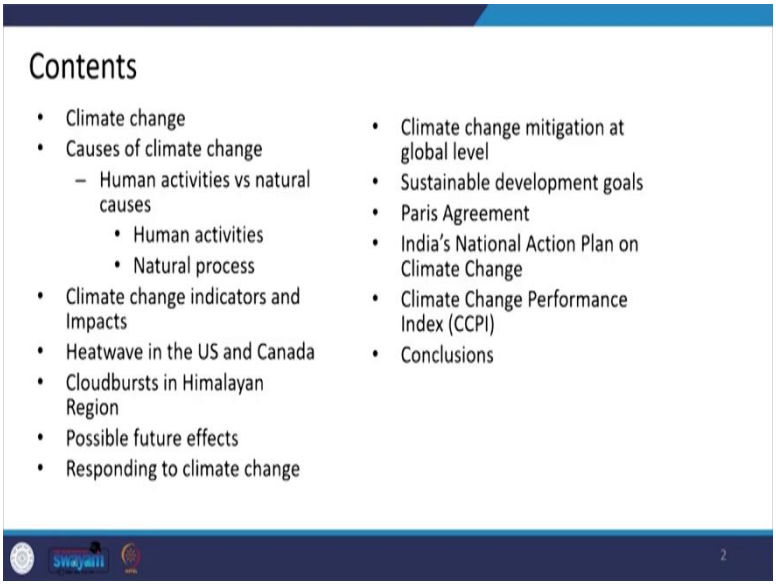
Air Pollution and Control
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture 39
Global and Regional Environment Issues: Climate Change

Hello friends. So, these days we are discussing about global and regional environmental issues. We have already discussed ozone depletion and global warming related issues. Today we will discuss about climate change related issues.

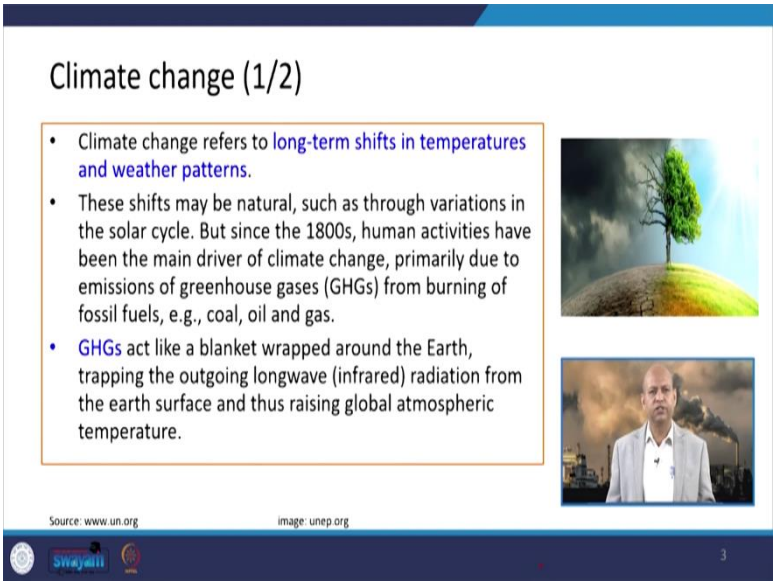
(Refer Slide Time: 0:45)



So, in this presentation we will cover like what is the climate change, what are its causes, whether it is natural regions or natural causes or there are contributions of human activities, then climate change indicators and their impacts and impacts in terms of like heat waves or cloudbursts etc. in different regions of the world and possible future effects, then how to respond to the climate change if you want to mitigate or adapt with it.

So, those policy issues at the global level like Paris Agreement, etc. And then we will also see at the India level like what kind of national action plans they are initiating for mitigating the climate change related issues and ultimately, we will conclude on the basis of these presentations or data.

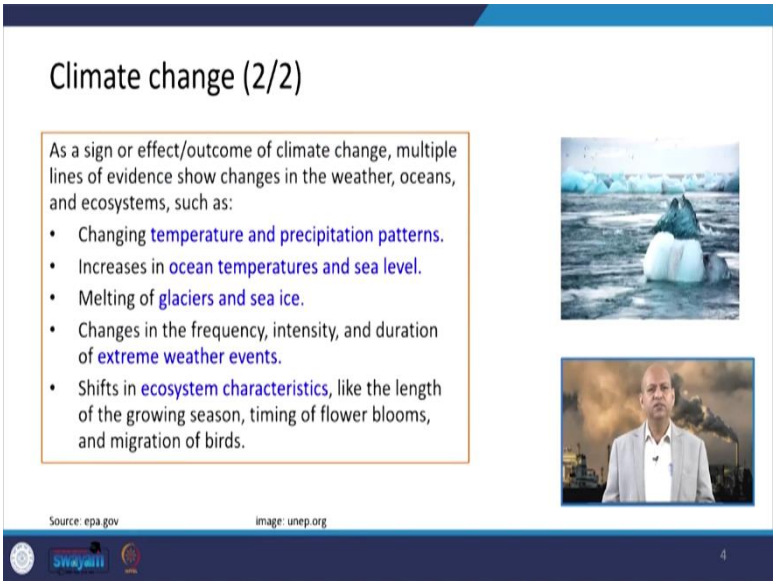
(Refer Slide Time: 1:31)



If we talk about climate change, then basically, this climate change is the long-term shift in the temperature and weather patterns otherwise, in weather, day to day we have this change in the temperature etc. but in long term like seasons, if you see how seasons are varying, so, like hundreds or thousands of years, some pattern is there in weather and seasons, if they are changing then we have to be like alarmed, because it may have implications, negative or positive implications, we can see, we can debate, but of course, there are certain indicators which show that there may be very negative impacts in terms of like a storm or cloudburst or global warming and then sea level rise and there are many issues.

When we talk that what are the reasons for this shifting of these patterns of the temperature and weather in terms of the climate change, then there are two schools of thoughts like some people argue that this is naturally occurring and in past geological ages, some evidences they bring out but the mainstream of the scientific body they believe with the help of evidences that this is because of greenhouse gas emissions and it has scientific region of this global warming effect of the greenhouse gases, emissions basically, they remain in the atmosphere and they trap the infrared radiation which goes out of the earth and then increase the temperature. And accordingly, there are issues and these greenhouse gases are being emitted by fossil fuel burning activities, which are needed for energy, meeting our energy demand.

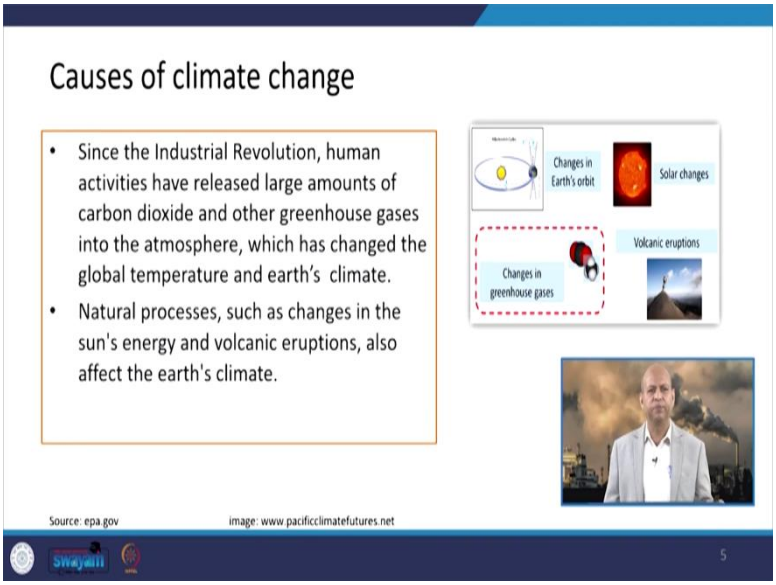
(Refer Slide Time: 3:18)

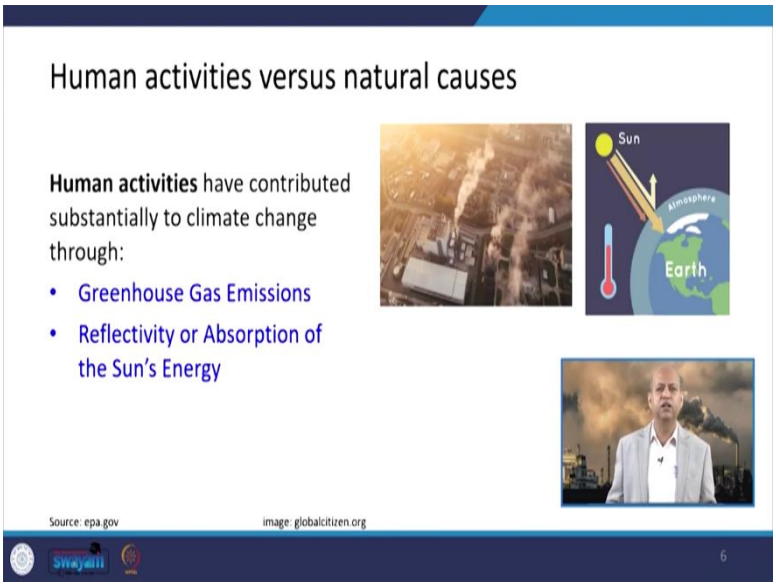


And if we talk about like what are the different signs then we can see that there are several signs or outcomes or effects of the multiple evidences we have in terms of like changing in temperature and precipitation patterns, which we observe. Then there are increasing the ocean temperature as well as sea level rise is there, melting of glaciers are observed sea ice is also melting and then changes in the frequency and intensity and duration of extreme weather events have been observed throughout the world.

