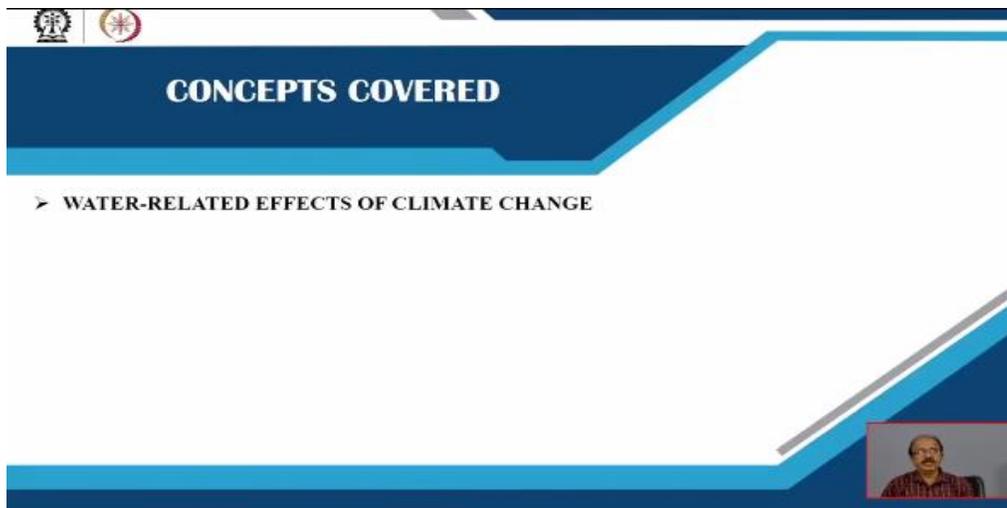


Availability and Management of Groundwater Resources
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Lecture – 57
Impact of Climate Change on Water Resources (Contd.,)

Welcome you all in the part 3 of the module 12 impact of climate change on water resources. So, we have seen the adverse effects of climate change on the water resources in the previous parts of the lectures.

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Now, in this part, I will discuss the water related effects of climate change.

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What Are the Water-Related Effects of Climate Change?

Warmer air temperature is anticipated to have the following water-related effects:

- Increases in water temperature.*
- Changes in the location, timing, form and amount of precipitation.*
- Increases in tropical storm intensity and sea level rise*
- Changes in oceans and coastal regions— chemical and physical.*

1. Air and Water Temperature Increases

The Effect on Water Resources

- An increase in the air temperature will cause water temperatures to increase as well. As water temperatures increase, water pollution problems will increase, and many aquatic habitats will be negatively affected.

Air and water temperature increases are expected to result in changes in marine species abundance and distribution.

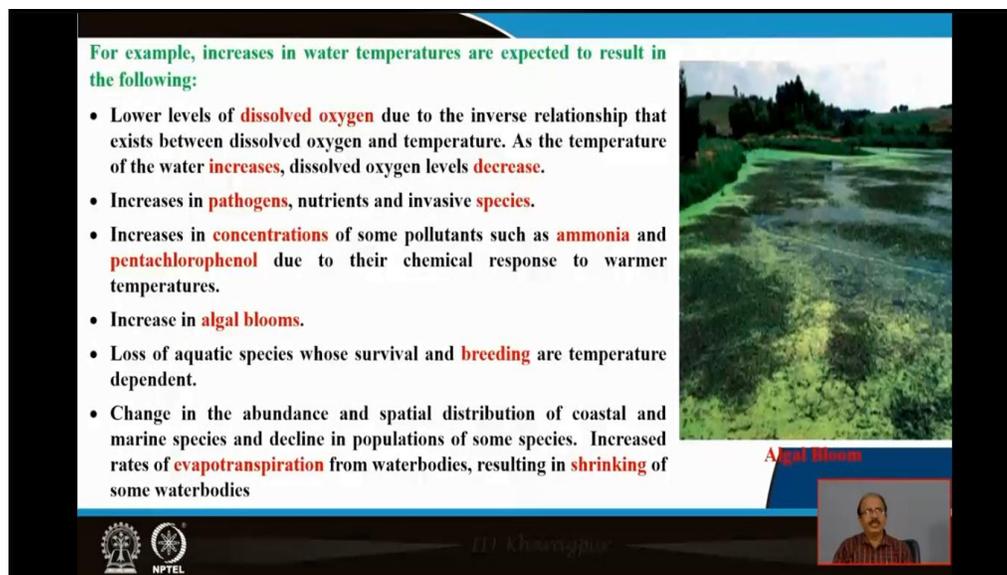
The slide includes a photograph of a vibrant coral reef with various colorful corals and fish swimming in clear blue water. In the bottom left corner, there are logos for IIT Dhanbad and NPTEL. In the bottom right corner, there is a small video inset showing the same man as in the previous slide.

