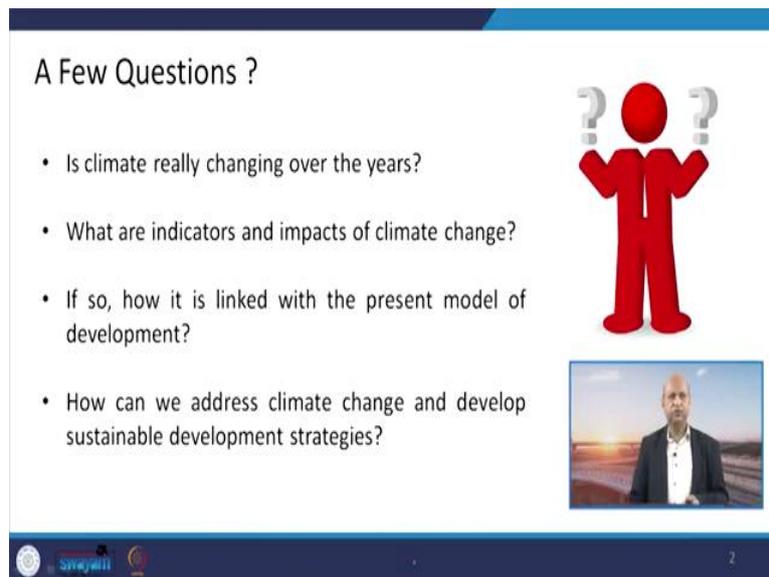


Sustainable Transportation Systems
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology Roorkee
Lecture 05
Climate Change: Indicators and Impacts

Hi friends. So, you may recall last time we discussed about three major components of sustainable development which are social, economic and environmental. When we talk about environmental impacts of transportation activities or even any other kind of economic activities done by human beings, then climate change is a big debate or big topic which people talk about very frequently.

So, today we will discuss about what is climate change and what are its drivers, what are its indicators and how does it impact our life and how, means we will try to relate it with the transportation activities that is part of anthropogenic activities or human activities.

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A Few Questions ?

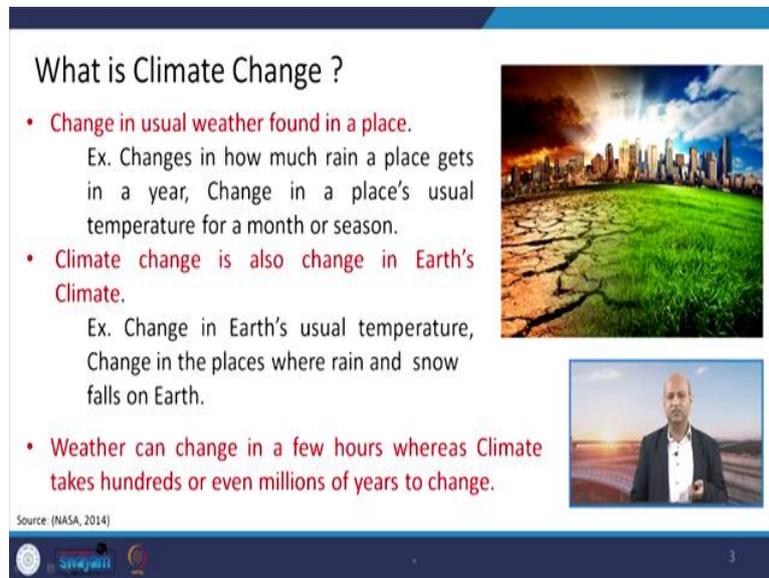
- Is climate really changing over the years?
- What are indicators and impacts of climate change?
- If so, how it is linked with the present model of development?
- How can we address climate change and develop sustainable development strategies?

The slide features a red 3D stick figure holding two question marks above its head. Below the figure is a small inset video frame showing a man in a suit speaking. At the bottom left, there are logos for IIT Roorkee and Swayam. At the bottom right, the number '2' is visible.

So, when we talk about climate change then some questions are very pertinent like climate is really changing or is it just a perception or a kind of very general idea? And what are different indicators or impacts of the climate change if climate change is really happening? In addition to that, the present development model, does it contribute to the climate change or climate change is occurring due to some natural reasons without any contribution of the development activities or human activities?

And if climate change is the real issue, then how can we address those aspects of climate change which are directly or indirectly affecting us? So, these are some questions which will be answered while we go through this today's lecture.

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What is Climate Change ?

- **Change in usual weather found in a place.**
Ex. Changes in how much rain a place gets in a year, Change in a place's usual temperature for a month or season.
- **Climate change is also change in Earth's Climate.**
Ex. Change in Earth's usual temperature, Change in the places where rain and snow falls on Earth.
- **Weather can change in a few hours whereas Climate takes hundreds or even millions of years to change.**

Source: (NASA, 2014)

The slide features two images: a large one showing a city skyline with a cracked, dry landscape in the foreground, and a smaller one showing a man in a suit speaking.

First of all, what is climate or how does it change? So, in day to day life we talk about weather is hot or weather is cold, so in day to day life when these metrological parameters like temperature, humidity, precipitation, all these things change then we call it weather. But over the years, means like centuries 100s or 1000s of years if we average it out and we find that at certain locations these weather patterns are having a particular trend then we call it a climate.

So, climate is a kind of thousands of years average of the weather, you can call indirectly that way. So, when it changes, then we have to see the parameters in long term. If we want to observe the climate change issues then we have to see it in long term because weather changes may be there, like today it may be very hot day and tomorrow it maybe little colder, so that does not mean that world is cooling world is warming up, we cannot say like that.

But if we observe over the years, some data of the temperature or precipitation or any other events, and then we do some sort of time series analysis, then we can say that this climate change is happening whether good or bad that is another issue.

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How is Climate Changing ?

- **Natural reasons (Not Controllable)**
 - Earth's distance from the sun
 - Oceans, Volcano eruptions etc.
- **Humans (Controllable)**
 - Anthropogenic activities.
 - GHG emissions.



Source: (NASA, 2014)

So, how does it happen? So, there are two reasons basically. One is natural like Earth's distance from the sun and Earth is tilted as you know, so the solar insolation is not uniformly distributed around the Earth. Somewhere it is more, and in other parts it is less. And also Sun's activity also varies. So, there are natural reasons of climate change.

Plus there are contributions of natural happenings like oceans activities or volcanic eruptions or those kind of things, but then there are contributions by human activities which are controllable, means natural reasons we cannot control. That is happening and that is being taking place since centuries and millennium kind of things.

But human activities which are governed by our own economic models or our political policies, those things can be controllable, so those are anthropogenic activities means man made activities and especially the greenhouse gas emissions. Why it is so? Because you might be knowing that greenhouse gases have the tendency of trapping the long wave radiation which goes out of the Earth's surface. So, it traps and it warms up the atmosphere and below the atmosphere.

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Is Global warming manmade ?

- The amount of solar energy received by the Earth has followed the Sun's natural 11-year cycle of small ups and downs **with no net increase** since the 1950s.
- Over the same period, global temperature has risen markedly.

It is therefore **extremely unlikely** that the Sun has caused the observed global temperature warming trend over the past half-century.

