

## 5. Global Climate Change



### Can you tell?

The graph in fig. 5.1. shows the difference between the global average temperature of the twentieth century and global monthly temperatures from 1985 to 2015. Answer the questions given below :

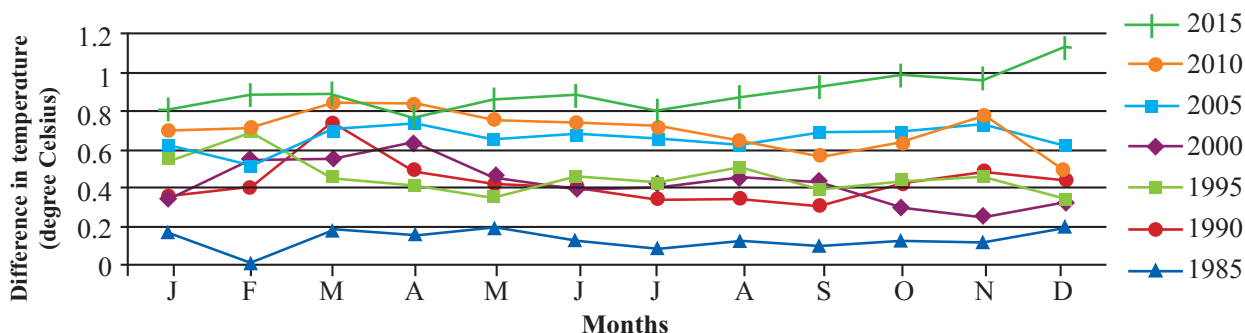


Fig. 5.1

- 1) In which year is the difference the least?
- 2) What is the difference between the mean temperatures of the twentieth century and temperature in 2015?
- 3) Why do the temperatures differ in different months?

### Geographical explanation

We see that the differences in 2015 are above the rest of the given years. This shows that the average temperature of the Earth is rising. Scientists around the world have collected more than a century's temperature records. These analyses all point to a rise of close to  $0.8^{\circ}\text{C}$  in the average surface air temperature of the Earth over the last century.



### Do you know?

How do scientists calculate the average earth temperature?

To get a complete picture of Earth's temperature, scientists combine measurements from the air above land and the ocean surface collected by ships, buoys and sometimes satellites, too.

The temperature at each land and ocean station is compared daily to find out what is 'normal' for that location and time, typically the long-term average over a 30-year period. The differences are called 'anomalies' and they help scientists to evaluate how temperature is changing over time. A 'positive' anomaly means the temperature is warmer than the long-term average; a 'negative' anomaly means its cooler. Daily anomalies are averaged together over a whole month. These are, in turn, used to work out temperature anomalies from season-to-season and year-to-year.

Let us have a look at the surface temperatures of a few planets in the following table.

Planet	Average Surface Temperature ( $^{\circ}\text{C}$ )
Venus	456.85
Mars	-87 to -5
Mercury	467
Earth	14

This table shows that the Earth's surface temperature makes it suitable for life to exist.

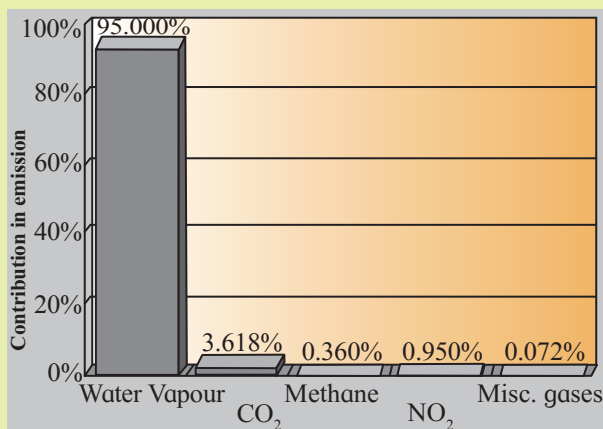


### Try this.

Look at the following graph. Answer the following question.