Generally, the because of the warmer air temperature some of the water related effects are as first one is increase in water temperature, second is the changes in the location timing form and amount of precipitation. Third is the increase in tropical storm intensity and sea level rise and the fourth is the changes in oceans and coastal regions chemical and physical characteristics. So, because of this climate change, generally warmer air is anticipated with the following effects as discussed.

So, first I will take the air and water temperature increasing if the increase in air and water temperature then what will happen or what will be the effect on water resources. So, an increase in the air temperature will cause water temperatures to increase as well. As water temperature increases, water pollution problems will increase and many aquatic habitats on habits habitats will be negatively affected.

So, because of the increase in air temperature we have seen that the water temperatures are also increasing and because of the increasing in the water temperatures the water pour problem pollution problems originates and by this, what we are noticing that aquatic habitats get disturbed. So, they are many more aquatic lives they become disturbed and even they die also. So, air and water temperature are expected because of the climate change in marine species abundance and distribution the figure is also mentioned here in this figure it can be seen.

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For example, increases in water temperatures are expected to result in the following:

- Lower levels of **dissolved oxygen** due to the inverse relationship that exists between dissolved oxygen and temperature. As the temperature of the water **increases**, dissolved oxygen levels **decrease**.
- Increases in **pathogens**, nutrients and invasive **species**.
- Increases in **concentrations** of some pollutants such as **ammonia** and **pentachlorophenol** due to their chemical response to warmer temperatures.
- Increase in **algal blooms**.
- Loss of aquatic species whose survival and **breeding** are temperature dependent.
- Change in the abundance and spatial distribution of coastal and marine species and decline in populations of some species. Increased rates of **evapotranspiration** from waterbodies, resulting in **shrinking** of some waterbodies

Algal Bloom

NPTL

Now increase in water temperature are expected the following others results also as lower levels of dissolved oxygen due to inverse relationship that exists between dissolved oxygen and temperature as the temperature of water increases, dissolved oxygen level DO levels decrease so, that if the temperature will increase the DO will decrease. So, increase in pathogens, nutrients and invasive species, increase in water temperature.

These all are happening because of the increase in water temperature increasing concentration of some pollutants such as ammonia and pentachlorophenol due to their chemical response to warmer temperatures. Next is the increase in algal blooms because of the increase in water temperature. It has been noticed that increasing algal blooms also taking place loss of aquatic species whose survival and breeding are temperature dependent.

So, because of the high temperature high water temperature may be the loss of the aquatic species take place changing the abundance and the spatial distribution of coastal and marine species and decline in population of some of the species. So, increased rates of evapotranspiration from water bodies, resulting in shrinking of some of the water bodies or catchment sector. So, this is the effects of climate change because temperature is increased temperature increasing so, increase in water temperatures take place.

And because of the increase in water temperatures so many we have seen lower levels of the DO then increase in pathogens, nutrients and invasive species, increasing algal blooms. So, lots of other adverse effects are noticed because you have the high water temperatures.

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2. Precipitation Changes

- As the air **temperature warms**, the rate at which water evaporates from soils and waterbodies increases, and that **increases** the amount of water being held in the **atmosphere**.
- Because there is more atmospheric **moisture**, there are heavier downpours when it **rains**.
- While moderate increases in **annual average precipitation** are expected, there is likely to be a wider variation in the pattern of rainfall, specifically dry periods punctuated by more intense rainfall.

The Effect on Water Resources

- Changes in the location and amount of precipitation will affect **water availability** and **water quality**.



Now, precipitation changes the pattern the erratic pattern of the precipitation we are noticing. As the air temperature warms, the rate at which water evaporates from soil and water bodies it will increase. So, because of the increase in the air temperature, the evaporation rate and transpiration rate from the soil from the surface water bodies as well as the planet's surface will increase and that increases the amount of water being held in the atmosphere.