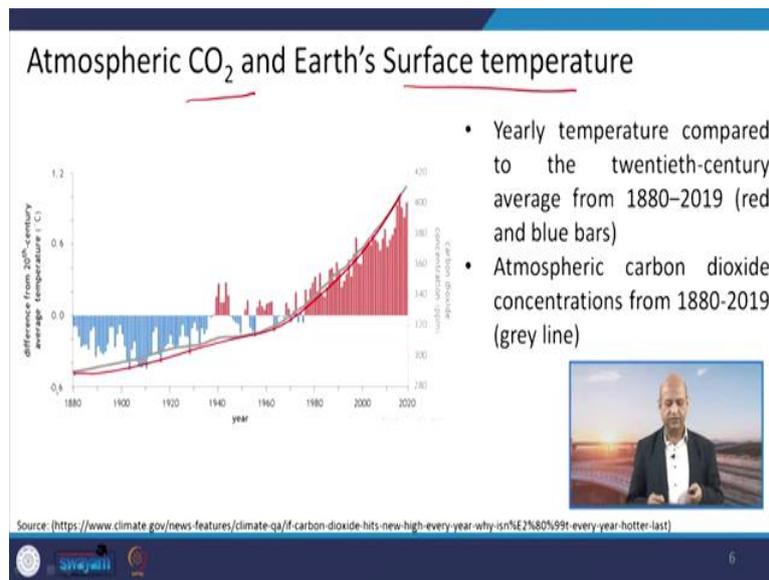


Source: (NASA, 2020. https://climate.nasa.gov/climate_resources/189/graphic-temperature-vs-solar-activity/)

Well, if we want to try to relate it with the temperature and solar activity then you will see that these are the solar activities which are varying and like within some 11-year data if we see or 11-year's cycle then we see that no net increase is there, it is just sometimes it goes up, sometimes it goes down but the temperature is increasing, so that is one indicator.

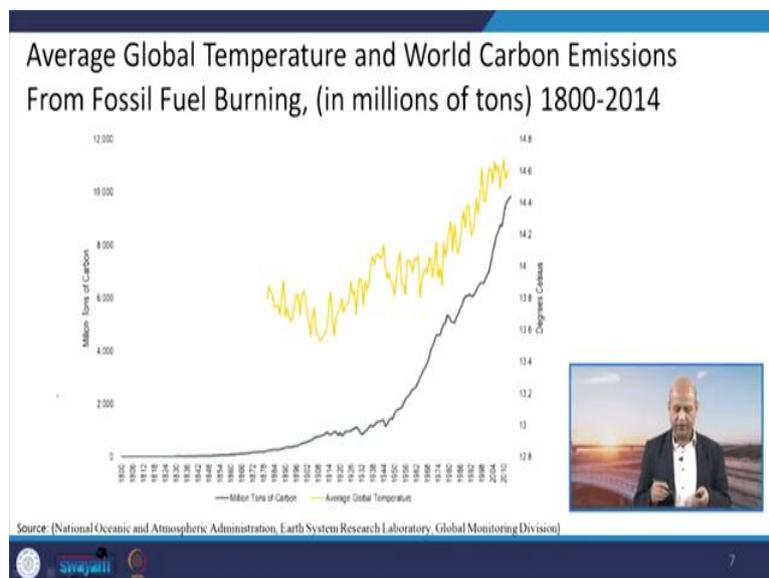
How temperature is increasing? Like from 1880, means soon after this industrialization happened, steam engine, lot of fossil fuel burning started, so from that era we can relate that as we are emitting lot of greenhouse gases, carbon dioxide etc., the temperature is also rising. It is not linear of course, but there is a trend, means sometimes it goes up and down. There are so many variables, we cannot expect that it would just go in a linear fashion, but of course, there is a trend of increasing.

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So, here you can see this carbon dioxide concentration is increasing over the years in last two centuries and this difference between the average temperatures is also increasing.

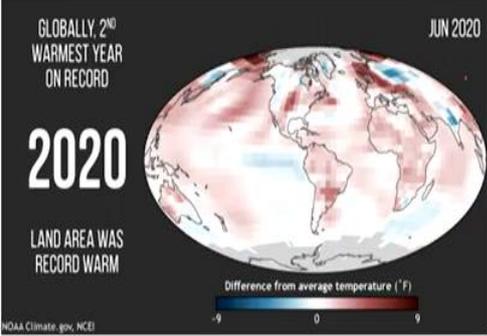
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Here it is more clear, you can see like this Average Global Temperature and World Carbon Emissions from Fossil Fuel Burning, so the emissions are increasing, this grey line and this temperature has this increasing trend. So, means there is a kind of relationship and not only these emissions have air pollutants but greenhouse gases also which are the real culprit of increasing the global warming or temperature.

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2020: 2nd Warmest Year on Record



- 2016 was the warmest year on record and 2019 the 3rd warmest.
- World's 7 warmest years have all occurred since 2014.
- World's 10 warmest years have all occurred since 2005.

NOAA Climate.gov, NCEI

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Well, if you see, the warmest years when temperature was highest, so if we compare from earlier temperature record, you can see in 2016 it was the warmest year, on record and then 2019 the third warmest, so the 7 warmest years have all occurred since 2014, so earlier it was not that kind of frequency that so frequently warm years are happening. And then, the 10 warmest years have all occurred after 2005 that means the rate of increase of global average temperature is also increasing.

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Climate Change Drivers

Greenhouse Gases (GHG)

- Most significant driver of observed climate change since the mid-20th century
- GHGs resulting from human activities- **Electricity, Transportation, Agriculture, Commercial & Residential**
- When comparing emissions of different gases, the concept called "global warming potential" is used to convert amounts of other gases into carbon dioxide equivalents.



Source: (USEPA, <https://www.epa.gov/climate-indicators/greenhouse-gases>)

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Now, there is a clear cut relationship of greenhouse gases and this Global Average Temperature, this has been established by several researchers, so we need to see what are the drivers of climate change and one of the major drivers is the greenhouse gas emissions.

That is again from different human activities, whether it is from industries or coal power plants or thermal power plants and transportation activities, or agriculture, livestock, everything, they can contribute to greenhouse gas emissions. So these are the basic drivers and they can come from different sectors.

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Climate Change Drivers: Major GHGs and its Characteristics

| Greenhouse gas | Sources | Average lifetime | 100-year GWP |
|-------------------|---|-------------------------|----------------------|
| Carbon dioxide | Burning of fossil fuels, solid waste, and trees and wood products, Deforestation and soil degradation | Varies* | 1 |
| Methane | Production and transport of oil, natural gas & coal, Livestock and agriculture, waste decomposition | 12.4 years** | 28-36 |
| Nitrous oxide | Agricultural and industrial activities, Combustion of fossil fuels and solid waste. | 121 years** | 265-298 |
| Fluorinated gases | Industrial processes and commercial and household uses | Few weeks to 1000 years | Varies upon the gas) |

*CO₂ may get absorbed quickly (ocean surface) or may remain even thousands of years

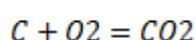
**Perturbation lifetimes



Source: (USEPA, <https://www.epa.gov/climate-indicators/greenhouse-gases>)

When we see like not only the CO₂ but we talk about greenhouse gas means all those gases which has this potential of warming up the atmosphere, so they are many, like carbon dioxide, methane, nitrous oxide, and then other like CFCs and other gases. If we assume carbon dioxide's global warming potential as 1, then we find that methane's potential is around 28 to 36 times and nitrous oxide, it is 300 times more global warming potential it has in comparison to the carbon dioxide.