- 1) Which of these gases has the highest contribution?
- 2) Which of these gases come from natural and man-made sources?
- 3) Which activities are responsible for their emission?
- 4) Out of these, whose emission can be controlled by humans?

#### Global Greenhouse Gas Emissions



#### Geographical explanation

The average temperature on the surface of the Earth depends on a number of factors. These include the time of day, the time of year, and where the temperatures measurements are being taken.

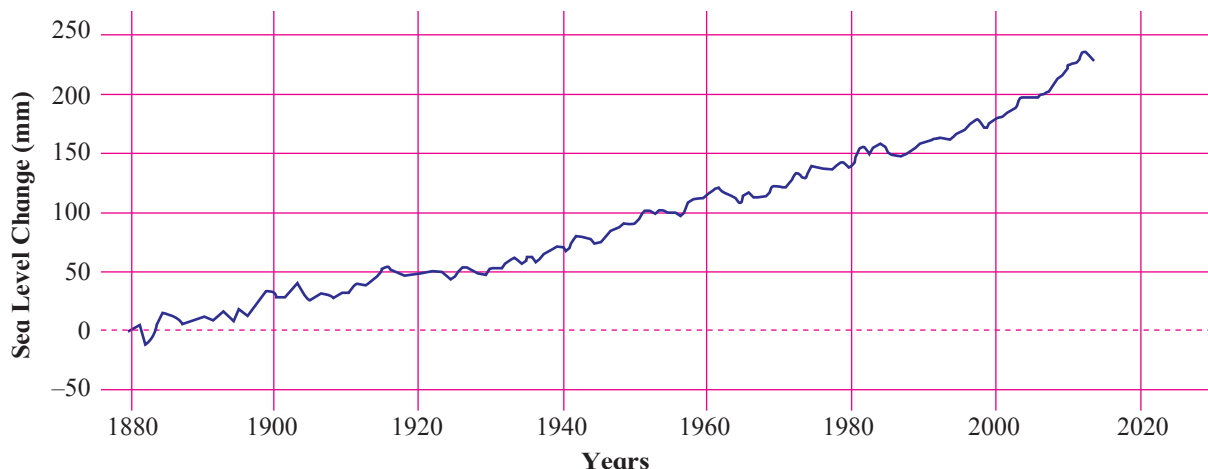


Fig. 5.2

The average temperature of the Earth is around 14°C. As given in the earlier graph, this average temperature has increased by 0.8° C. The average surface temperature of the earth is increasing and is likely to increase. It has been found that the impact of gases such as carbon dioxide, methane, etc. has been enormous. It has led to increase in the heat holding capacity of the atmosphere which in turn increases the temperature. This phenomenon is called global warming.

#### Is this small rise a big concern?

It may sound like a 0.8° C is not such a big number, but the impact of this rise appears to be phenomenal.

#### Let's look at the effects of global warming.

- 1) **Heat Waves :** Increases in heat holding capacity of the atmosphere increases the temperature especially during summers. Summers can become even more intense or even deadlier and could bring hot spells. Heat waves of Chicago (1995) and Paris (2003) led to deaths of hundreds of people.
- 2) **Heat Islands :** Global warming serves as a base from which heat waves become much worse – especially in big cities where the heat island effect comes into play. Urban areas heat up more readily because of paved surfaces and concrete constructions

as compared to a field or forest areas. This phenomenon may further increase the temperature of the earth.

**3) Increase in sea level :** Look at the graph in fig. 5.2 and answer the following questions:

- i) What does the graph show?
- ii) In which year is the change around 225 mm?
- iii) What conclusions can you draw by seeing the graph?
- iv) What correlation can be seen in this graph and the graph of rising temperatures?

#### Geographical explanation

The graph shows increase in global sea level from 1880 till present. With continued global warming, sea levels are likely to rise. Global sea level has been rising over the past century. As seen in the graph, global sea level is around 50 mm more than that in 1990s. Sea level continues to rise at a rate of about 3 mm/per year. This global sea level rise is apparently being caused because of increased melting of ice such as glaciers and ice sheets.