And there is a shift in ecosystem characteristics like the length of the growing season, timing of flowering or blooming and migration of birds, there are changes basically, and which are very-very like important prominent changes.

(Refer Slide Time: 4:09)





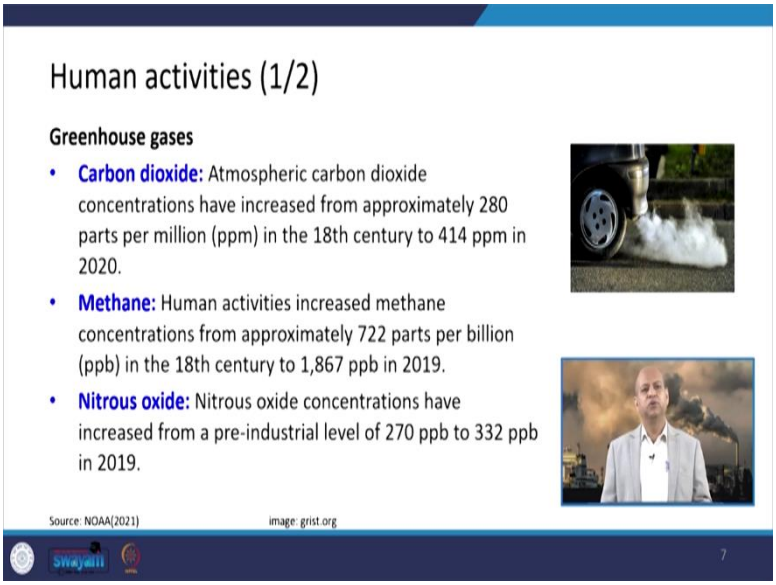
Well, so, when we talk about the causes of climate change as I said, some people believe that this is because of natural regions like solar, change in solar insulation and the solar radiation etc. but because of industrial revolution human activities have released large amounts of carbon dioxide and other greenhouse gases, this is also affect. And it has changed the global temperature and Earth's climate there are evidences, robust evidences, and irrefutable evidences basically.

If you talk about natural processes, then sun's energy volcanic eruptions or they can also affect the climate change, but climate but up to that scale, which we are observing within shortest

span of time, and which correlates with this industrial era and the emissions of greenhouse gases is very-very authentic and very strong.

So, when we look at human activities which have contributed substantially into climate change, these are through greenhouse gas emissions and also at the regional level there are changes it is not only the global, but regional level changes are there which are because of reflectivity or absorption of the sun's energy is different at different places, because of many human activities which we will see in subsequent slides.

(Refer Slide Time: 5:34)

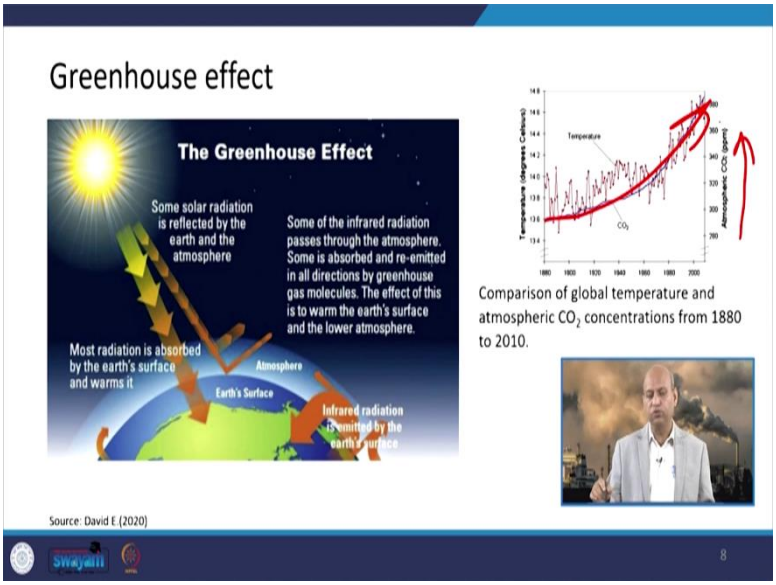


Like greenhouse gases as you know carbon dioxide or methane or nitrous oxide and there are even water vapor is also greenhouse gas, ozone is also greenhouse gas, and they have increased like atmospheric carbon dioxide concentration has increased from approximately 280 parts per million (PPM) in 18 century it was, and now it is 414 ppm in 2020 it has been observed. So, within a short period of time these 280 parts per million have been for centuries all together and soon after this industrial era, this has started to increase because of emissions of fossil fuel burning, so, now, it is around 414 ppm in the atmosphere.

When we talk about the methane human activities also released the methane concentration like rice paddy and other animal husbandry those activities and this concentration, it was like 722 parts per billion (PPB) in 18th century and now it is 1867 ppb, more than twice you can say in 2019 it was absorbed 1867. Nitrous oxide if you talk then its concentration was in pre-industrial era around 270 ppb, now it is 332 ppb and these potential global warming potential of green

these methane and nitrous oxide is much more than the carbon dioxide, so that we also there problem enhances.

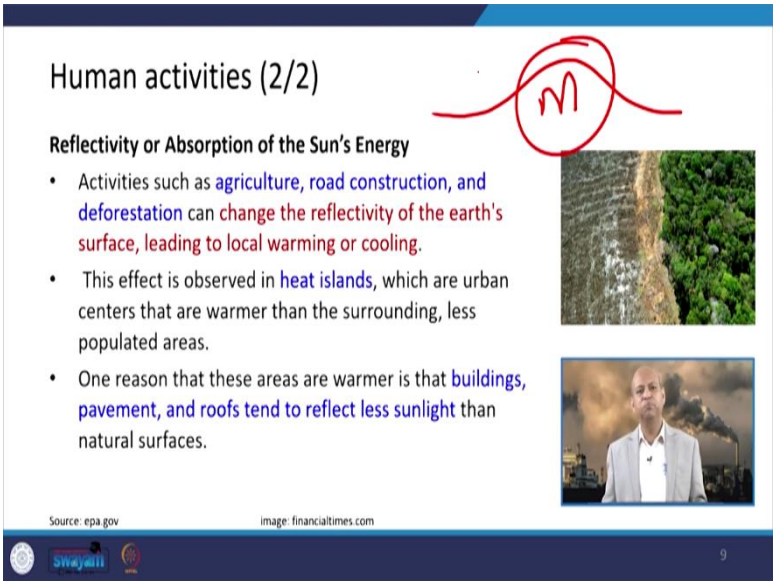
(Refer Slide Time: 7:09)



So, you all know this greenhouse effect, like solar insulation, short waves come to their surface, then it is reflected, some absorbed, whatever is reflected then it is absorbed or again reflected by aerosols etc. but when greenhouse gas is there, it has the tendency to trap this infrared radiation, when Earth releases this infrared radiation or longer wave radiation, this is trapped by these greenhouse gases, they do not trap these, like they are not opaque to shortwave radiation, they allow shortwave radiation to come up to the surface of the Earth, but when infrared radiation or long wave radiation goes into the sky, then they act as a blanket, they capture it, they do not allow it to go outside and that way the temperature increases of the near surface atmosphere and the Earth's surface temperature increases.

You can see this temperature degree in Celsius and from 1880 to 2000 you see the increasing trend, very-very prominent trend is there, nobody can deny it that the temperature is increasing and this CO_2 concentration is also increasing at the same time this relationship is very strong with the global warming because of greenhouse gas concentration into the atmosphere.

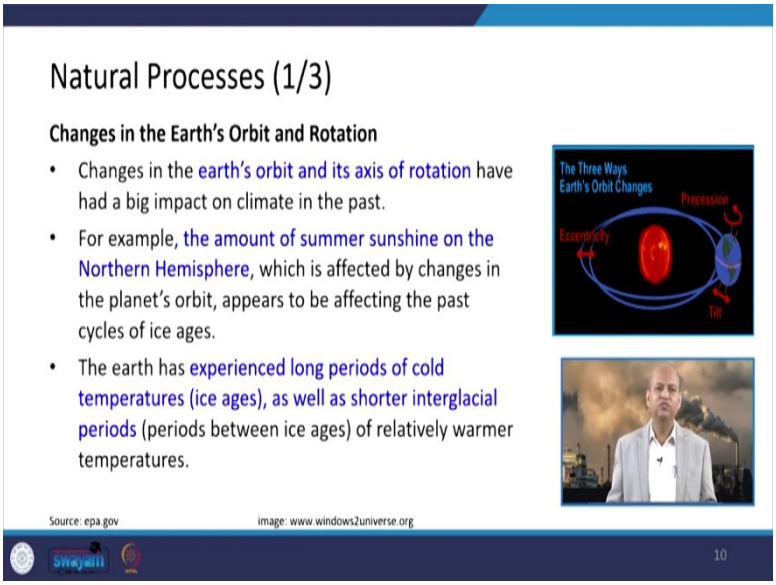
(Refer Slide Time: 8:32)



When we talk about reflectivity or absorption of the sun's energy, then there are issues like we have roads or we do deforestation, we do agricultural activities. So, we are changing the reflectivity of the surface, like bitumen they absorb or cement concrete buildings they also absorb these heat radiations and that way the localized area is warmed, this temperature increases and it is known as heat island impact in fact.