So, it will increase the amount of water in the atmosphere, because there is more atmospheric moisture, there are heavier downpours when it rains. while moderate increase in annual average precipitation are expected very likely to be a wider variation in the pattern of rainfall, especially dry periods punctuated by more intense rainfall, this is generally being noticed in general, then, what is the effect on water resources changes in the location and amount of precipitation will affect the water ability as well as water quality.

So, in both the sector in the water ability sector as well as the water quality sector both will get affected by the change in the climate changes or change in the precipitation pattern of the area.

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The screenshot shows a video player window titled "Impact of climate change on water resources.mp4". The main content is a slide with the following text:

Water availability:

- The net impact on water availability will depend on **changes in precipitation** (including changes in the total amount, form, and seasonal timing of precipitation).
- In areas where **precipitation increases** sufficiently, net water supplies might not be affected or they might even increase.
- If the precipitation remains the same or **decreases** though, net water supplies would decrease. This is in part due to the predicted temperature rise in most areas, which will cause evaporation rates to **increase**.
- Where water supplies **decrease**, there is also likely to be an **increase** in demand as a result of **higher** temperatures, which could be particularly significant for agriculture and energy production (the largest consumers of water) and also for municipal, industrial and other uses.

On the right side of the slide, there are three small images with captions: "Drought" (showing a dry riverbed), "Wildfires and increased soil erosion" (showing a large fire), and "Overwhelmed infrastructure" (showing a flooded street). To the right of these images is a list of bullet points under the heading "Water availability":

- Reduced ground water and surface water supply in some areas
- Increased water demand due to higher temperatures

Below these is another heading "Water quality" with two bullet points:

- Increased runoff resulting in erosion and sedimentation
- Overwhelmed water infrastructure due to flooding

The video player interface includes a progress bar at the bottom showing 00:08:25 out of 00:19:24, and a small video thumbnail of a man in the bottom right corner.

Now, water ability, the how it will affect the water ability, the net impact on water ability will depend on changes in precipitation, including changes in the total amount form and seasonal timing or presentation. So, in areas where precipitation increases sufficiently, net water supply might not be affected or they might even increase if the precipitation will increase the net water supplies might be even increase. If the precipitation remains the same or decreases, then what will happen net water supplies would decrease.

This is in part due to the predicted temperature rise in most areas, which will cause evaporation rates to increase. So, this generally happens if the precipitation remains the same or decrease, then the net water supplies of the area would decrease. And the predicted this is a part in part of the predicted due to the predicted temperature rise in most area, which will cause evaporation rates to increase. Where water supplies decrease, there is also likely to be an increase in demand as a result of higher temperatures.

Higher temperatures, which could be particularly significant for agriculture and energy production the largest consumers of water and also for municipal industrial and other uses. So, where water supplies generally decrease, there is also likely to be an increase in demand as a result of high temperatures, which particularly significant for agriculture energy production. So, in this way, the ability of water also get affected by the change in the climate.

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Water quality:

- Changes in the **timing, intensity, and duration** of precipitation can negatively affect water quality. Flooding, a result of increased precipitation and intense rain storms, transports **large volumes** of water and contaminants into water bodies.
- Flooding also can overload storm, combined sewer, and wastewater systems, resulting in **untreated** pollutants directly entering waterways.
- In regions with **increased** rainfall frequency and intensity, more pollution and sedimentation might be produced because of **runoff**.
- Reduced rainfall can also result in more frequent wildfires, and land areas where wildfires have occurred are more vulnerable to **soil erosion**.



Drought



Wildfires and increased soil erosion



Overwhelmed infrastructure

Water availability

- Reduced ground water and surface water supply in some areas
- Increased water demand due to higher temperatures

Water quality

- Increased runoff resulting in erosion and sedimentation
- Overwhelmed water infrastructure due to flooding

— J.T. Khoury —



Now water quality, how it is affected, changes in the timing, intensity and duration of precipitation can negatively affect the water quality. If the intensity will change, the duration will change you say precipitation will change definitely the water quality will get affected flooding as a result of increased precipitation and intense rain storms transports large volume of water and contaminants into the water bodies. So in this way the contamination are increasing in the water bodies because of the high precipitation increased precipitation.

Flooding also can overload storm combined sewer and wastewater system resulting in untreated pollutants directly entering the waterways just entering into the waterways. In regions with increased rainfall frequency and intensity, more pollution and sedimentation might be produced because of runoff. So this is important because in regions with increased rainfall frequency, generally more pollution and sedimentation has been noticed. And because of this because of runoff only might be produced because of runoff.