Higher sea levels may lead to deadlier cyclones and also frequent flooding of coastal areas. Many islands are also at risk of getting submerged. It also means loss of habitat for fishes, birds and plants.

In India too, sea levels are changing at different rates along the coast as per the studies carried out by the Indian National Centre for Ocean Information Services. It projects sea level rise by 9 to 90 cm between 1990 and 2100. This may result in saline coastal groundwater endangered wetlands and flooding of cities and coastal communities around Kutch in Gujarat, Mumbai parts of Konkan coast and southern Kerala. The deltas of the Ganga, Krishna, Godavari, Kaveri and Mahanadi on the East coast are threatened too.



#### Do you know?

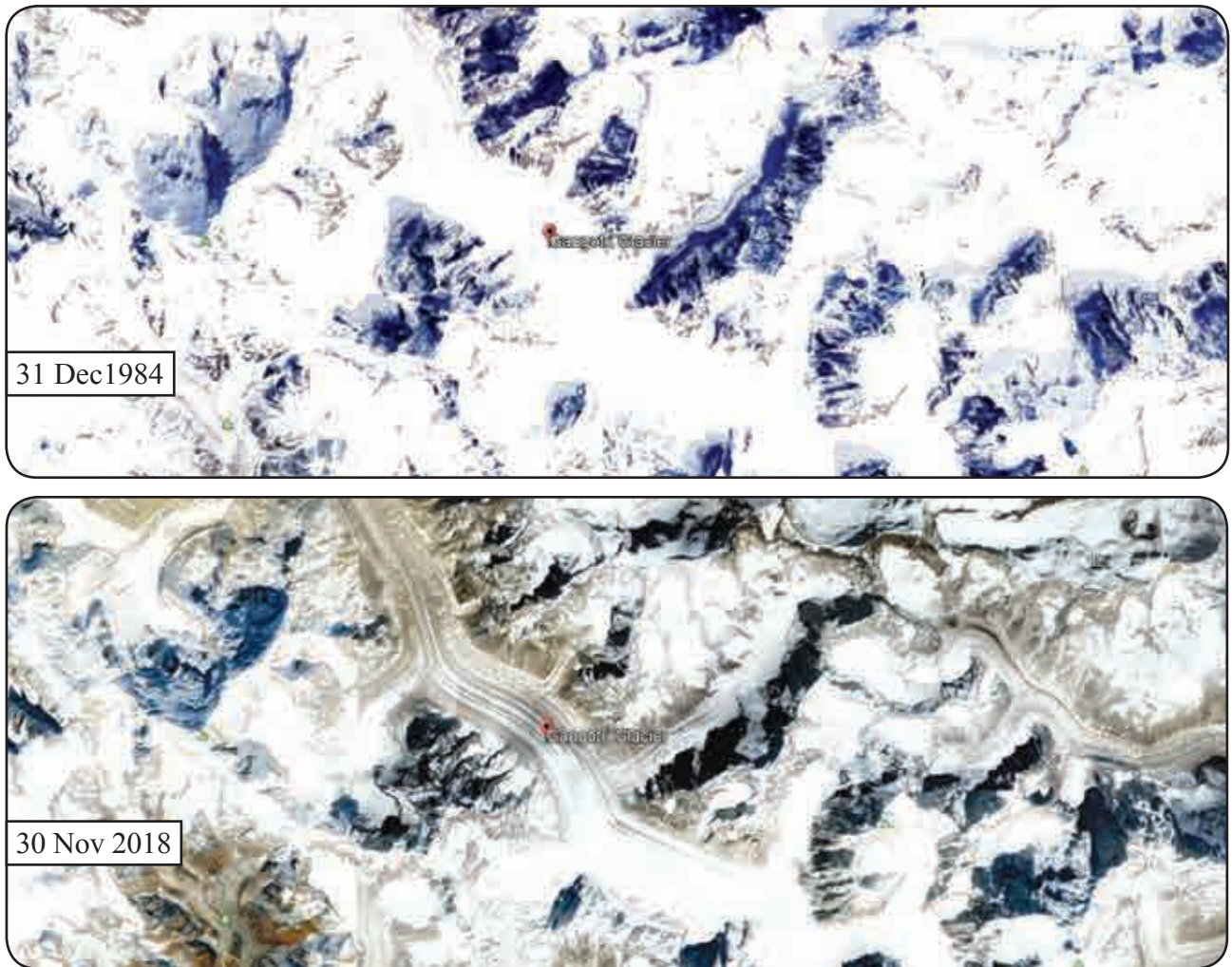
What is the difference between global and local sea level? These are two different measurements. Sea level rise at specific locations may be more or less than the global average due to local factors like subsidence of land, flood control in upper part of the river, regional ocean currents, etc.