When you go towards cities from countryside you will find that the temperature is increasing as soon as we reach to the city and at the city center temperature is very high. So, like if this is the city and you are approaching, so, temperature will increase and decrease like this, you go outside the city then temperature again decreases. So, this is the heat island impact, which is localized impact or at the regional scale it can be there this is because of these kinds of activities of the anthropogenic activities or human made activities.

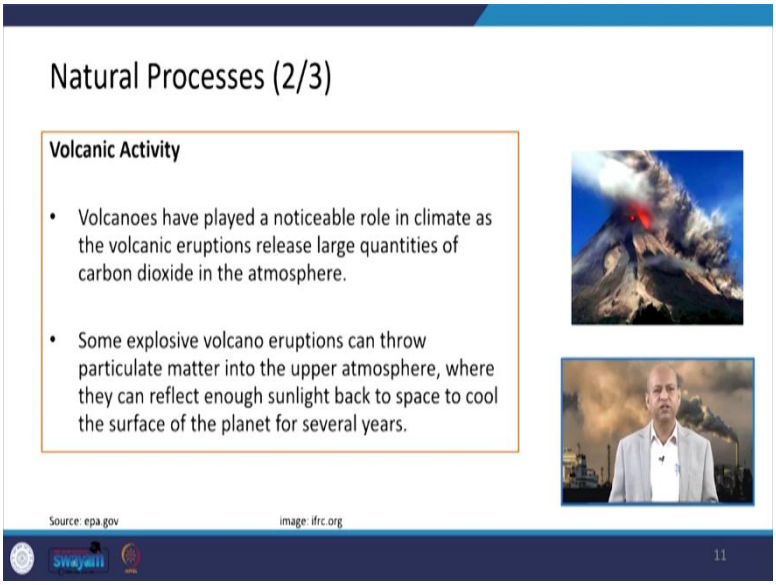
(Refer Slide Time: 9:37)



When natural processes, we have already seen like changes in Earth's orbit or rotation that also that is also responsible for changes in these temperature and other phenomena. The amount of summer sunshine on the northern hemisphere, which is affected by changes in the planet's orbit appear to be affected the past cycles of ices, this is again very scientific evidences are there. So, we cannot deny it that there is no natural contribution into the climate change, there are.

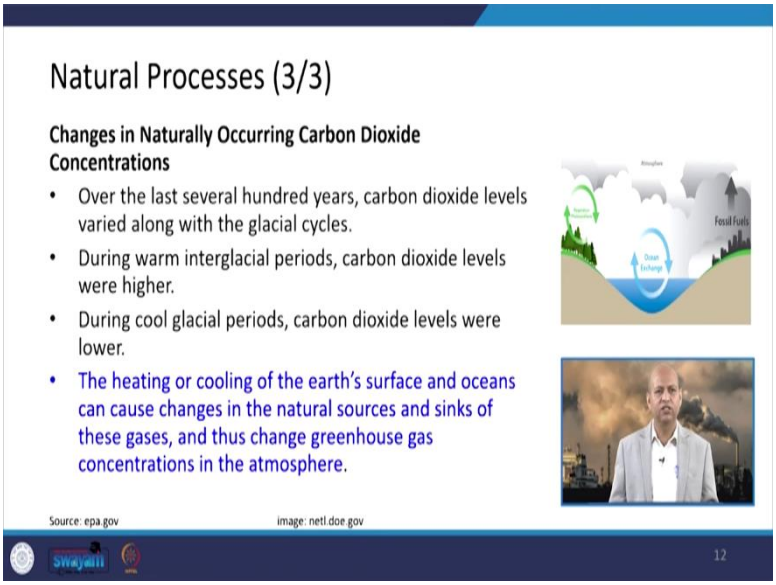
The Earth has experienced long periods of cold temperatures, mini-ice age, you can call them as well as shorter in interglacial periods, like periods between ice ages of relatively warmer temperatures. So, those kinds of natural phenomena have been there, they are well recorded, but the way this temperature increased after this industrial era started, so, that is again also robust evidences are there and we cannot deny it that anthropogenic responsibility, anthropogenic activities are responsible for global warming and climate change.

(Refer Slide Time: 10:48)



Volcanic eruptions are there, naturally they are part of the natural processes, they also emit a lot of CO_2 and then like sulfur dioxide then sulfate particles, maybe in the atmosphere, because of that reaction as and then it can reflect solar radiation. So, that can also change the temperature or solar insulation at the Earth's surface. So, those are the natural surfaces.

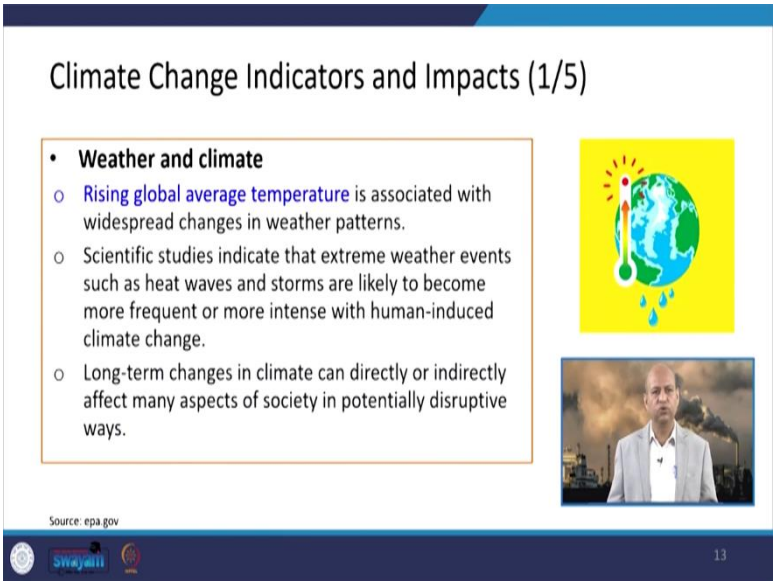
(Refer Slide Time: 11:13)



Also, at the same time, you can see like, over the last several 100 years, carbon dioxide levels varied along with the glacial cycles, there is a cyclic pattern in that. During warm interglacial periods, carbon dioxide levels were higher, naturally it was emitted from them, during cold glacial periods, carbon dioxide levels were lower.

So, the heating or cooling of the Earth's surface and oceans can cause changes in the natural sources and sinks of these gases, because ocean is also a great sink of the carbon dioxide. So, temperature increases then it can release the CO_2, depending upon how much temperature is there. So, the change in the greenhouse gas concentration in the atmosphere can vary according to these natural changes also.

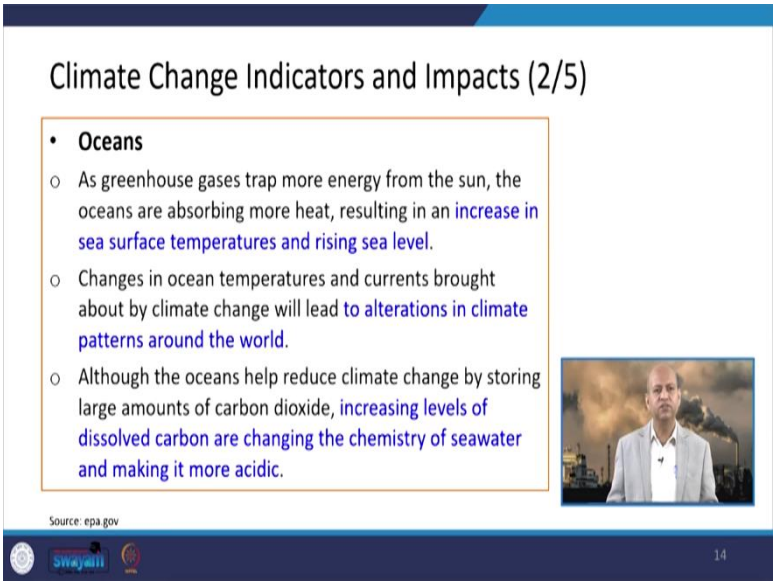
(Refer Slide Time: 12:01)



Now, if we talk about like weather and climate, I mean the climate change indicators and impacts, then if you see weather and climate so, the rising global average temperature is associated with widespread changes in the weather patterns also, there are scientific studies which indicate that extreme weather events such as heat waves or storms, they are likely to become more frequent or more intense with human induced climate change, because of these greenhouse gases and the long term changes in the climate change can directly or indirectly affect many aspects of the society in potentially disruptive ways.

