India's impetus on following up on a low carbon energy path without impending economic growth and quality of life of people. WWF-India feels that the Plan brings a balanced perspective on mitigation and adaptation through some new dimensions. Creation of National Mission on Strategic Knowledge for Climate Change is another good initiative as this would ensure exchange of knowledge and informed research in India.

It is now clear that initiatives to prevent climate change are started but, most importantly, these initiatives must be continuous and sustainable and every individual of every country will need to contribute to prevent climate change. By releasing the NAPCC, the government has shown India's commitment to address climate change issues and also sent a positive message to the public, industries, and civil society about the government's concern to address the climate change issue through concerted action. Issues related to the awareness regarding global warming and climate change among the general population and the issue related to agriculture and health hazards due to climate change must be addressed strongly and effectively.

4.7 PUBLIC PARTICIPATION TO MITIGATE CLIMATE CHANGE

Public awareness initiatives seek to enhance general understanding, impact attitudes and help people make climate friendly choices. Popular media, such as television, radio, and print, together with social media, are among the most important means of communication and outreach. This entails spreading information about the causes and effects of climate change, and the practical and creative solutions that are urgently needed.

While public awareness strategies are grounded on efforts to share information as widely as possible, they also enable diverse voices to contribute to global and local discussions.

Public awareness is a core element of Article 6 of the Rio Declaration developed in 1992 at the United Nations Conference on Environment and Development (UNCED) because it has the power to create critical mass engagement for one of the greatest challenges that we face.

Public participation under Action for Climate Empowerment

Public participation recognizes that everyone has something important to say and gives everyone a voice. Almost half a century ago, scientists and technical experts dominated national and global discussions on environmental change. Today, the role of people, particularly a progressive private sector and civil society, contributes to a diversity of voices that are fresh, vocal and innovative.

Public participation is about long-term collaboration among different groups, as much as it is about the quality of how and the extent to which citizens partner with local and national governments to craftpolicies.

At its core, public participation is one of the key resources in implementing the vision of Article 6 of the Convention. It can transform society by giving people a voice and showing how their individual action can make a difference.

Public access to information under Action for Climate Empowerment

Closely related to building public awareness are many actions that ensure climate information remains transparent and accessible. Public access to information is not just about the dissemination of knowledge. It brings into question wider community-based structures and societal forces that shape how knowledge travels within multiple sectors, and across local, national, regional and international communities.

Public access to information encompasses the feedback loops and mechanisms that connect decision-makers, practitioners, and those directly impacted by the adverse impacts of climate change to share their understanding and experience.

More recently, the power of compelling stories and positive messaging have coloured local and international public communication strategies. Beyond the old “gloom and doom” narratives, collaborative action-oriented strategies have changed how climate change is discussed, not just in policymaking, but in everyday life. Vibrant youth and indigenous movements are taking the lead in sharing their own experience and wisdom in increasingly visible ways.

There are five ways in which the Public participation can be effectively used.

1. Deliberative events: Conferences, seminars and other academic events where deliberations are carried out between the academicians, policy makers and other stakeholders are important to create awareness of the problems and probable solutions.

2. Participatory Budgeting: As has been observed in all the studies regarding Climate Change, is that the problem is global but the impacts are seen on a local scale. Hence the solutions also have to be locally adopted. The local governing bodies should involve the local support groups and citizens awareness groups in the budgeting of the climate change combat programmes.

3. Constructive Dialogue: Public Participation can be achieved by establishing a constructive dialogue with the citizens. Most of the issues arise out of lack of awareness and a lethargic indifference to the environmental problems. Majority of the people struggle with 'How am I alone responsible?' and 'What difference, I alone can make?' type of questions. A constructive dialogue can help establish a confidence that their participation can and does make a difference.

4. Citizen Science: This involves empowering the people into believing that their voice makes a difference. Children and young adults are more attracted to the scientific approach of combating climate change and their participation can be increased by using awareness programmes.

5. Social innovation and local action: Encouraging people to innovate and bring ideas of combating climate change and its effects will increase public participation. An excellent example in India is of Ramon Magsaysay Award winning engineer SonamWangchukwho invented the ice stupa, which is an artificial glacier and helps in addressing the water shortage in the region of Ladakh.