Sea level is measured using tidal data from stations with the help of satellite and laser altimeters around the world. Tide stations tell about local levels. Satellite data provides us with average height of the whole ocean. Together, both of these help us to know how our ocean levels are changing over time.

**4) Melting of glaciers at high altitudes and snow in polar areas :**

Melting of ice is a very natural process. But when glaciers and icebergs melt at an alarming rate, it is a cause of concern. Evident impacts of global warming are retreating glaciers. Studies using satellite data from 1989 till present show that glaciers have retreated. See fig 5.3 A and B. The satellite images show the Gangotri Glacier, situated in the Uttarkashi District of Garhwal Himalayas. Compare these images. Gangotri glacier is one of the largest in the Himalayas. Over the last 25 years, Gangotri glacier has retreated more than 850 meters, with a recession of 76 meters from 1996 to 1999 alone. You can notice the change in between the years 1984 and 2018. This is an indicator of glacial retreat. This means that there is lesser ice formation each year than its rate of melting. This retreat is around 22 m per year.

Many scientists regard receding glaciers as a symptom of global climate change. Similar observations have also been made



**Fig. 5.3 A) and B) Deglacification of Gangotri**

in the glaciers near Mt. Kilimanjaro in Africa. In general glaciers in polar areas have also been reported to have melting at faster rates. Similarly, glaciers all across the Alps are retreating and disappearing every year.

**5) Other effects :** Because the earth is warming up, some other indirect effects are also seen. Some of them are as follows:

- i) Around the world the jellyfish seem to be reproducing heavily and congregating in places where they were never seen before. This is happening because of warmer waters and changes in the acidity level of the oceans.
- ii) Spread of insects in newer regions : Global warming will apparently increase the number

of mosquitoes. Adult mosquitoes prefer higher temperatures and wet conditions to breed. In areas where temperatures are now rising higher than averages, mosquitoes are thriving and diseases like dengue are spreading.

- iii) Coral reefs : When temperatures change, corals throw out the algae living in their tissues. These algae are responsible for their colour. An increase of  $1^{\circ}$ -  $2^{\circ}$  C in ocean temperatures for a long time can lead to bleaching, turning corals white. If corals are bleached for prolonged periods, they eventually die. Coral bleaching leads to death of large amounts of corals. More than one-fifth of the coral reefs are already lost.





### Find out !

Use internet and reference books on climate change and make a list of species vulnerable due to climate change.

### Climate Change :



### Try this.

Talk to the elders in your family or those around you. Ask them what difference do they feel today than what they felt in their childhood while experiencing the seasons.

### Geographical explanation

If you have discussed the difference in experiencing seasons with the elders, they will tell you many things about the change they feel in the intensity, duration and spell of the seasons. These are some of the observations of the elders at local level. Changes in this similar pattern have been observed even at the global level. They may include changes in arrival of Monsoons, quantity and frequency of rainfall, change in seasons, changes in flowering, increase in occurrence of floods or drought, etc. This frequent change in the patterns of climate at the global level is considered as climate change.

There have been many instances where the climate patterns have shown a drastic change in their occurrence. The IPCC (Intergovernmental Panel on Climate Change) has been mentioning about these indicators in their reports regularly. Let's discuss these in detail.