So reduce rainfall can also result in more frequent wildfires and land areas where wildfires have occurred are more vulnerable to soil erosion. So, these areas are very, very vulnerable to soil erosion also. So in this way because of the climate change the water availability as well as water quality, both are being affected by the change in the temperature or precipitation pattern on the Earth's surface.

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3. Increases in Storm Intensity

- Tropical storms and hurricanes are likely to become more **intense**, produce **stronger** peak winds, produce increased rainfall, and cause larger storm surges because of warming sea **surface temperatures** (which can energize these storms).
- The relationship between sea surface temperatures and the frequency of tropical storms is **direct and near-exponential**.

The Effect on Water Resources

- Increased tropical storm intensities will have **negative** effects on water resources.
- More intense tropical storms can damage **infrastructure**, cause **increased flooding**, which can overwhelm water infrastructure, and cause pollutants to directly enter waterways and contaminate water supplies.
- Coastal erosion is also often a result of **storms**.

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Now, the third is the increase in the storm intensity, so, tropical storms and hurricanes are likely to become more intense, produce stronger peak winds, produce increased rainfall and cause the larger storm surges because of warming sea surface temperature. So, the relationship between sea surface temperature and the frequency of tropical storms is direct and nearly exponential. Now, what is the effect on water resources? Increased tropical storm intensity will have negative effects on water resources.

More intense tropical storms can damage infrastructure causes increased flooding, which can overwhelm water infrastructure and cause pollutants to directly inter waterways and contaminate the existing water supplies of the area. Coastal erosion is also often a result of storms. So, because of this increase in storm intensity, generally the more intense tropical storms are damaging the infrastructure and also enhancing the risk of flooding in the area.

And in this way, this coastal erosion is also taking place because of the intense tropical storms because of the change in the climate change.

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4. Sea Level Rise

- The factors driving sea level rise include the following:
 - ✓ Ocean water expansion caused by warmer ocean temperatures.
 - ✓ Mountain glaciers and ice caps melting.

The Effect on Water Resources

- Rising sea levels will increase erosion rates and cause the displacement of coastal wetlands, alter shorelines and cause high-value habitat to be lost.
- Low-lying coastal areas, such as wetlands, deltas, coastal plains, salt marshes, mangrove forests and coral reefs will be affected by sea level rise.
- Rising sea level increases the salinity of both surface water and ground water through salt water intrusion.

Dr. Khuram

Now, next is the sea level rise. The factors driving the sea level rise generally includes oceanic water expansion caused by warmer ocean temperatures. So, the water expansion they will cause because of the warmer ocean temperatures and melting of the mountain glaciers and ice caps. So, because of these 2 factors, generally it is giving rise to sea level rise then what is the effect on water resources?

Rising sea levels will increase the erosion rates and cause the displacement of coastal wetlands after altering the soul lines and also causes loss to the high value to the habitat or high your valued habitat generally these are also lost. So because of the high rising sea levels generally increasing erosion rates take place, and it caused the displacement of the coastal wetlands altering the shorelines and causing the high value habitat to be lost.

Whereas low lying coastal areas such as wetlands, deltas, coastal plains, salt marshes, mangrove forests and coral reefs, these are getting affected also by the rising the sea level. So low lying coastal areas also getting affected because of the change in the climate change because of the climate change, and this because of the climate change only the sea level generally rising also rising sea level increasing the salinity of both surface water and groundwater through saltwater intrusion.

So because of this rise in sea level, it is increasing the salinity of both surface water and groundwater through saltwater intrusion.

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5. Ocean and Coastal Changes

- In addition to **rising sea levels**, the characteristics of the ocean are expected to change as the **planet warms**.
- Corals are believed to be **surviving** at or close to their temperature tolerance levels. If air and water temperatures continue to **increase**, corals might not be able to survive.

Biological habitat changes (other than sea level rise) are expected in the oceans as the air temperatures increase.

- ✓ **Estuarine waters become more saline** as sea levels rise.
- ✓ **Ocean temperatures increase** posing a threat to ocean life, e.g., corals.
- ✓ **Oceans become more acidic**.

The abundance and spatial distribution of saltwater species might change with the changes in water temperature and salinity levels in estuarine systems. Also, oceans are expected to **become more acidic**.