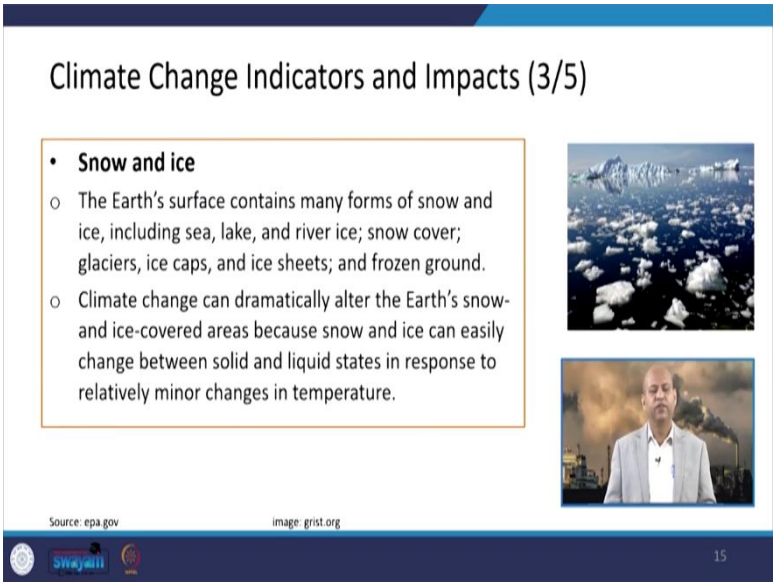
For example, in hilly areas or where tourism is because of snow and those kinds of things, if warming is there, there is no snow then this business will be affected, there will not be tourists on these places. And at the same time like if sea level rises are there then again, the coastal cities maybe at the big danger.

(Refer Slide Time: 13:06)



So, you can see like in oceans, this is a big sink and at the depending upon the temperature it can release or it can get this CO_2 concentration plus also at the same time when temperature rises the ocean kind of swelling is there or means the volume increases, so, sea level rise is there, so, sea level rise may be there. And then you can see it is acidic nature can also be affected by CO_2 concentration, because it is acidic in nature and different ecosystems of these aquatic systems can be disrupted because of the changes in the pH and other contents.

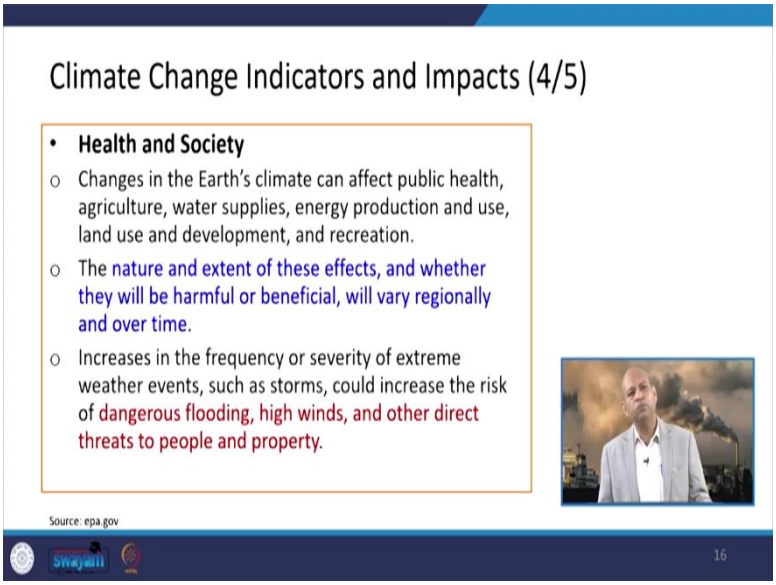
(Refer Slide Time: 13:48)



Well, when we talk about the snow and ice, the Earth surface contains many forms of the snow and ice including like sea, the sea also there are icebergs and in lakes also then river ice is there, snow cover is there, glaciers, ice caps, and ice sheets, there are so many things. And climate

change can dramatically alter these Earth surfaces snow and ice-covered areas, because snow and ice can easily change between solid and liquid states in response to the relatively minor change in the temperature. And accordingly, this the capacity to absorb the solar radiation or to reflect it, it changes this albedo is changed and this can change the pattern of this temperature patterns.

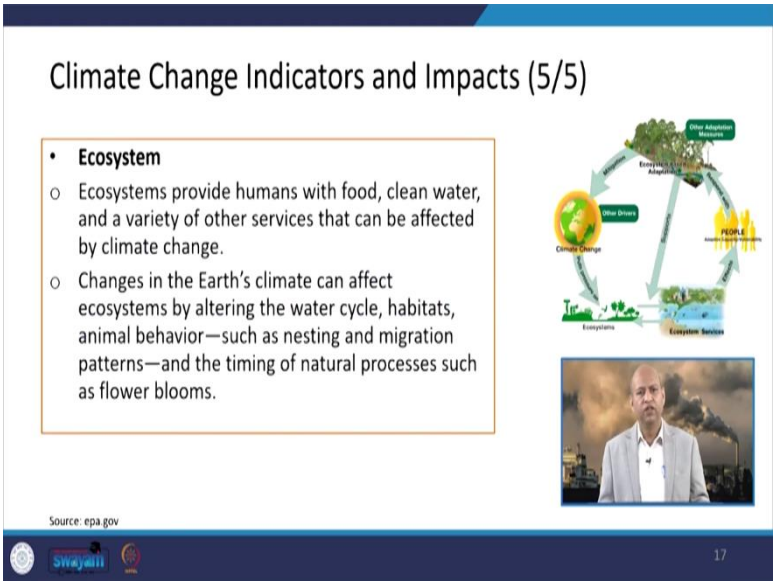
(Refer Slide Time: 14:34)



When we talk about health and the society. So, changes in the Earth's climate can affect public health in a big way, because like heat waves etc. when lot of heat waves, intensified heat waves are there old people cannot survive and those people who are susceptible to these kinds of problems and agriculture activities or water supplies, energy production and use all these kinds of things can be or recreation like tourist places etc. land use and development activities all these things can be affected of the society, of the human society because of climate change.

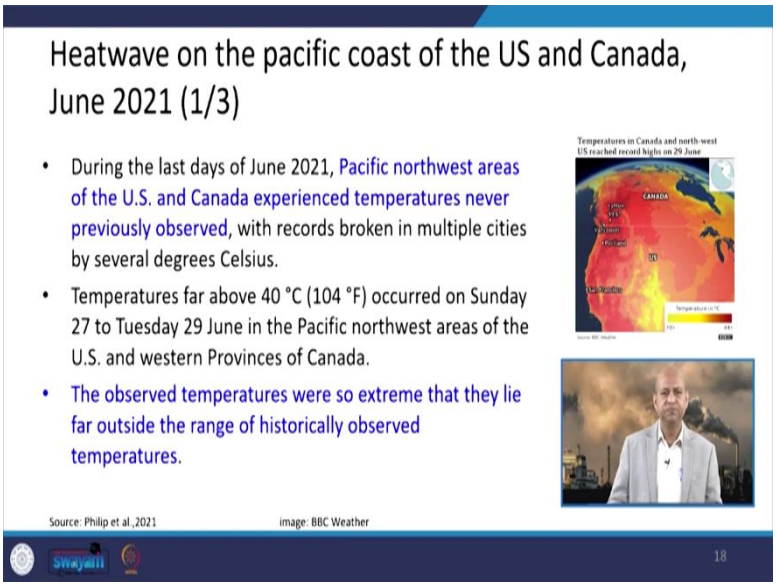
And the nature and the extent of these effects, whether they will be harmful or beneficial will depend upon the location. Sometimes people say that because of this global warming there may be some negative impact at particular altitude or latitude. So, some even diseases can travel depending upon the temperature, increases in the frequency or severity of extreme weather events such as storms, it can cause increasing of the risk and like in terms of these dangerous floods or high winds and other direct threats to the people and the property, which you often see like, very intensified storms nowadays we witness near coastal regions. So, these are because of these climate changes.

(Refer Slide Time: 16:02)



When we talk about the ecosystem, basically ecosystem provide all kinds of services to us, whether in terms of food or clean water, a variety of other services we get from the ecosystem forest etc. And the changes in the Earth's climate can affect the ecosystems all together, water cycle, habitats, animal behavior, such as nesting and migration patterns can also be changed because of changes in the temperature of different regions, timing of natural processes such as flower blooming can also change. So, that way the complete ecosystem can get changed because of climate change.

(Refer Slide Time: 16:38)



Now, one example we will cite here, like heat wave on the Pacific coast of the US and Canada that was witnessed recently in June 2021. And during the last days of June 2021, Pacific, this Northwest areas of the US and Canada, they experienced temperatures, like never previously

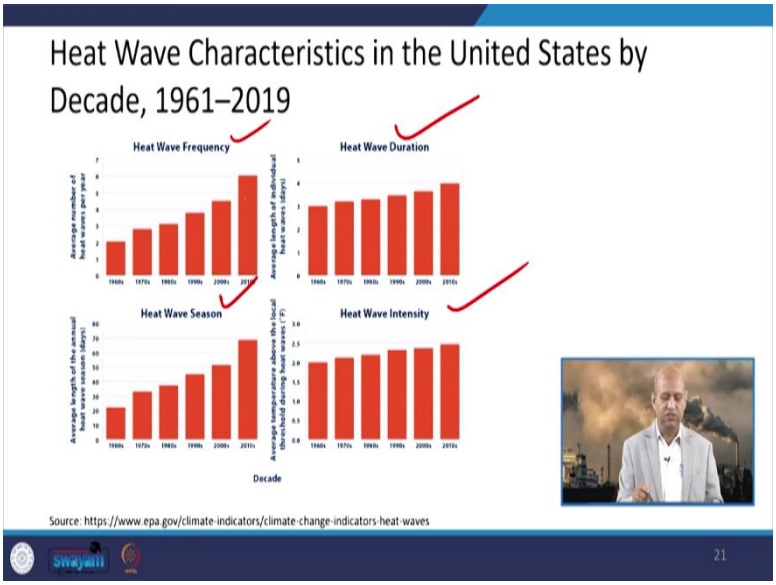
observed. The records were broken in multiple cities by several degrees of Celsius, if it was very high then which was recorded in the past, like temperature above from 40 degrees Celsius, which was not recorded earlier like that occurred on Sunday of like 27 or Tuesday 29 in Pacific northeast areas of the US and western provinces of the Canada.