#### 1) Increase in the number and intensity of floods :

There has been an increase in number of flash floods and also the duration of the floods. This could be because of very high precipitation in one day (Mumbai, 2005; Kedarnath, 2013) or because of changed weather conditions like cyclones (Chennai, 2015). Overall, many cities or regions have reported of increased flooding activity. Urban areas have seen more of flash floods. Also, coastal cities like Venice are facing flooding issues.

#### 2) Increase in the intensity of droughts and cyclones :

In addition to triggering more rainfall, global warming could also increase the occurrence of drought. A study has shown that the percentage of Earth's land area undergoing serious drought has doubled since 1970s. The roots of both flooding and drought lie in the physical process known as evaporation. As global warming heats the world's oceans, the water molecules near the sea surface become more energetic and tend to evaporate into the

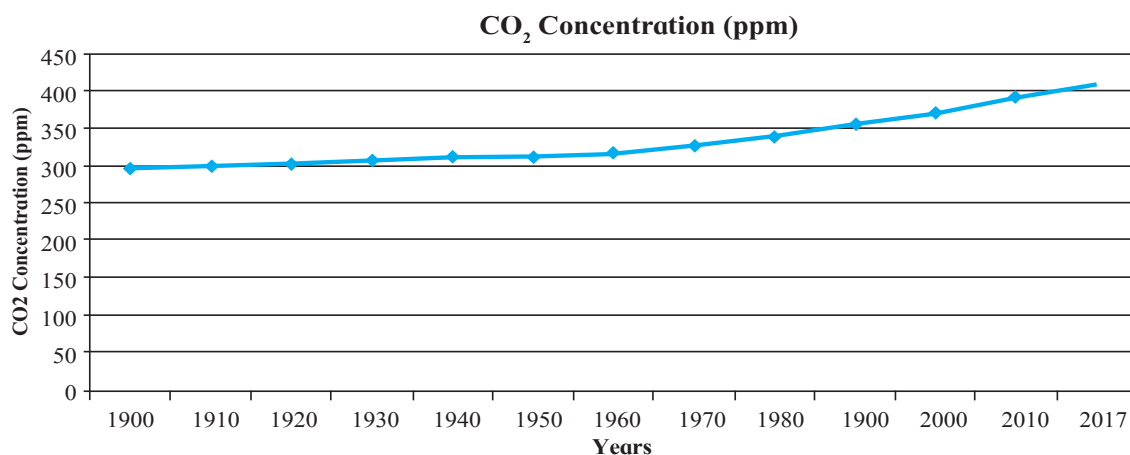


Fig. 5.4

atmosphere more readily. Thus, the air gets more water vapour. This effect gets stronger with each additional degree of warming. Similarly, the number of cyclones in a year has increased in the tropical regions and so have their intensities.



### Can you tell?

Look at the graph in fig. 5.4 and answer the question

- 1) What does the graph show?
- 2) What does ppm mean?
- 3) Since which year has the increase been phenomenal?
- 4) Can you think of the reasons behind the increase in carbon dioxide?

**3) Carbon dioxide and crop yields :** The graph shows increasing levels of carbon dioxide in the atmosphere in parts per million (ppm). Increasing amount of CO<sub>2</sub> in the air has an impact on health, climate, agriculture, air pollution and global warming. The World Health Organisation (WHO) suggests that more than 350 ppm of CO<sub>2</sub> is harmful to the environment. It has been observed that with more CO<sub>2</sub> in the air, crop yield has increased. Some areas in colder climates have been brought under agriculture because of warming. In some places, amount and continuity of rainfall has increased. This, in turn, affects the crop yield.

**4) Rainforests and climate change :** Studies say that rainforests play a major role in cooling the earth. But in the moist tropics, the broad leaves of a rainforest canopy help trap moisture and allow it to slowly evaporate, providing a natural air –cooling effect. When rainforests are slashed and burned over large areas, hotter and dryer

conditions set in. When these forests are burned, they release huge amount of carbon dioxide adding to the atmosphere's load. Deforestation at a large scale has also been reported to alter rainfall patterns and amount of precipitation.