And there are various sources, like carbon dioxide from any kind of burning activity, whatever fuel you burn, then CO₂ has to be there because oxidation occurs and because of oxidation all these organic matters have carbon, so

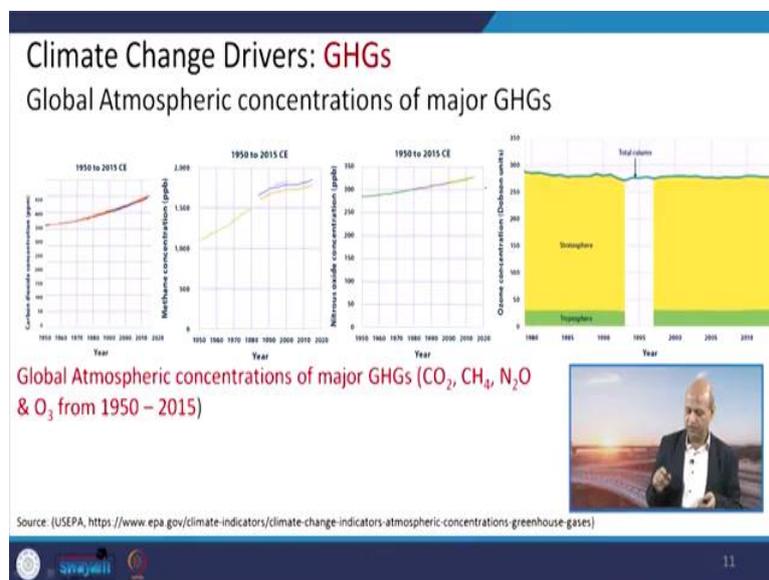


is there, then methane maybe like from anaerobic digestion or some other activities like natural gas or coal extraction, livestock, agriculture activities.

Nitrous oxide also, that is also emitted by agricultural practices or fertilizers and manure activates, then some from combustion of fossil fuels and solid waste also. And industrial processes they have other emissions like CFCs, etc. Even water vapour is also greenhouse gas, ozone is also greenhouse gas.

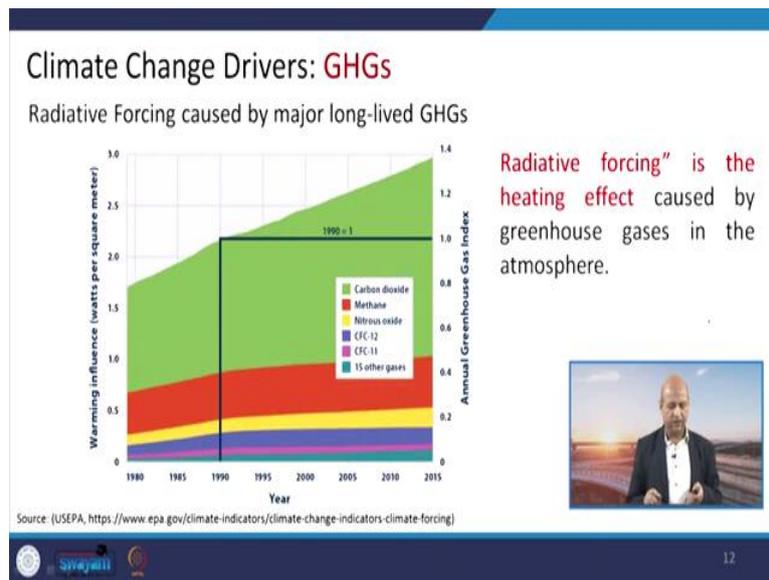
Although ozone is not a primary gas or pollutant, it is a secondary pollutant you can say in the troposphere where we are living and it is because of these ozone precursors like NO_x and CO, these produce ozone because of photochemical reactions in the presence of sun light. But in stratosphere ozone is good because it protects us from ultraviolet rays, but in troposphere it is problematic, it is air pollutant as well as the greenhouse gas.

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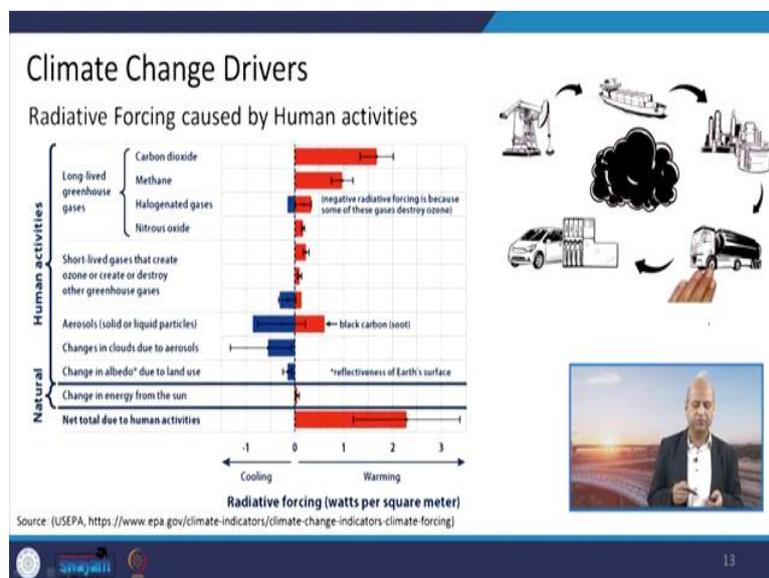
If we want to see like major greenhouse gases like CO₂, methane and N₂O, and ozone, then you see all these gases are increasing like CO₂, methane and N₂O, but in stratosphere and then this ozone and this troposphere green colour, this is the lower layer, in troposphere it is very less amount, the major amount of the ozone is in stratosphere itself, so that is almost constant, that is not making much difference.

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But if we see radiative forcing, which really contributes to the temperature increase, so the carbon dioxide has the maximum radiative forcing and after that this is methane and then nitrous oxide, and then CFC12, CFC11, all those, so radiative forcing is the real cause of increasing the temperature.

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Then if you want to see because radiative forcing can be plus or minus, means it can increase the temperature or it can decrease the temperature, accordingly this figure shows. For example, particulate matters or aerosols, if they are sulphate aerosols, light colour aerosols, they reflect the solar insulation, radiation, so it reduces the temperature you can say, but black

carbon, all those dark colour aerosols which captures the heat then it increases the temperature.

So, the positive one red colour, negative one is blue colour, so you can see different gases has like carbon dioxide has positive radiative forcing but some gases which destroy ozone, because ozone formation and destruction occurs very quickly and it is a cyclic process, so those gases can contribute negatively also, plus as I said that some aerosols which reflects the lights they can also contribute negatively, but ultimately the forcing is positive, the forcing is positive, if you calculate, the sum total is positive.