Well, the observed temperatures were so extreme that they lie far outside the range of the historically observed temperature. So, those kinds of events really create kind of fear in our mind that what will happen if such events frequently occur and they affect the life of the people, like there are two possible sources of these extreme jumps in the peak temperature, theories you can say opinion like, maybe it is very low probability, which occurs once in a while it is not going to occur again and again, in the current climate. So, it will be like about 1.2 degrees Celsius of the global warming. So, in that range, it is kind of once in a while kind of low probability event.

The second hypothesis could be like in non-linear interactions in the climate have substantially increased the probability of such extreme heat and much beyond the gradual increases heat extreme that was observed up to now. So, those kinds of uncertainties are there and this creates, again, kind of like fear that what will happen if such events occur again and again, and they disrupt the whatever social setup, whatever infrastructure setup, we have.

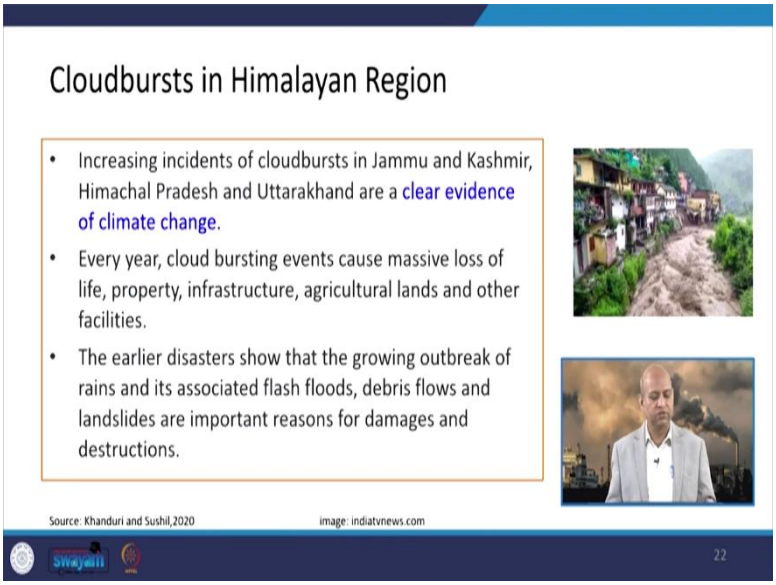
More than 300 sudden deaths were reported throughout the province on one day alone, that was never before. So, this shattered Canada's old time temperature record, basically in 2021 and the overall number of these sudden deaths represented and nearly 300 percent increase from the average number of deaths, which was recorded over the same week every year since 2016, so, that creates a worrisome situation.

(Refer Slide Time: 19:14)



Well, when we talk about like, these heat wave characteristics in the United States over the years like 1960 to 2010, then weather this heat wave frequency or heat wave duration or heat wave season and heat wave intensity, everything is increasing, you can see the frequency is increasing so, drastically. So, that is again worrisome, and we need to be alert about this.

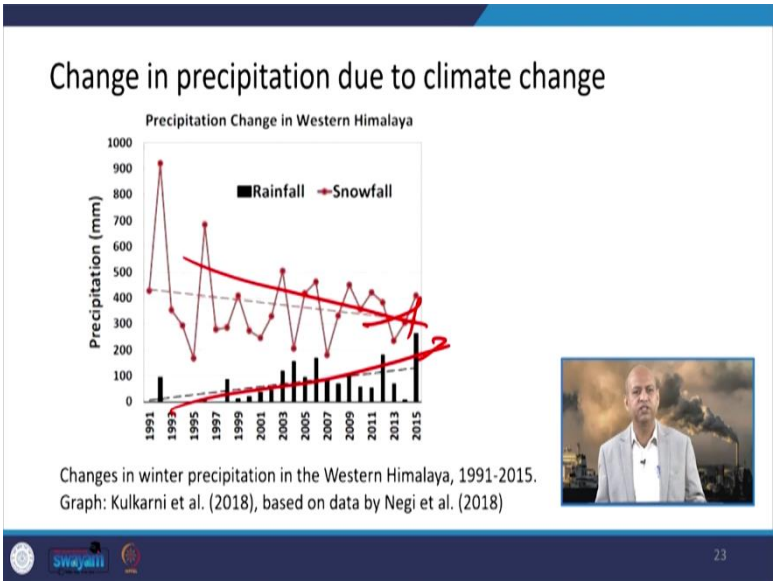
(Refer Slide Time: 19:34)



Then there are issues like cloudburst are happening in Himalayan region very frequently, which was not so frequently earlier. In Jammu Kashmir region, Himachal Pradesh, Uttarakhand region of India, there are clear evidences of climate change because of these cloudbursts.

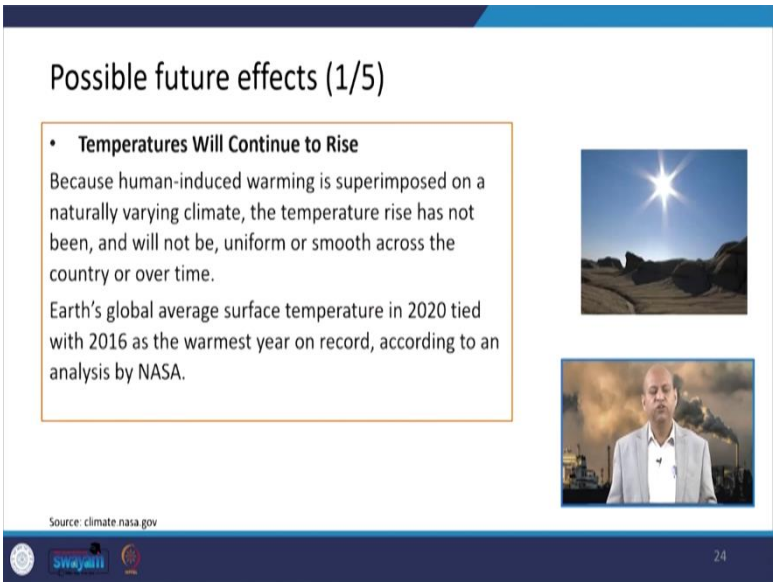
Every year cloud bursting events caused massive loss of life, property, infrastructure, agricultural lands and other facilities and the earlier disasters show that the growing outbreak of the rains and its associated flash flood kind of phenomena, debris flows or landslides, they are important regions for damages and destructions in those regions, and they are very much related to the climate change phenomena.

(Refer Slide Time: 20:15)



So, if you see these changes in the precipitation due to climate change, if you see precipitation is increasing this way overall and the snowfall is decreasing, so that is clear evidence of these kinds of drastic changes, because of climate change.

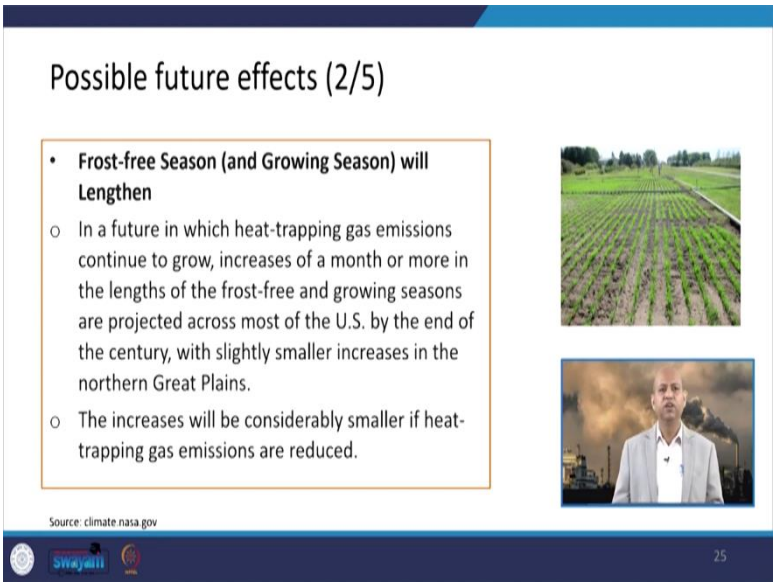
(Refer Slide Time: 20:32)



And if we talk about like possible future effects, which may be because of this climate change or temperature variation, like it is assumed or it is predicted that temperature will continue to rise, because of these human induced warming it is superimposed on a naturally varying climate and the temperature rise has not been and will not be uniform or smooth across the country or over time. So, this will have uncertainty component in a very high variability.