### Causes of climate change :

Though we believe that humans activities are a major cause behind climate change, there are some natural causes for climate change. Some of the natural causes of climate change are as follows:

- 1) The amount of energy output by the Sun is not the same always. Low energy output by the Sun can reduce amount of insolation received by the earth. This can lead to cooling of the earth.
- 2) Another cause are the Millankovitch oscillations. Earth revolves around the Sun. Variations in the earth's orbital characteristics around the sun and the changes in the earth's axial tilt occur. Scientists believe that these changes alter the amount of insolation received from the sun, which in turn, might affect its climate. They can cause the Earth to be closer to the Sun (warmer) or further from the sun (colder). Ice ages can occur when we are further from the Sun.
- 3) Volcanism is considered as another cause for climate change. Volcanic eruptions throw lots of particulates and aerosols (especially sulphur dioxide) into the atmosphere. These aerosols remain in the atmosphere for a considerable period of time. The winds spread it around the world reducing the sun's radiation reaching the Earth's surface. It has been observed that all of the coldest years on record in the past two centuries have occurred in the year following a major volcanic eruption. After the recent El Cion (1982) and Pinatubo (1991) volcanic eruptions, the average

temperature of the earth fell to some extent for some years.

- 4) The scientists believe that the earth lies in a habitable zone called the Goldilocks Zone. Earth experienced cooler climate early in its history, when it was located in the outer reaches of this zone. As the size of the Sun increases the zone moves outward over time. Such changes in the zone causes earth to warm or cool.

Besides these natural causes, we have already seen the anthropogenic effect on the climate. The emission of  $\text{CO}_2$  mainly comes from fossil fuel combustion. Large scale deforestation also increases  $\text{CO}_2$ . The atmosphere takes around 20 to 25 years to adjust these high levels of  $\text{CO}_2$ . Therefore, it is generally regarded that man and his activities are a major cause of climate change.

### Is climate change happening for the first time?



#### Do you know ?

##### Ice age :

An ice age is a period in Earth's history when the ice on the polar caps significantly expanded due to an overall lowering of the Earth's global temperatures. During these periods land in North America and Northern Europe were covered by huge ice fields and glaciers.

Infact, we are currently living in an ice age. The Earth is in a warmer stage of the ice age called an interglacial period.

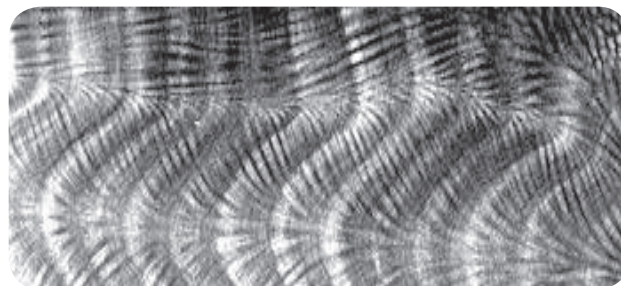
It is not the first time that we are experiencing this change in climatic patterns. There have been many major and minor fluctuations in the type of climate we experience now. The Earth has witnessed many variations in climate since the beginning. There are various geological records that show alteration of glacial and inter-glacial periods. The sediment deposits

in glacial lakes also reveal the occurrence of warm and cold periods. The rings in the trees provide clues about wet and dry periods. Historical records describe the variations in climate. All these evidences indicate that change in climate is a natural and continuous process. There are periods within ice ages that scientists define as glacial and interglacial. A glacial period is a cold period when the glaciers are expanding. On the other hand, in an interglacial period, a warm climate makes the glaciers recede.

### Some Tools for studying climate change

Paleoclimatology is the study of the weather and climate of the Earth's past. Scientists and meteorologists have been using instruments to measure climate and weather for the past 140 years only! Then how do they tell about the climate millions of years ago? They use historical evidence called proxy data. Examples of proxy data include tree rings, ice cores, coral reefs and ocean sediments.