4.8 SUMMARY

- Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil, and gas), which produces heat-trapping gases.
- Anthropogenic climate change is defined by the human impact on Earth's climate while natural climate change are the natural climate cycles that have been and continue to occur throughout Earth's history.
- Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.
- Examples of greenhouse gas emissions that are causing climate change include carbon dioxide and methane. These come from using gasoline for driving a car or coal for heating a building, for example. Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main emitters.
- The consequences of climate change now include, among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.
- What will be affected by temperature rise?
- Agriculture

- Frequency of Extreme Weather Events
- Increasing Sea Level
- Threats to Wildlife
- India will likely face irreversible impacts of climate change, with increasing heat waves, droughts and erratic rainfall events in the coming years if no mitigation measures are put in place, experts warn.
- India will suffer more frequent and intense heat waves, extreme rainfall events and erratic monsoons, as well as more cyclonic activity, among other weather-related calamities, in the coming decades, a report of the Intergovernmental Panel on Climate Change (IPCC) has warned.
- Climate change has already hit India hard, causing huge economic and social losses in recent years.
- In 2021, for instance, India has witnessed severe floods, cloudbursts and landslides in several states across the country, causing death and destruction.
- The most important impacts of climate change will likely include the following:
- Agriculture. High-input, high-output agriculture will be negatively affected even as demands for food and other agricultural products rise because of an increasing population and expectations for an improved standard of living. Millions of subsistence and smallholder farmers will experience hardship and hunger through being less able to predict climate conditions. To a certain extent, trade may compensate for these deficits.
- Water: Glacier melt may yield more runoff in the short term but less in the medium and long terms. More severe storms (especially cyclones) will cause more damage to infrastructure and livelihoods and exacerbate salt water intrusion in storm surges. Changes in the timing and amount of monsoon rains will make the production of food and other agricultural products more uncertain, so that, even in good-weather years, farmers will be more likely to make decisions leading to lower-productivity.
- Exacerbation of Inequality: The welfare of those who are affected by climate change and who have limited means to adapt may act as a force that can change governments, strain public budgets, and foster unrest. About one-third of Indians are extremely poor, and 60 percent depend upon agriculture for their livelihoods.
- Energy: As India searches for additional sources of energy to meet rising demand, climate change mitigation efforts may constrain its use of indigenous and imported coal, oil, and gas, while development of nuclear energy will be slow at best and likely to encounter opposition. Other non-emitting technologies will require technology transfer and capacity-building.
- Migration: India receives immigrants from a number of countries. Under climate change conditions, it may be flooded with many more, particularly from Bangladesh. Such migration may exacerbate tension between the two countries as well as putting a strain on Indian central

and state governments. Adaptive capacity in India varies by state, geographical region, and socioeconomic status. Studies point to influential factors such as water availability, food security, human and social capital, and the ability of government (state and national levels) to buffer its people during tough times. Where adaptive capacity is low, the potential is greater for impacts to result in displaced people; deaths and damage from heat, floods, and storms; and conflicts over natural resources and assets.

- Climate change is one of the most critical global challenges of our times. Recent events have emphatically demonstrated our growing vulnerability to climate change. Climate change impacts will range from affecting agriculture – further endangering food security – to sea-level rise and the accelerated erosion of coastal zones, increasing intensity of natural disasters, species extinction, and the spread of vector-borne diseases.India released its much-awaited National Action Plan on Climate Change (NAPCC) to mitigate and adapt to climate change on June 30, 2008, almost a year after it was announced.
- The action plan outlines a number of steps to simultaneously advance India's development and climate change-related objectives. The National Action Plan on Climate Change (NAPCC) encompasses a range of measures.
- Public awareness is a core element of Article 6 of the Rio Declaration developed in 1992 at the United Nations Conference on Environment and Development (UNCED) because it has the power to create critical mass engagement for one of the greatest challenges that we face.
- Public participation recognizes that everyone has something important to say and gives everyone a voice. Almost half a century ago, scientists and technical experts dominated national and global discussions on environmental change. Today, the role of people, particularly a progressive private sector and civil society, contributes to a diversity of voices that are fresh, vocal and innovative.

4.9 CHECK YOUR PROGRESS/EXERCISE

4.9.1 Choose the most appropriate alternative and complete the following sentences. (1 mark)

1. Climate change refers to long-term shifts in_____.

A. wind systems

B. temperatures and weather patterns

C. ocean currents

D. air pressure

2. Burning fossil fuels generates _____that act like a blanket wrapped around the Earth, trapping the sun’s heat and raising temperatures.