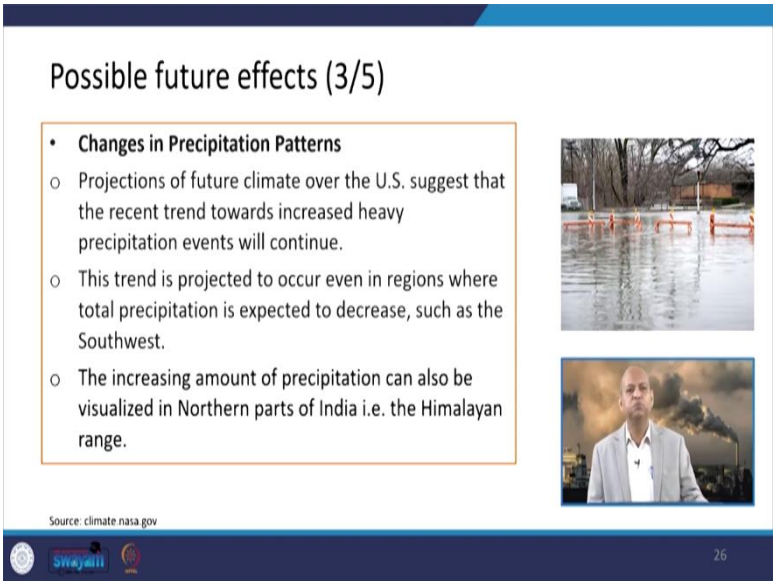
And the Earth's global average surface temperature in 2020 tied with 2016 as the warmest year on record according to an analysis of NASA. So, these are very worrisome signs of the global warming and climate change.

(Refer Slide Time: 21:18)



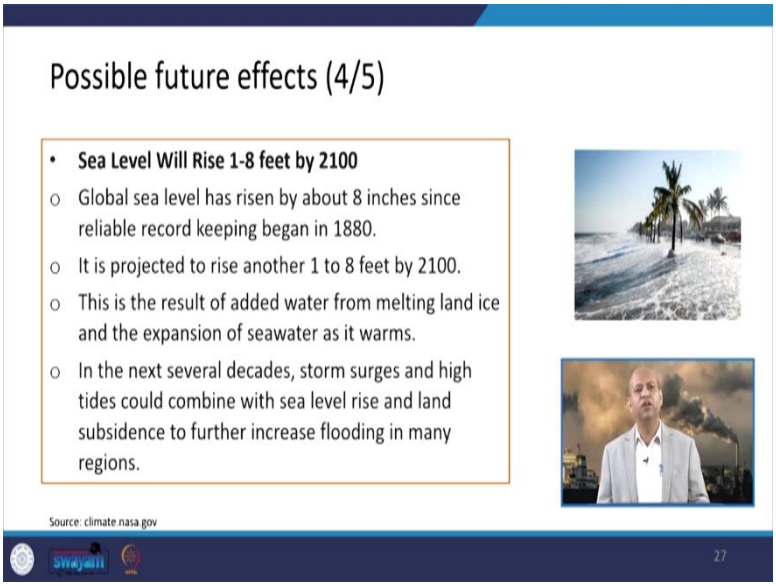
Well, the, this frost-free season and growing season will also lengthen because of these possible future effects of climate change, because in a future in which heat trapping gas emissions continue to grow, if we do not do like renewable resources or other resources, if we do not harness, if we continue in the business as usual scenario, then their emissions will continue to grow and it will increase, of a month or more in the length of the frost-free and growing seasons and it is projected across most of the US by the end of the century with slightly smaller increase in the northern Great Plains. So, that season, frost-free season can lengthen basically and the increase will be considerably smaller, if heat trapping gas emissions are reduced, so, that is linkages.

(Refer Slide Time: 22:14)



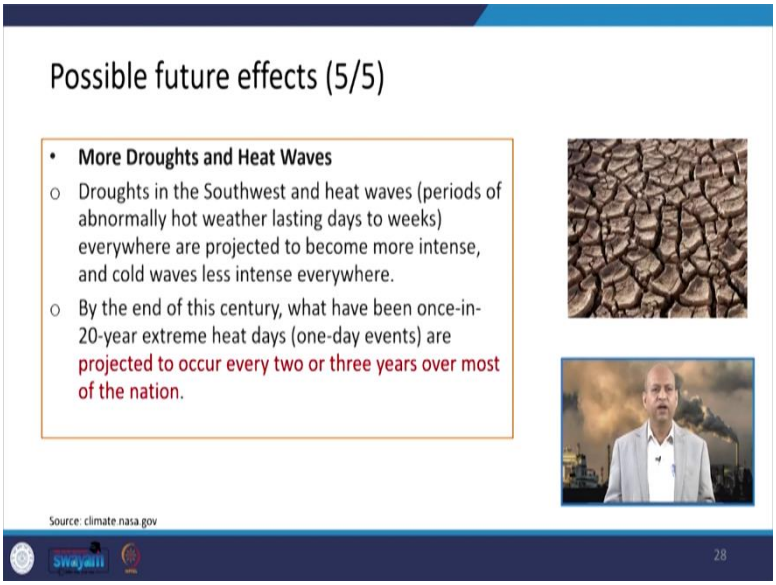
Well changes in precipitation patterns is also very predominant. Projections of future climate over the U.S. suggest that the recent trend towards increased heavy precipitation events may continue, and this trend is projected to occur even in regions where total precipitation is expected to decrease such as the southwest, so, again the worrisome situation. The increasing amount of precipitation can also be visualized in northern part of India that is the Himalayan range, which we have witnessed recently in a very big a very high intensity.

(Refer Slide Time: 22:49)



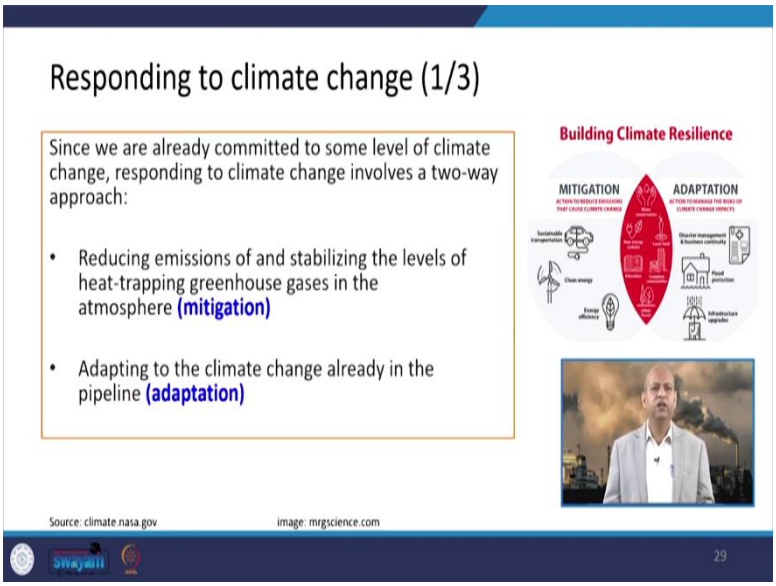
Sea level will rise 1 to 8 feet by 2100 that is the kind of model predictions or model estimations. So, in coastal regions or cities have to suffer because of this if we do not control the carbon emissions or greenhouse gas emissions.

(Refer Slide Time: 23:07)



And the possible future effects also include like more droughts or heat waves may occur, and that way, the agricultural, land or agricultural practices in the regions where population is dependent on agriculture, that can be affected very badly. And by the end of the century, what have been once in 20-years extreme heat days are projected to occur every two or three years over the most of the nations. So, that is very alarming situation, we should think about.

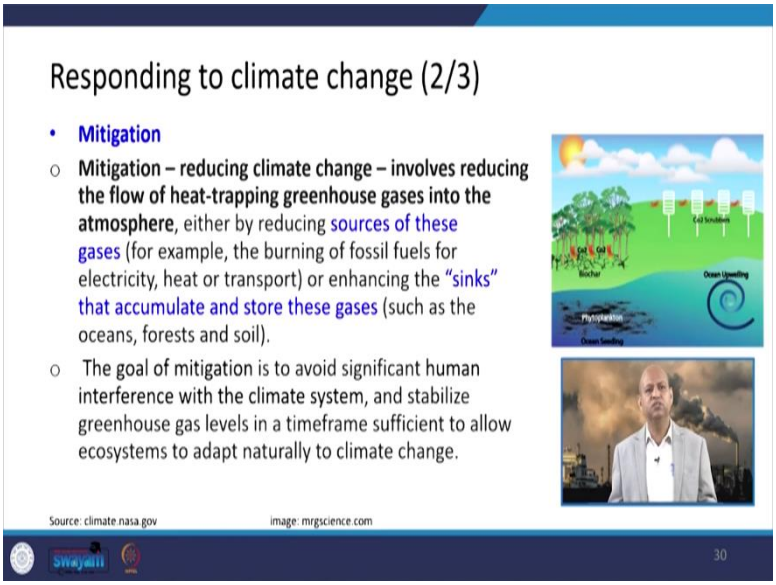
(Refer Slide Time: 23:43)



Well, this responding to climate change, what should we do basically? So, there are two ways basically to handle it, either we mitigate, we reverse it, like climate change means greenhouse gas emissions, we should control, we should reduce it or we should get rid of it, that is the