**Coral reefs** - are very sensitive to changes in climate. Corals form skeletons by extracting calcium carbonate from the ocean waters. When the water temperature changes, densities of calcium carbonate in the skeletons also change. Coral formed in the summer has a different density than coral formed in the winter. This creates seasonal growth rings on the coral. Scientists can study these rings to determine the temperature of the water and the season in which the coral grew. See fig. 5.5.



**Fig. 5.5 Coral rings under X-ray. Each of the light/dark bands in this X-ray is a cross-section of a coral core formed during a year of growth.**

**Tree rings** - Variation in these rings is due to variation in environmental conditions when they were formed. Thus, studying this variation leads to improved understanding of past environmental conditions. See fig. 5.6.

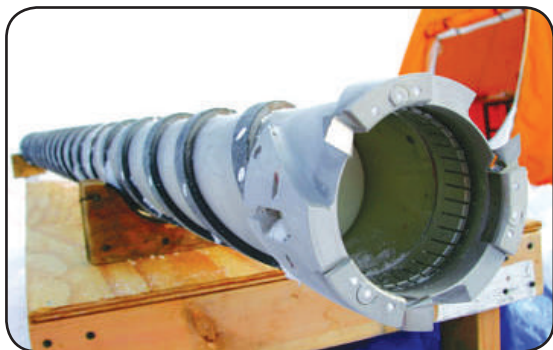


**Fig. 5.6 Tree rings**

**Ice cores** - are samples of ice taken from the inner sides of the ice sheets. Throughout each year, layers of snow fall over the ice sheets in Greenland and Antarctica. Each layer of snow is different. Summer snow differs from winter snow. Each layer gives scientists a lot of information about the climate each year. See fig. 5.7 and 5.8.



**Fig. 5.7 Ice core sample**



**Fig. 5.8 Ice driller used for taking sample from ice**

Many parts of the world experienced alternate wet and dry periods. Geological findings show that the Rajasthan desert experienced wet

and cool climate around 8000 years back. It became drier around 4000 years ago after the Harappa civilisation. In the geological past, the earth was also warmer around 500-300 million years ago. Approximately 10,000 years ago, the last glacial period ended. The well-preserved fossils from animals and plants, such as the mammoth, are from this late era.

The changes in the climate in the past century do not actually point out that humans are involved in this.



### **Find out !**

Make a list of movies based on ice age and climate change.

### **If the climate of the Earth has changed many times before, then why are we concerned now?**

The current warming trend is of particular significance because most of it is extremely likely to be the result of human activity since the mid-20th century and proceeding at a rate that is unprecedented over decades to millennia.

Earth-orbiting satellites and other technological advances have enabled scientists to see the bigger picture, collecting many different types of information about our planet and its climate on a global scale. This body of data, collected over many years, indicates a changing climate.

Ice cores samples drawn from ice cores in Greenland, Antarctica, and tropical mountain glaciers show that the Earth's climate responds to changes in greenhouse gas levels. Ancient evidence can also be found in tree rings, ocean sediments, coral reefs, and layers of sedimentary rocks. The ancient evidence also reveals that current warming is occurring roughly ten times faster than the average rate of warming.

### **What steps have been taken to tackle climate change?**

In the twentieth century, many researchers had started working on topics such as climate



history of the earth, use of fossil fuels, local climate changes, etc. In 1950s, precise measurements of CO<sub>2</sub> in the atmosphere confirmed its steady increase in the atmosphere. Later on, the greenhouse gases were also reported to increase. By 1980s, it was found that the temperature of the earth is rising.

A lot of research has been tackled by the Inter governmental Panel on Climate Change (IPCC). Till now, the IPCC has published 5 reports on climate change and several special reports with the latest one published in October 2018 on Special Report on "Global Warming of 1.5°C" (SR1.5).

The reports have given targets to all countries so that together we prevent the earth from warming. Besides these, the countries have also signed Kyoto Protocol the Paris Agreement (2016), etc.