- Increased atmospheric carbon dioxide levels result in increased ocean absorption of carbon dioxide
- Increased ocean carbon dioxide absorption causes a deficit of the carbonate ions that coral and other marine organisms need to build their skeletons

NPTEL

Dr. Khurshid

Next is the ocean and coastal changes. So in addition to the rising sea levels, the characteristics of the ocean are expected to change as the planet warms. Corals are believed to be surviving at or close to their temperature tolerance levels. If air and water temperature continue to increase the corals might not be able to survive. Therefore, biological habitat changes are expected in the oceans as the air temperature increases.

Estuarine water becomes more saline, as sea levels rise will take place, ocean temperature increases posing a threat to ocean life as well. Example is corals oceans are becoming more acidic also, the abundance and spatial distribution of saltwater species might change with the changes in water temperatures and salinity levels in the estuarine systems. Therefore, oceans are expected to become more acidic because of the climate change issues. These are the some of the interesting facts.

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Ocean Acidification

- Oceans naturally **absorb** carbon dioxide from the atmosphere.
- When there are increased levels of carbon dioxide in the atmosphere, oceans increase the absorption of carbon dioxide in a process called **ocean acidification**.
- The mixture of ocean water and the **carbon dioxide** forms **carbonic acid**.
- Carbonic acid reacts with **carbonate ions** that are also found in seawater, which are a vital component to the structure of corals and the shells of marine organisms, such as calcifying **phytoplankton** that form the first tier of the ocean **food web**.
- In other words, **elevated** levels of carbon dioxide in the atmosphere lead to less of the building blocks that are needed to form the calcium carbonate skeletons of corals and other organisms that require **calcium carbonate** to make their shells.



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Now, ocean acidification few points we must know oceans naturally absorb carbon dioxide from the atmosphere. When there are increased levels of carbon dioxide in the atmosphere, ocean increase the absorption of carbon dioxide in a process called ocean acidification. The mixture of ocean water and the carbon dioxide forms the carbonic acid. Carbonic acid reacts with carbonate ions that are also found in seawater, which are a vital component to the structure of corals and the shells of the marine organisms.

Such as calcifying phytoplankton that form the first tier of the ocean food web. This is the first tier ocean food web. In other words, elevated levels of carbon dioxide in the atmosphere lead to the less of the building blocks that are needed to form the calcium carbonate skeleton of corals and other organisms that require calcium carbonate to make their shells. So, elevated levels of CO₂ in the atmosphere lead to the less of the building blocks that are needed to form the calcium carbonate skeleton of corals. And other organisms that require calcium carbonate to make their shells.

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- The response of marine biota to **ocean acidification** is not yet clear, both for the physiology of individual organisms and for the **ecosystem** functioning as a whole.
- Extinction thresholds will likely be **crossed** for some organisms in the coming century.
- Ocean acidification is not a direct consequence of warming temperatures, but like **warmer** temperatures, it is caused by increased levels of **carbon dioxide** in the atmosphere.



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Now, the response of marine biota to ocean acidification is not yet clear. It is not clear both for the physiology of individual organisms and for the ecosystem functioning as a whole. Extinction thresholds will likely to be crossed for some organisms in the coming century. Ocean acidification is not a direct consequence of warming temperatures, but like warmer temperatures, it is caused by increased level of CO₂ in the atmosphere after knowing this much about the effects of your acidification of the soil water, ocean water.

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The Effect on Water Resources

Ocean acidification, warmer ocean water, and more saline estuaries are expected to have several impacts on coastal and ocean resources:

- Potential marine food web **breakdowns** from ocean acidification.
- **Coral, calcifying phytoplankton, and zooplankton** growth will be inhibited or slowed because of ocean acidification.
- **Habitat loss** with the loss of coral reefs because of coral bleaching.
- **Aquatic plants and animals** that cannot tolerate increased salinity levels are lost.



Air and water temperature increases are a threat to corals and cause bleaching of corals.



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Now what are the effects on water resources? Oceans acidification, warmer ocean water and more saline estuaries are expected to have several impacts on coastal and ocean resources. First is the potential marine food web breakdown from ocean acidification. The coral calcifying

phytoplankton and zooplankton growth will be inhibited or slowed because of the ocean acidification habitat loss with the loss of coral reefs because of coral bleaching.

And aquatic plants and animals that cannot tolerate increased salinity levels are lost. So, in this way, we are noticing that air and water temperature increases are a threat to corals and cause bleaching of corals. So, the generally this is the main impact because of the change in the climate to the water resources. Thank you very much to all.