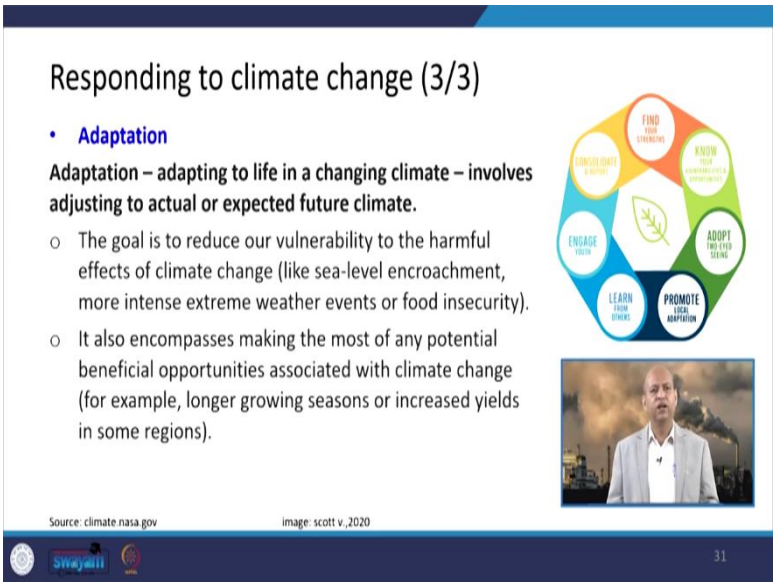
mitigation, reducing emissions and destabilizing the levels of heat trapping greenhouse gases in the atmosphere. Second is adaptation, adapting to the climate change already in the pipeline.

(Refer Slide Time: 24:11)



So, the mitigation basically has like in pipeline, for example, we can reduce the burning of the fossil fuel by shifting our energy needs towards like renewable resources like solar, etc. And the goal of mitigation is to avoid basically the significant human interference with the climate system, so that this greenhouse gas emissions can be stabilized.

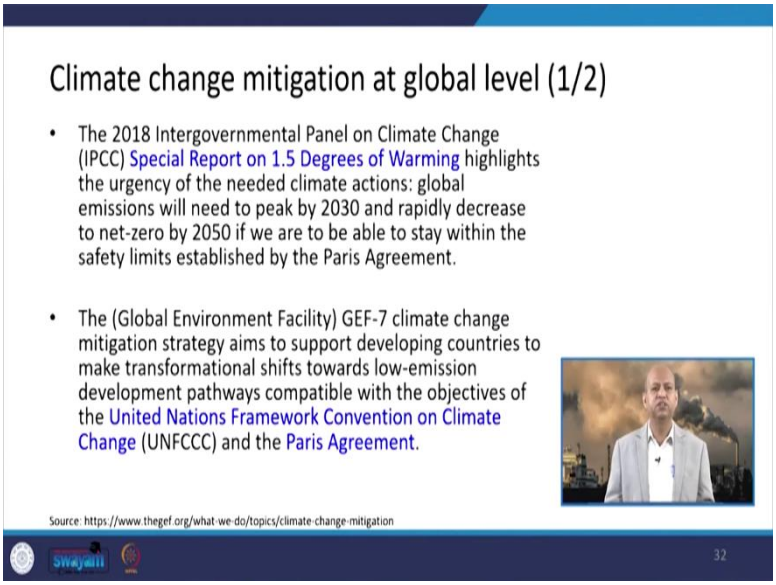
(Refer Slide Time: 24:36)



And then adaptation is like whatever changes are there, we have to think about so that the harmful effects can be minimized. And the goal is to reduce the vulnerability of the population

in terms of these harmful impacts of the climate change, like the sea level encroachment. So, we can have some structures which can protect people who are near to the seashore etc. It also encompasses like making the most of any potential beneficial opportunities associated with climate change, like longer growing seasons or increase deals in some regions are there, so, regional related policies can be framed.

(Refer Slide Time: 25:33)

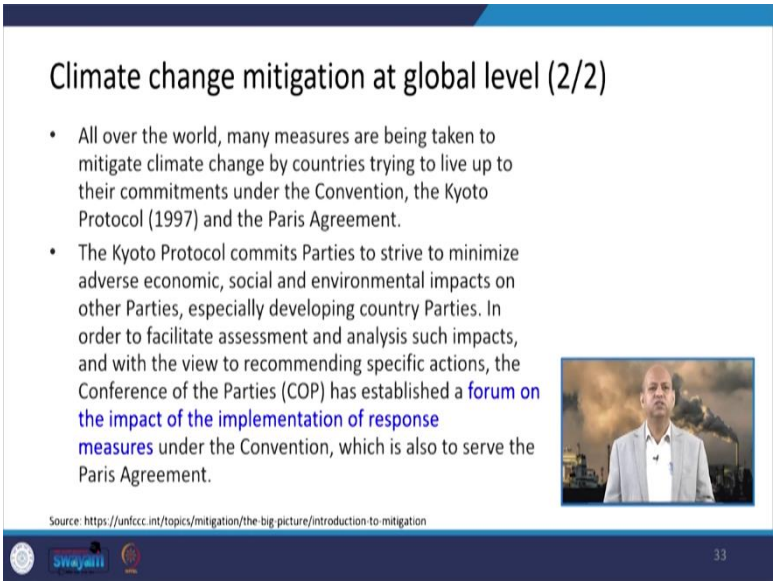


Well, when we talk about climate change mitigation at the global level then there have been several initiations and several bodies have emerged over the years like in 2018 this Intergovernmental Panel on Climate Change (IPCC) especial report on 1.5 degree of warming, this was highlighted and it was agreed that we should control this, like temperature we should not allow to increase the global temperature beyond this 1.5.

And these emissions will need to be peak at that 2030, beyond that, we cannot afford it. And rapidly decrease to net-zero by 2050. So, that kind of policies technological interventions, we have to have in different countries. So, for that Paris Agreement was signed by so many countries basically.

Then the Global Environment Facility, they have 7-climate change mitigation strategy, aim to support developing countries to make transformational shift towards low emission development pathways compatible with the objectives of this UNFCC and Paris Agreement related policy plans.

(Refer Slide Time: 26:33)

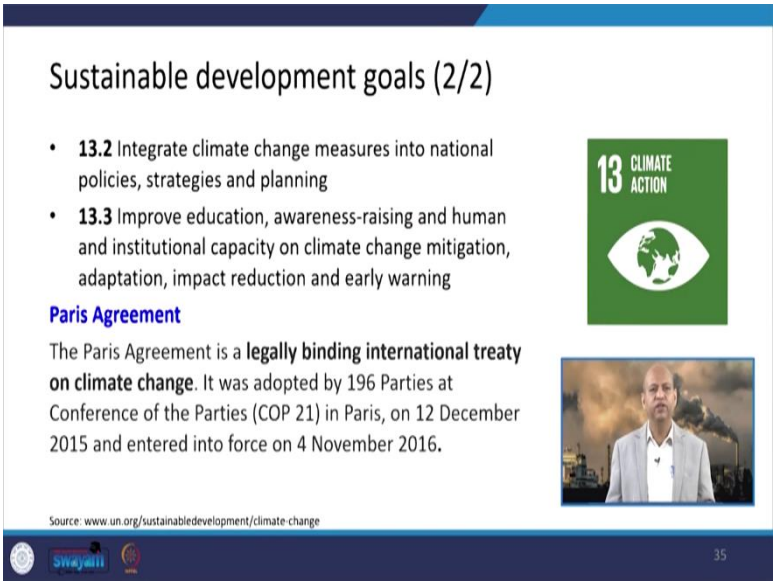


Then, you can see like, there are these Conference of the Parties. So, they meet after some time periodically, and they discuss what they can do, there are pledges, there are commitments, every country wants to honor. So, in that sense India has done very well.

(Refer Slide Time: 26:52)

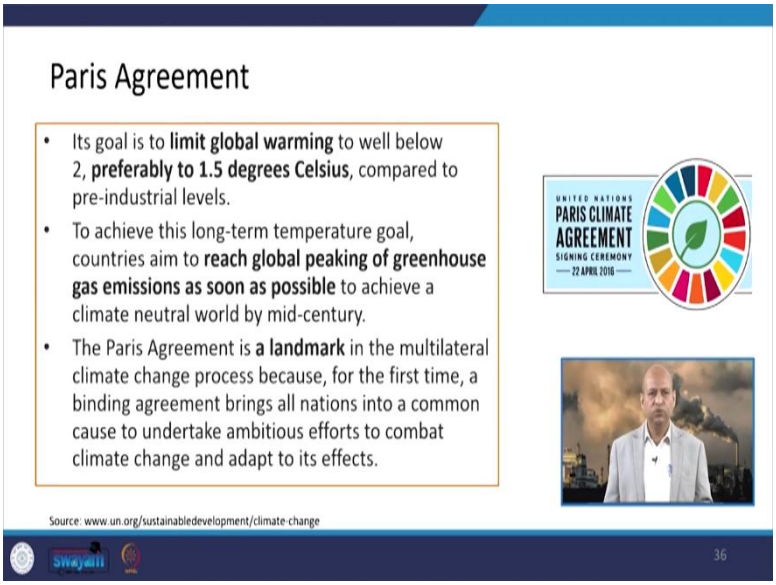
Basically, and these are the Sustainable Development Goals, which also include this global goal number 13, which includes like to take urgent action to combat climate change and its impacts. So, basically it has like strengthening, resilience and adaptive capacity to climate raised, climate related hazards and natural disasters in all countries.