### Do you know?

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty adopted on 9 May 1992 at the Earth Summit in Rio de Janeiro. The Kyoto Protocol is an international treaty that commits member countries to reduce greenhouse gas emissions. The Montreal Protocol, finalized in 1987, is a global agreement to protect the stratospheric ozone layer by phasing out the production and consumption of ozone-depleting substances (ODS). In the adopted version of the Paris Agreement, the parties will also "pursue efforts to" limit the temperature increase to 1.5° C. The 1.5° C goal will require zero emissions sometime between 2030 and 2050, according to some scientists.



### Do you know?

The Nobel Peace Prize 2007 was awarded

to Intergovernmental Panel on Climate Change (IPCC) "for its efforts in combating climate change.

### Climate change and india :

Developing countries, the Least Developed Countries (LDCs) and small island nations are at the highest risk of damage due to the climate change. For example, it is predicted that Fiji will be underwater within 50 years. These countries such as India and China who now contribute significantly to global emissions have an important role to play. However, at the same time they have to fulfill their development needs through utilization of natural resources and industrialization.

India has high vulnerabilities to climate change impacts due to its peculiar economy and geography. Besides, promoting clean energy and taking steps to protect environment, the government of India has taken the important steps for combating climate change :

#### 1) National Action Plan on Climate Change (NAPCC), 2008

It consists of 8 sub missions which together make up the national plan.



### Find out !

With the help of Internet, find out the details of the National Action Plan on Climate Change (NAPCC), 2008 and its missions.

#### 2) National Adaptation Fund for Climate Change (NAFCC)

To assist State and UTs particularly vulnerable to the adverse effects of climate change in meeting the cost of adaptation. NABARD has been appointed as National Implementing Entity for the fund

#### 3) National Clean Energy Fund (NCEF)

Fund has been created using the carbon tax

on coal for funding R&D projects in clean energy technologies of public or private sector. An assistance of up to 40% of the total project cost will be provided either in the form of loan or grants

effectively. This could include only buying things that are necessary, walking smaller distances, using energy efficient devices, reducing our dependence on wood, not using plastic , etc.

### Lifestyle changes and climate change :

It is now believed that we can all make changes in our lifestyle to combat climate change



#### Try this.

Make a list of things you need to change in your lifestyle.



### Exercise

#### Q. 1) Complete the chain :

A	B	C
1) Melting of snow	1) Methane	1) Flooding
2) Effects of insolation	2) Average temperature of the earth	2) Agriculture
3) Greenhouse gases	3) Erratic rains	3) Existence of life on earth
4) Climate change	4) Increase in sea level	4) Increase in frequency of cyclones

#### Q. 2) Identify the incorrect factor:

- 1) The causes of global warming
  - a) Emission of greenhouse gases
  - b) Deforestation
  - c) Apparent movement of the sun
  - d) Industrialization
- 2) The indicators of climate change
  - a) Retreat of glaciers
  - b) Increase in the frequency of floods
  - c) Increase in the frequency of cyclones
  - d) Increase in the minimum and maximum temperature
- 3) The tools for studying climate change
  - a) Ice cores
  - b) Coral reef
  - c) Tree rings
  - d) Ancient forts
- 4) Measures to combat climate change
  - a) Banning the use of pesticides and insecticides.
  - b) Promoting afforestation and banning deforestation

- c) Banning public transport
- d) Banning fossil fuels

#### Q. 3) Give geographical reasons:

- 1) It is important to study climate change
- 2) There is a great possibility that we may not see Maldives on the world map in the future.
- 3) The snowline is retreating
- 4) There is an increase in the frequency of droughts and cyclones

#### Q. 4) Write short notes :

- 1) Bleaching of coral reefs
- 2) Flash floods
- 3) Tools to study Paleoclimatology
- 4) Greenhouse gases

#### Q. 5) Answer in detail :

- 1) Climate change has not always been anthropogenic in nature. Explain.
- 2) What measures will you suggest to combat climate change in your village/city.

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