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Climate Change Indicators

Weather and Climate

- Rising global average temperature is associated with widespread **changes in weather** patterns.
- **Extreme weather events** such as heat waves and large storms are likely to become **more frequent or more intense** with human-induced climate change.
- **Long-term changes** in climate can directly or indirectly affect many aspects of society.
- **Extreme variations** in weather are also a threat to society- Illness to Death

Source: (USEPA, <https://www.epa.gov/climate-indicators/weather-climate>)

Then there are indicators like climate change happens not only in terms of global warming but there are extreme weather patterns, recently you might have observed this, in coastal regions there were strong storms and their frequency is increasing, local level, means you might have heard in TV, local people they say that we never so frequently and so intensive these storms which are occurring now-a-days and scientists, these weather scientists and meteorologist, they link it with the climate change issues. Because of climate change their frequency is increase, their intensity is also increasing. Then there are other events which we will look in later slides.

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Climate Change Indicators

Weather and Climate

- **Increased precipitation** can replenish water supplies and support agriculture (**Positive effect**)
- **Intense storms** can damage property, cause loss of life and population displacement, and temporarily disrupt essential services such as transportation, telecommunications, energy, and water supplies (**Negative effect**)

Source: (USEPA, <https://www.epa.gov/climate-indicators/weather-climate>)

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Like increased precipitation, precipitation can be increased or decreased, means it is not the uniform effect, for example, air pollution also plays role, like small particles which act as the nucleus for the cloud formation, if it is very-very fine particles, then the clouds, these droplets will be small and they will have tendency of hanging around, they will not precipitate very frequently, but aerosols or particles are larger size, then larger droplets maybe there and there are chances of more rain.

So, similarly, means because of this non-uniform distribution of temperature, etc., precipitation may occur in different ways, and it may be like very high rain within small period, so lot of flood occurs, storm water does not drain out very quickly, so these kind of frequent events, which disrupt our life, they are also related to the climate change.

So the intense storms or increased precipitation of even decreased precipitation, means as I said it is not uniform, somewhere it may suppress the precipitation, somewhere it can increase and flood maybe there and these kind of storms maybe there, which Tornados, etc., and they may be very-very disastrous.

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Climate Change Indicators: Oceans

- Covers about 70% of Earth's surface
- Changes in weather can influence the weather from local to global scales and can alter many properties of Oceans
- As GHGs absorb more energy from the sun, Oceans absorb more heat, resulting in an increase in sea surface temperatures and rising sea level.
- Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns around the world.



Source: (USEPA, <https://www.epa.gov/climate-indicators/oceans>)

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Well, oceans, they are also one big part of CO₂ sink. Oceans as you know, this is very simple science that these gases are absorbed by water and it is dependent on temperature also. So CO₂ is absorbed by oceans, so this is a big sink but it also increases the temperature because of global warming, so sea level rise is happening, some coastal regions are having some troubles.

And if temperature increases there are some hypotheses that at some point this temperature may increase so much that this dissolved CO₂ from oceans may get emitted into the atmosphere, that would be very disastrous kind of thing, because more CO₂ will increase, more GHG related effect of global warming and then it will increase the emissions of more CO₂ from the oceans and more temperatures, so that maybe very disastrous and that situation should be prevented.

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Climate Change Indicators: Oceans

- Oceans help reduce climate change by storing large amounts of carbon dioxide (Positive effect)
- Increasing levels of dissolved carbon are changing the chemistry of seawater and making it more acidic (Negative effect)
- Could substantially alter the biodiversity and productivity of ocean ecosystems (Negative effect)
 - Ex. Increased ocean acidity makes it more difficult for certain organisms, such as corals and shellfish, to build their skeletons and shells.



Source: (USEPA, <https://www.epa.gov/climate-indicators/oceans>)

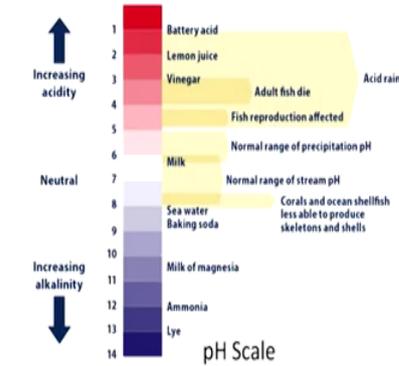
17

Well, positive effect and negative effect in the sense like carbon dioxide is absorbed that is positive effect but negative effect because it can change its chemistry because CO₂, this H₂CO₃ is formed by reaction with the water (H₂O) and then it can increase the acidity of the oceanic waters and aquatic life may be affected by it because after certain acidity there are several kind of fishes which die, so those are the negative effects because of acidity.

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Climate Change Indicators: Oceans

Ocean Acidity



- Measurements over the last few decades have demonstrated that ocean carbon dioxide levels have risen in response to increased carbon dioxide in the atmosphere, leading to an increase in acidity (a decrease in pH)



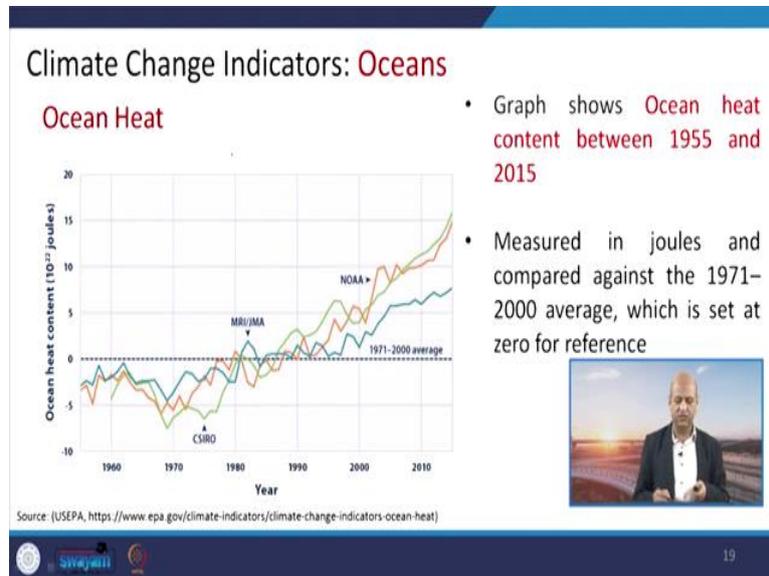
Source: (USEPA, <https://www.epa.gov/climate-indicators/climate-change-indicators-ocean-acidity>)

18

And acid rains which is linked with the air pollution, which is again from transportation sector because we have so many types of air pollutants coming out of tail pipes. Well, this is again just representation of like acidity increasing, this is neutral and like milk, how much

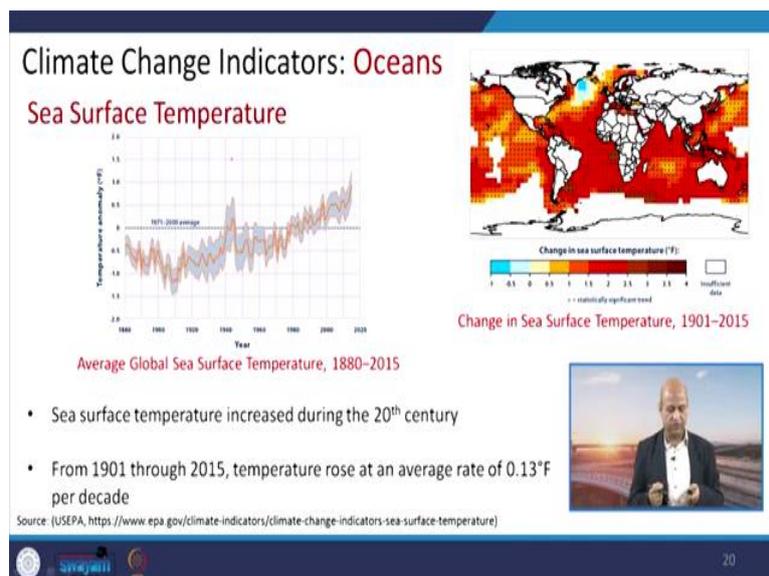
they have this pH level, and then vinegar, battery acid, this is just representation and if oceans have more acidity then it is a problem.