(Refer Slide Time: 27:16)



Then integrate climate change measures into national policies, strategies and planning and improve the education awareness reaching and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. So, Paris Agreement has done legally binding international treaty on climate change and it was adopted by 196 parties at Conference of Parties (COP 21), in Paris in 2015 and it was entered into force in 2016 basically.

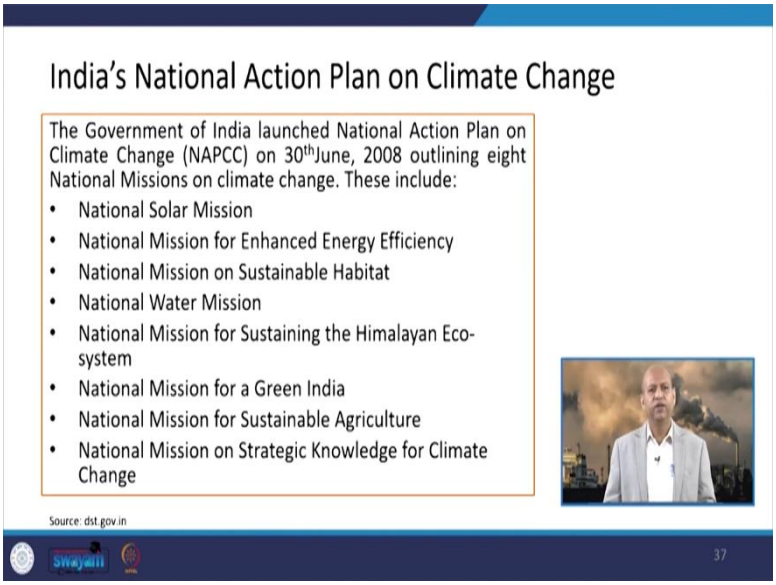
(Refer Slide Time: 27:51)



So, with this, this has like its goal is to limit global warming to well below 2 degrees Celsius, preferably 1.5 degrees Celsius, compared to pre-industrial levels, whatever temperature it was. So, beyond that try it should not exceed basically, if we want to keep our Earth safe. And to achieve this long-term temperature goal, countries aim to reach global peaking of these

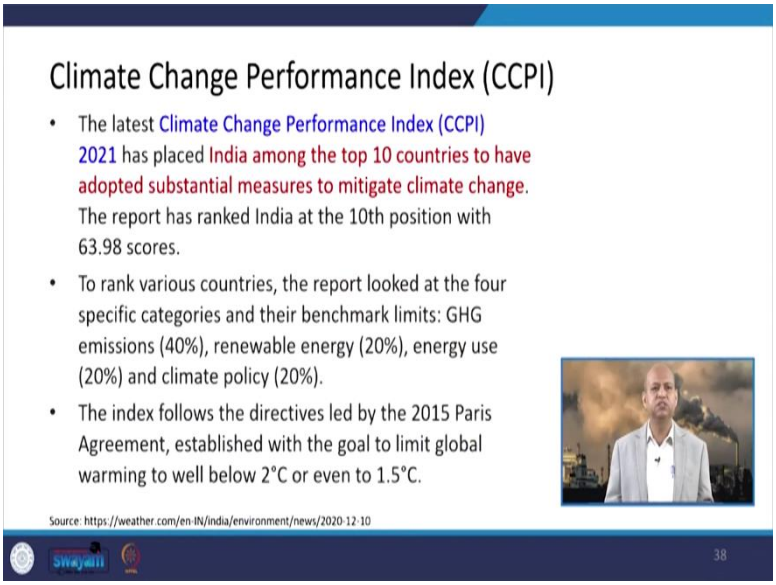
greenhouse gas emissions as soon as possible. So, in that direction many landmark multilateral climate change processes, and has been taken into place including Paris Agreement.

(Refer Slide Time: 28:30)



Like if we talk about India's National Action Plan on Climate Change. So, scenario is very encouraging, this government of India Launched National Action Plan on Climate Change (NAPCC) on 30th June 2008, and outlining eight major national missions on climate change related issues. And these include like national solar mission, national mission for enhanced energy efficiency, National Mission on sustainable habitat, National Water mission, national mission for sustaining the Himalayan ecosystem, then National mission for a green India, national mission for sustainable agriculture, National Mission on strategy knowledge for climate change. So, these are the very active national missions this government of India is working on that.

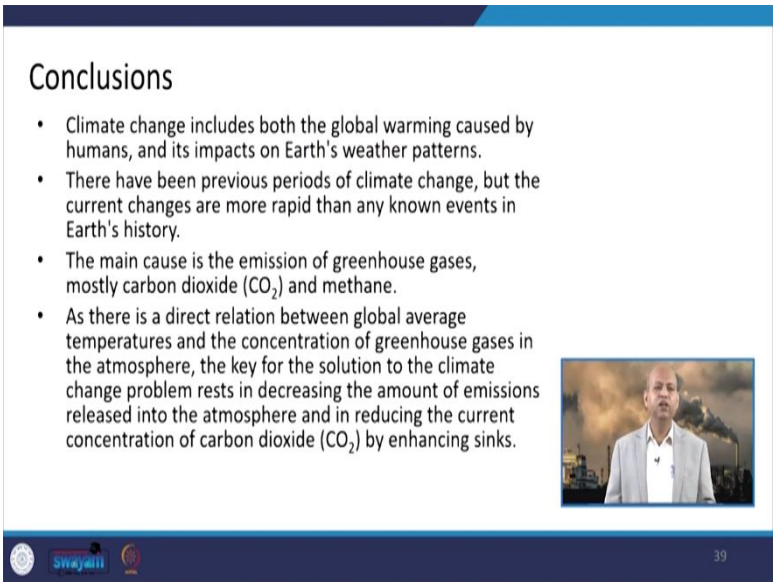
(Refer Slide Time: 29:30)



If you talk about its impact, like what is the progress from Indian perspective at the global level, then very happy scenario is there the latest Climate Change Performance Index (CCPI) 2021. It has placed India among the top 10 countries to have adopted sustainable measures and substantial measures have been taken into to mitigate climate change related problems.

And to rank various countries, the report looks at the four specific categories and their benchmark limits like greenhouse gases emissions, up to 40 percent weightage was there. Renewable energy related efforts if made then 20 percent, energy use related 20 percent, and climate policy related 20 percent. So, in all these weightage India has figured out very well.

(Refer Slide Time: 30:09)

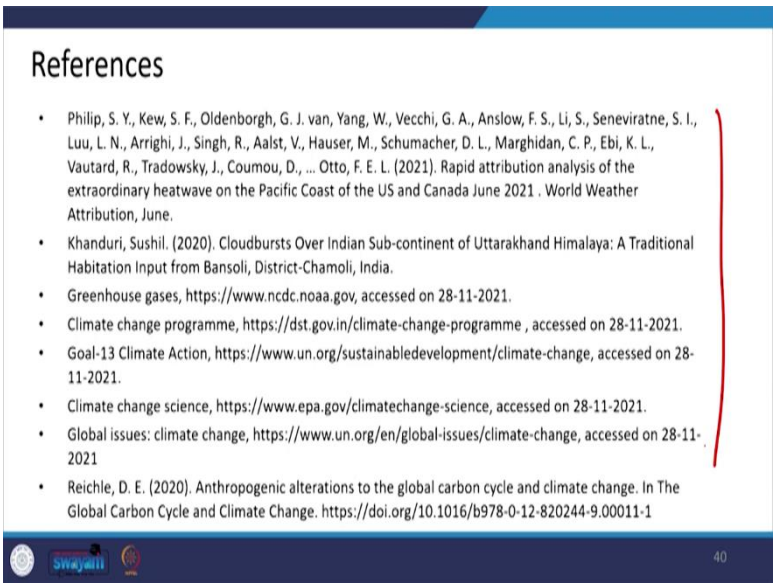


Well, in conclusion, we can see that this climate change includes both global warming caused by human as well as because of natural systems, but this human made or manmade or anthropogenic regions are very predominant and we have to do something to reduce greenhouse gas emissions so that we can stabilize this temperature of the global atmosphere. And the main cause is because of greenhouse gas emissions, so, we have to reduce them, we have to shift our energy needs from this fossil fuel or carbon economy to the renewable energy resources.

And as there is a direct relation between global average temperature and the concentration of greenhouse gases in the atmosphere, so, the key solution for the climate change is to reduce the emissions of the greenhouse gases and the reduction of emissions means, shifting energy needs, or shifting energy sources. So, like India is shifting a lot of energy sources from these fossil fuel to solar and wind and many other renewable resources basically.

There are also plans like shifting transportation fleet to battery base fleet. So, that way the emissions of greenhouse gases will be reduced significantly and we will have a better future, this is something which we can foresee because of these efforts, which we are making at the country level and at the global level.

(Refer Slide Time: 31:39)



So, this is all for today and references are given for your extra reading, you can go through that in free time. So, thank you for your kind attention, and see you again in the next lecture. Thanks.