A. energy

B. heat

C. greenhouse gas emissions

D. light

3. Examples of greenhouse gas emissions that are causing climate change include carbon dioxide and_____.

A. methane B. hydrogen

C. argon D. helium

4. Climate change can affect our _____.

A. health B. ability to grow food

C. housing, safety and work D. all of the above

5.Over the past 35 years, there has been an almost fivefold increase in the recorded number of disasters caused by_____.

A. volcanoes B. earthquakes

C. landslides D. natural hazards

6. As the Earth warms up, interactions between the oceans and atmosphere can amplify the frequency and intensity of weather events. These include_____.

A. hurricanes B. droughts

C. floods D. all of the above

7. India is a predominantly agriculture-oriented economy, as _____of the population directly depends on agriculture either as farmers or agricultural labourers.

A. 70 per cent B. 52 per cent

C. 75 per cent D. 80 per cent

8._____, will reduce the soil carbon storage due to increased decomposition of soil organic matter by carbon dioxide emission, and ultimately leading to low water holding and nutrient supplying capacity.

A. Increase in Rainfall B. Decrease in Rainfall

C. Increase in temperature D. Decrease in temperature

9. Climate change also causes extreme variability in the _____of the rainfall.

A. frequency B. spatial and timely distribution

C. schedule D. intensity

10. Because of pollution and heat from buildings, cities are usually at a _____temperature than rural areas.

A. higher B. lower

C. different D. similar

11.Recent studies show that a global increase of 2 degrees can result in a temperature increase of _____in the cities.

A. 4-5 degrees B. 5-6 degrees

C. 6-7 degrees D. 7-8 degrees

12.The term _____ was first coined to describe the increasing large-scale migration and cross-border mass movements of people that were partly caused by such weather-related disasters.

A. displaced people B. immigrants

C. "climate refugees" D. illegal migrants

13.Recently, the last two inhabited islands in the Sunderbans—Mousuni and Ghoramara—were evacuated_____.

A. due to earthquakes B. due to water shortage

C. due to landslides D. due to flooding

14.Global observations of melting glaciers suggest that climate change is well under way in the region, with glaciers receding at an average rate of _____.

A. 1–5 meters per year B. 10–15 meters per year

C. 5–10 meters per year D. 15–20 meters per year

15.Under climate change conditions, India may be flooded with many more migrants, particularly from_____.

A. Nepal B. Pakistan

C. Sri Lanka D. Bangladesh

16. Recent studies by Indian Scientists reveal that the trends in sea level rise are estimated to be _____ along the Indian coasts during the last 40-50years.

A. 1.3mm/year B. 1.5 mm/year

C. 2 mm/ year D. 2.5 mm/year

17. The National Action Plan on Climate Change has _____ missions.

A. six B. seven

C. eight D. nine

18.The NAPCC aims to support climate adaptation in agriculture through _____.

A. development of climate-resilient crops B. expansion of weather insurance mechanisms

C. agricultural practices D. all of the above

19. Public awareness is a core element of _____-of the Rio Declaration developed in 1992 at the United Nations Conference on Environment and Development (UNCED) because it has the power to create critical mass engagement for one of the greatest challenges that we face.

A. Article 4 B. Article 5

C. Article 6 D. Article 7

20.Ramon Magsaysay Award winning engineer SonamWangchuk invented the_____, which is an artificial glacier and helps in addressing the water shortage in the region of Ladakh.

A. thermal tent B. self-powered mill

C. ice stupa D. water mill

Answers : 1-B, 2- C, 3- A, 4- D, 5-D, 6- D, 7-B, 8-C, 9-B, 10- A,

11- A, 12- C, 13-D, 14-B, 15-D, 16-A, 17-C, 18-D, 19-C, 20-C

4.9.2. Write brief notes on the following (15 marks each)

1. Climate Change- an overview
2. Climate Change and Indian agriculture
3. Climate Change and public displacement in India
4. India's approach to global climate change
5. National Action Plan on Climate Change
6. Public participation in combating climate change

4.10 TASKS

1. Carry out a survey in your locality about the awareness of climate change and its impact. Prepare a survey report.

2. Organise/ Participate in a seminar or discussion on climate change. Make a list of the solutions that can be easily implemented by common people.

3. Adopt the solutions in your life and spread the awareness.

4.11 REFERENCES FOR FURTHER STUDY

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