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Heating problem which again there are observatories where temperature have been observed and it was found that this temperature is increasing over the years of the ocean water also and as I said if it will increase more than it will not be able to have more CO2 absorbed by ocean waters.

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So, average global sea surface temperature from 1880 to 2005 it is being shown here, and this line is 1971-2000 average, so before this 1960 or so, it was quite lower than this average but

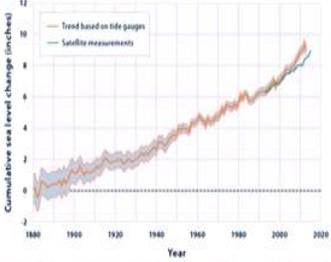
after 1980 and after 2000 it is beyond this particular average line, so the effect is distributed and it is shown over the globe.

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Climate Change Indicators: Oceans

Sea Level

- The Global average sea level rose throughout the 20th century, and the rate of change has accelerated in recent decades.
- (Absolute sea level has risen at an average rate of **0.06 inches per year from 1880 to 2013**)
- **Since 1993**, the average sea level has risen at a rate of **0.11 to 0.14 inches per year**—roughly **twice as fast as the long-term trend**.



Global Average Absolute Sea Level Change, 1880–2013



Source: (USEPA, <https://www.epa.gov/climate-indicators/climate-change-indicators-sea-level>)

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Then sea level, because of global warming and temperature difference and glaciers are melting, more water is going to the sea, and these coastal regions are being threatened by the sea level rise and this is happening like from 1880 to 2013, if we do the average then 0.06 inches per year sea level rise has occurred, but if we look it from 1993, then this value is around doubled, 0.11 to 0.14 inch per year. So, that means we are in this particular phase where global warming is doing its effects very intensively.

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Climate Change Indicators: Snow and Ice

- Earth's surface contains **many forms of snow and ice** including sea, lake, and river ice; snow cover; glaciers, ice caps, and ice sheets; and frozen ground.
- Climate change can dramatically alter the Earth's snow- and ice-covered areas in response to relatively minor changes in temperature.
- Reduced snow and ice can influence air temperatures, sea level, ocean currents, and storm patterns

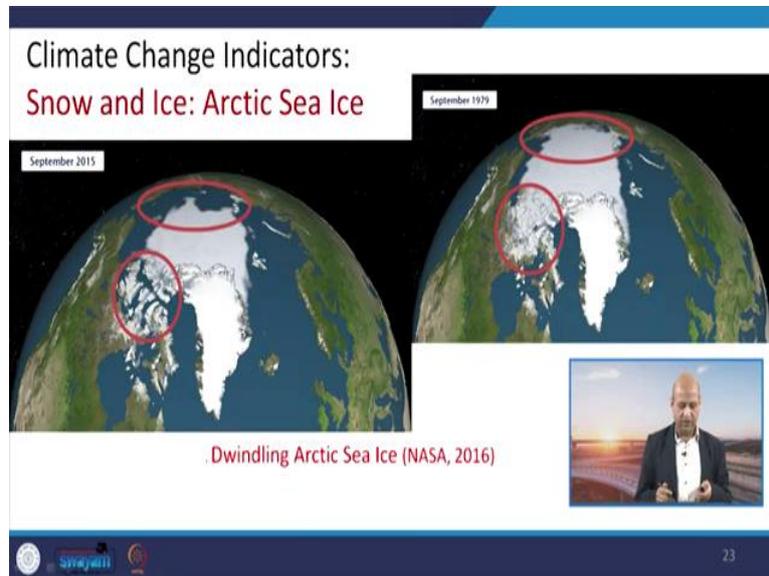


Source: (USEPA, <https://www.epa.gov/climate-indicators/snow-ice>)

22

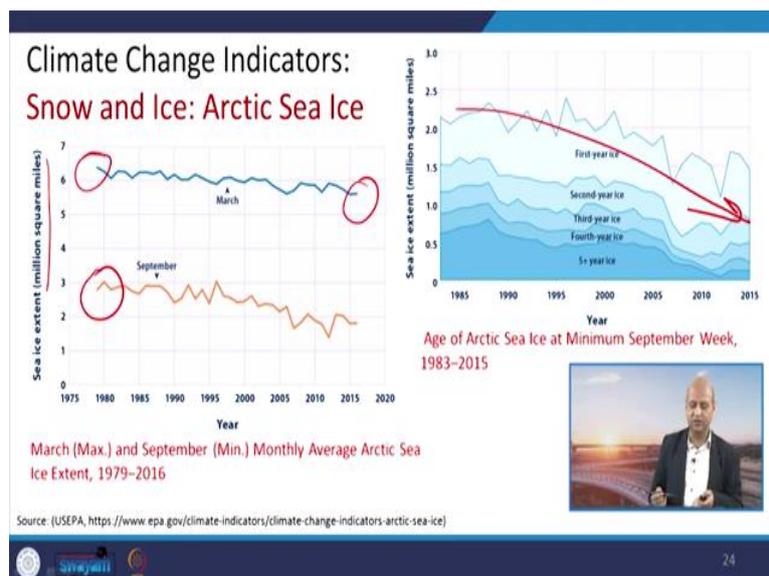
Then there are snow and ice glaciers, etc., which are also affected by climate change and global warming.

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And you can see in 2015 these satellite images of arctic sea ice is shown here, but earlier in 1979 it was bigger area, it is now, there have been very less ice, so this melting of ice and glaciers they are having very big impact on our climate and our even, agriculture like those rivers, etc., which are fed by the glaciers they are affected very negatively.

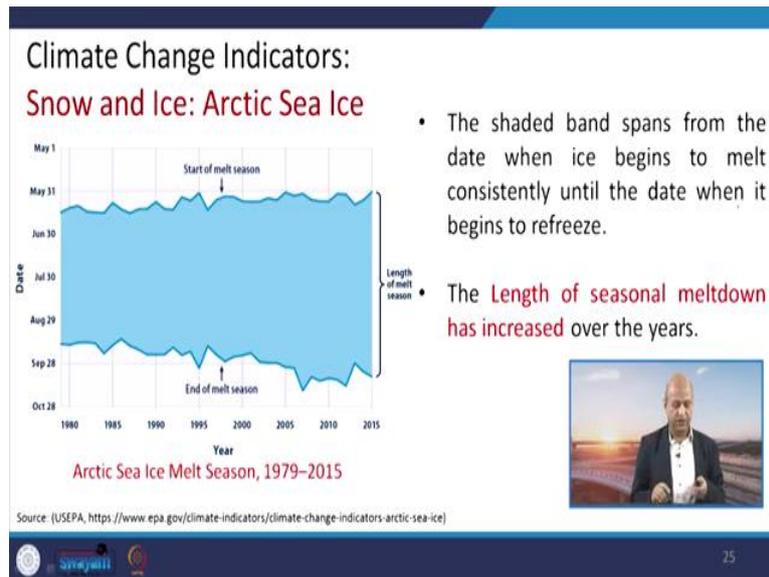
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Now, you see this million square miles area which is covered in different months like in March it used to be here more than 6, now it is less than 6 in 2015, so 1980 to 2015 that much

difference is there. Similarly, for September also, this average value which was around 3, now it is around 2, so that means the covered area is decreasing, glaciers are receding. Similarly, difference layers if you see 5 plus year rise or third, second, first, all these are in a decreasing trend. So, thickness is decreasing, so these are the indicators which show that big global change is happening around us and we should be aware, we should not ignore it.

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Now, if you want to see this month and dates when this arctic sea ice used to start melting, this was around June 15 or so, you can after May 31st and now it is starting around 31st May, means 15 days advanced, and when end of the melting season, it used to be in between like maybe 15th or 16th September, now it is beyond September means around maybe 10 or 15 October. So, this whole stretch has increased, the season has increased where melting starting and melting closing or stopping, so these are the big changes which we can observe.

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Climate Change Indicators:

Snow and Ice: Glaciers

- Glaciers worldwide have been losing mass since at least the 1970s, contributed in sea level rise significantly.
- The rate at which glaciers are losing mass appears to have accelerated over roughly the last decade.

Average Cumulative Mass Balance of Glaciers Worldwide, 1945–2015

Source: (USEPA, <https://www.epa.gov/climate-indicators/climate-change-indicators-glaciers>)

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Then glaciers we have already seen that they are receding over the years.

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Climate Change Impacts: Health and Society

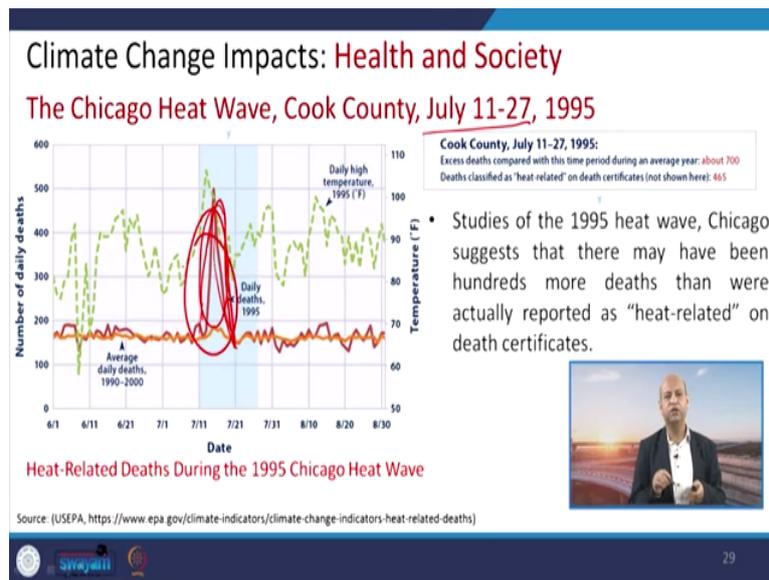
- Changes in the Earth's climate can affect public health, agriculture, water supplies, energy production and use, land use and development, and recreation.
- Impacts on human health are complex and mostly indirect, and dependent on multiple societal and environmental factors (including how people choose to respond to these impacts)
- The development of appropriate health-related climate indicators is challenging and still emerging.

Source: (USEPA, <https://www.epa.gov/climate-indicators/health-society>)

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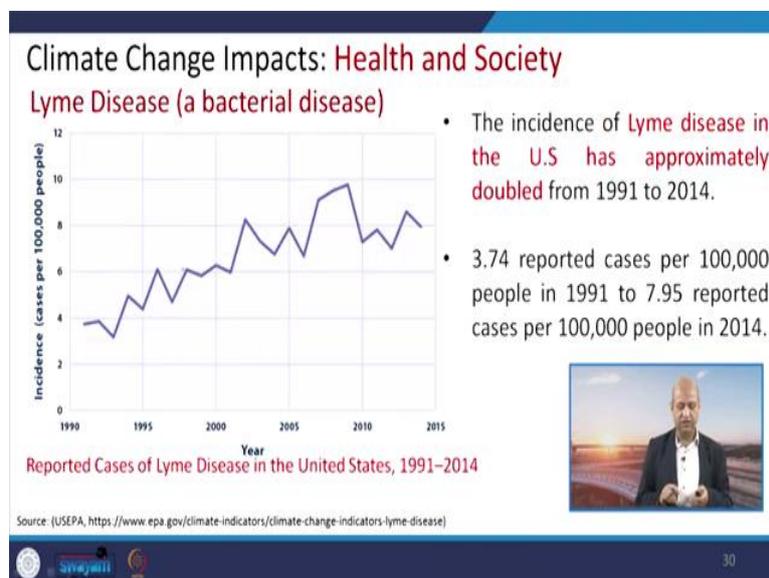
And if we want to see the human health effects or societal effect or social impacts, they are also drastic because like if heat waves are there then many people die because of heat waves, those are vulnerable, who are having some health issues, so those kind of data are also there, we will look at that. Even agricultural production is also affected; if ozone is there then it can reduce the yield of the crops. So, those kind of effects are also there.

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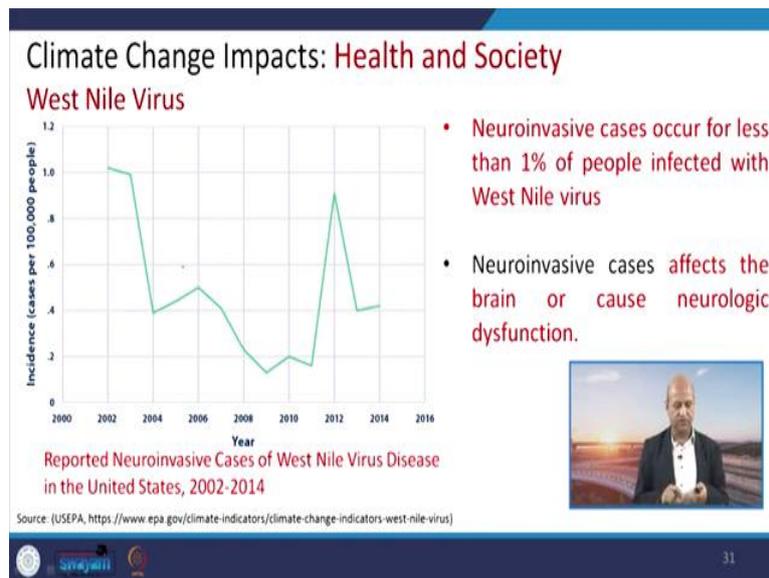
And these are the data like in 1995 from July 11 to 27, you can see like this yellow line is the average value of people used to die, daily death data and this brown color, maroon color is like peak, so this particular data because of heat wave so many people died, extra people died, so that can be related to the heat wave.

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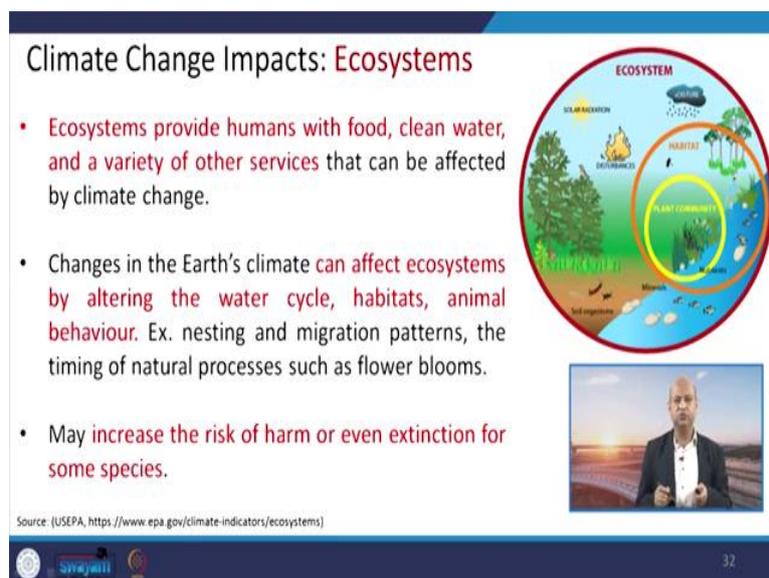
Similarly, this bacterial disease, Lyme disease which is a kind of a skin disease which also increased, they have been increased over the years because of some relationship with the change in the temperature, relationship with the bacteria and those kind of things.

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Nile virus also has shown some relationship with the temperature and spread over the area.

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You can see the ecosystems, so ecosystems have been affected and those are the ecosystems, all ecosystems are basically our source of everything, our life is dependent on ecosystems, whether it is food or water, all kind of natural services we derive from ecosystems and ecosystems have a balance from 1000 of years, if those balance is disturbed, then if some ecosystem ruptures or disrupts, its complete dependent, all population can be affected very negatively whether it is human being or animal, etc.

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Climate Change Impacts: **Ecosystems**

Wildfires



- Very intense Wild fires can significantly disrupt ecosystems, damage property, put people and communities at risk, and create air pollution problems even far away from the source.



Source: (USEPA, <https://www.epa.gov/climate-indicators/ecosystems>)

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So we have to be very careful, for examples, wildfires, there are some data that in some forest this occurrence of fire is also increasing, and this is also again linked with the temperature because of climate change. So, all these ecosystems have risks due to climate change.

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Climate Change Impacts: **Ecosystems**

Streamflow



- Changes in temperature, precipitation, snowpack, and glaciers can affect the rate of streamflow and the timing of peak flow.



Source: (USEPA, <https://www.epa.gov/climate-indicators/ecosystems>)

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Similarly, streamflow maybe changed, means, again as I said these, whether it is streams or rivers or big ecosystem in a particular location, they have balancing apt over the years and if it is disrupted by climate change then the dependent population of different species will be completely disrupted.

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Climate Change Impacts: Ecosystems

Bird Wintering Ranges

- Some birds shift their range or alter their migration habits to adapt to changes in temperature or other environmental conditions.

Ex. Long-term studies have found that bird species in North America have shifted their wintering grounds northward by an average of more than 40 miles since 1966, with several species shifting by hundreds of miles.

Change in Latitude of Bird Center of Abundance, 1966-2013

Source: (USEPA, <https://www.epa.gov/climate-indicators/climate-change-indicators-bird-wintering-ranges>)

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Migratory birds because of certain temperature, some birds like, in Bharatpur we have bird sanctuary and from Siberia also cranes come and they hatch babies here and then they go, so all, this is a big system which is interdependent to each other and if temperatures change then these birds cycle will also be there, their life cycle will also be completely disturbed.

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Summary: Potential Impacts of Climate Change

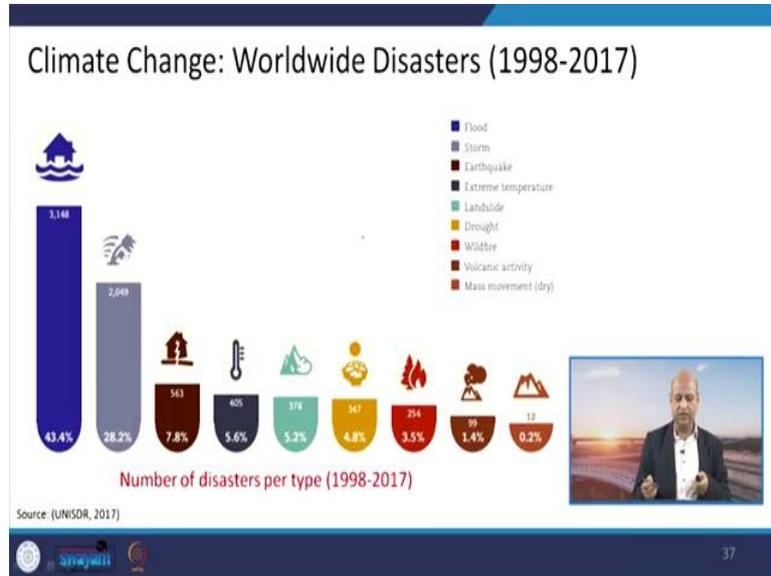
Source: (Cambridge Books online, 2010)

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So, we have to see that in overall sense the potential impacts of the climate change in terms of temperature, sea level rise or precipitation which translates into human health or agriculture production or forest or water resources or coastal areas and other these ecosystems, if we relate to that then a big picture emerges that climate change is the real issue

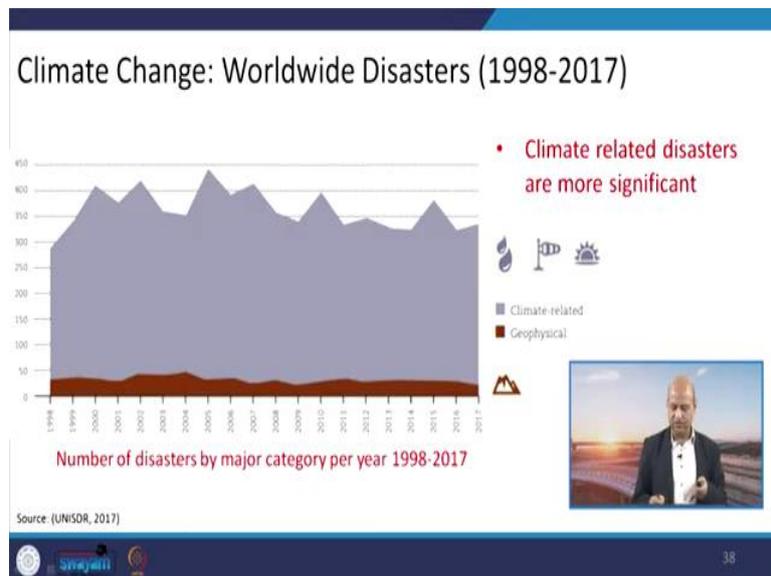
and this is related to the present development model which is based on this fossil fuel based economy or carbon economy we call it.

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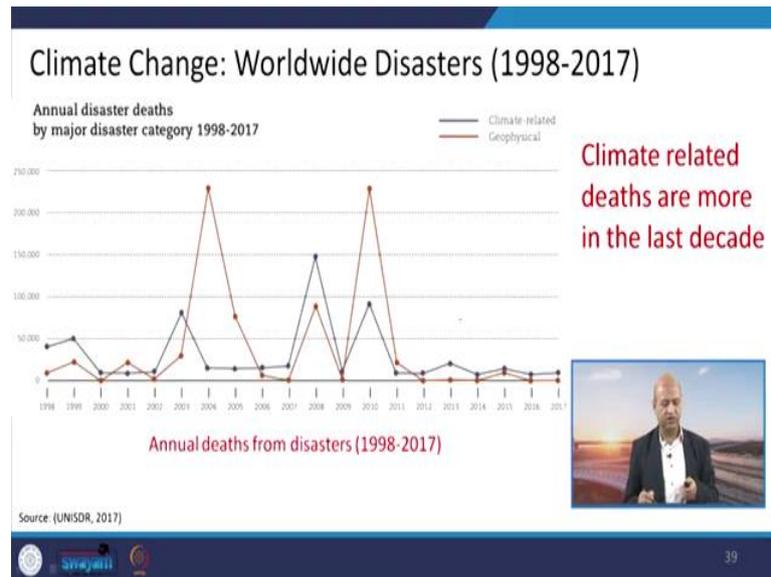
And again, if we want to see the disasters like floods, storms, these are natural ones or which are related to again the frequency of the climate change related patterns. Then earthquakes are there which are different kind of disasters, but the climate change related like draughts or floods and storms, they are the real indicators and their frequency and their intensity are showing that the climate change is just in front of us and we cannot close our eyes on that threat.

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Well, here you can easily see geophysical kind of, like landslide or, although you can relate landslide with climate change because of high intensity of precipitation, etc. But even if we discard that particular thing, and earthquakes and other geophysical disaster we see, these are very low in numbers, etc. But climate related like the floods and storms, etc., they are in a big number or their effect is very large.

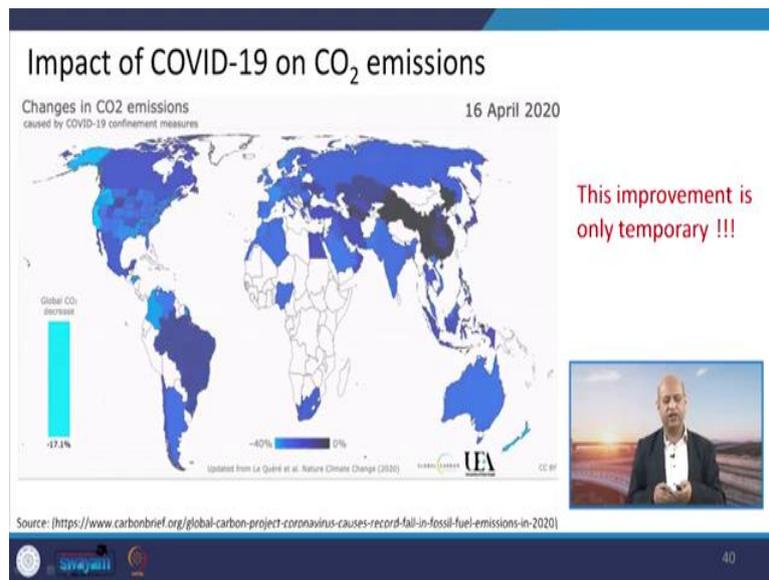
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So, Worldwide Disasters, annual disaster deaths, disaster related deaths have been here plotted and you can see at some point of time geophysical related disasters have caused many deaths but climate change related deaths have also increased, but thank to technology like now we have super computers, we can model, we can predict the rain or storms, etc., and that way our system is becoming good and we can save lot of life.

Although protecting property is not so easy because we cannot transfer our house from one place to another, but still human life is the most precious one and we have to save human life, we need to save.

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Well, the impact of see this COVID-19 on CO₂ emissions because of lockdown and other activities, as there were very less anthropogenic activities whether it is transportation or industrial activities, so there was advantage in the sense that emissions were very less, whether it is air pollutants or greenhouse gases, so that kind of simulation it shows, but this is very temporary.

This improvement in terms of clean sky and blue sky, and then you can see mountains, peaks from 100s of kilometres away because of clean air and clean atmosphere but as I said this is temporary phenomena because of our this lockdown kind of policies, but it is also damaging our economy and people are suffering. So we want to pursue our economic activities but we want to see that this present economic model is good or how can we change it.

So, earlier also we discussed about that if we change energy resources from this fossil fuel to renewable ones, natural ones then maybe there are good advantage, there are signs of development which are sustainable.

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Key facts

- Climate change **affects the social and environmental determinants of health** – clean air, safe drinking water, sufficient food and secure shelter.
- Between 2030 and 2050, climate change is **expected to cause approximately 250,000 additional deaths per year**, from malnutrition, malaria, diarrhoea and heat stress.
- The **direct damage costs to health** is estimated to be between **USD 2-4 billion/year** by 2030.

Take urgent action to combat climate change and its impacts

Reducing emissions of GHGs through better transport, food and energy-use choices can result in improved health, particularly through reduced air pollution.

Source: (WHO, 2018)

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So, the key facts, if we want to summarize, if we want to have clean air, safe drinking water and sufficient food, etc., so we should care for the environment and we should see that this climate change does not happen up to that extent that our ecosystems get disrupted very badly or beyond repair or we cannot take it back to the same level as it used to serve us.

So, there are data that how different kind of climate change have given us very additional deaths because of heat waves or other disasters and those deaths are avoidable if we can curb the climate change. So that is the view point for this lecture that we need to address the climate change in a way that it does not go beyond this balance level and it remains in the, that average value where we can do our activities in normal, it does not become a new normal.

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Conclusion

- Climate change is affecting every country on every continent.
- It is disrupting national economies and affecting lives.
- Weather patterns are changing, sea levels are rising, and weather events are becoming more extreme.
- Although travel bans and economic slowdowns resulting from the COVID-19 pandemic may reduce the GHG emissions, but this improvement is only temporary.
- Climate change is not on pause.

Switch to Sustainable measures

Sustainable development, that essentially includes Sustainable Transportation Systems, is the most feasible mitigation measure to Climate change.



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So, disrupting of national economies or affecting lives, these we have to change, weather patterns or sea levels, etc., which are direct indicators of the climate change, so all these things we have to see and we have to go for those kind of resources where we can control the greenhouse gas emissions and that way we can stop this, which is increasing day by day and we can flat like, monitorial protocol really helped us to address this ozone whole issue.

So, similarly, IPCC is giving reports and all countries are doing their bit, but maybe we need to do this positive measures or technological interventions very, in a speedy way so that we do not become late.

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And these are the references which any curious audience can go through, who wants to know more about climate change and its different aspects, it is a huge subject, we have given you in nutshell just to make you aware about the different aspects of the climate change and as climate change is directly related to the greenhouse gas emissions.

And greenhouse emissions are released from various sources and transportation sector is one of the major sources of greenhouse gas and these air pollutants emissions. That's why this climate change issue we have discussed so that in later lectures we can relate its impacts and relationship with the transportation sector in a nice way. So, thank you for your kind attention and see you in the next lecture. Thanks again.