Availability and Management of Groundwater Resources
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Lecture - 59
Impact of Climate Change on Water Resources (Contd.,)

Welcome you all in the part 5 of the module 12 impact of climate change on water resources. So, we have seen in the last 4 parts about the different aspects of the climate change and its effect on the groundwater resources.

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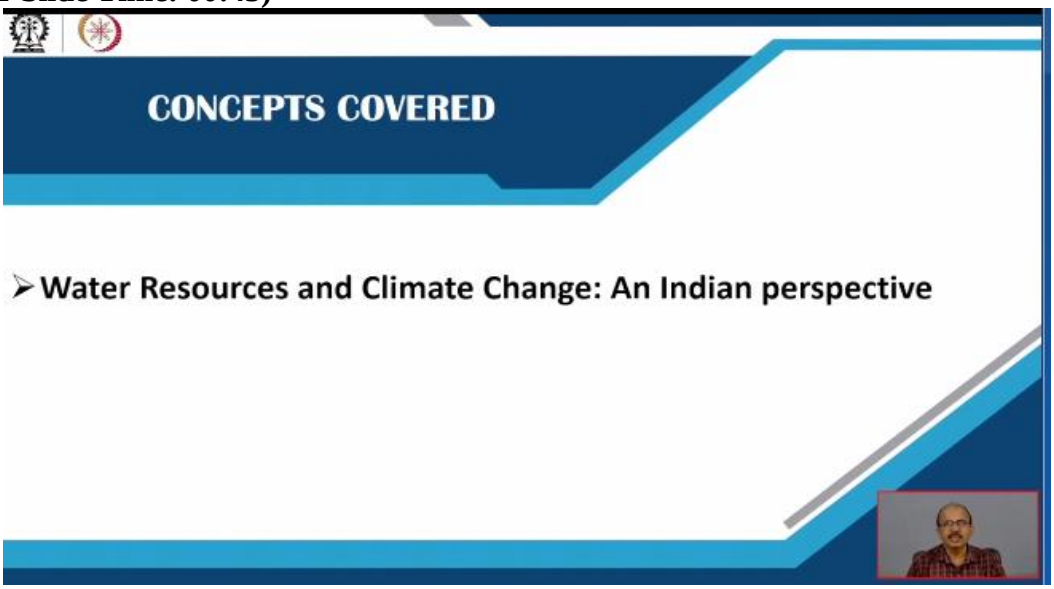

So, in this part we will discuss about the water resources and climate change especially with an Indian perspective.

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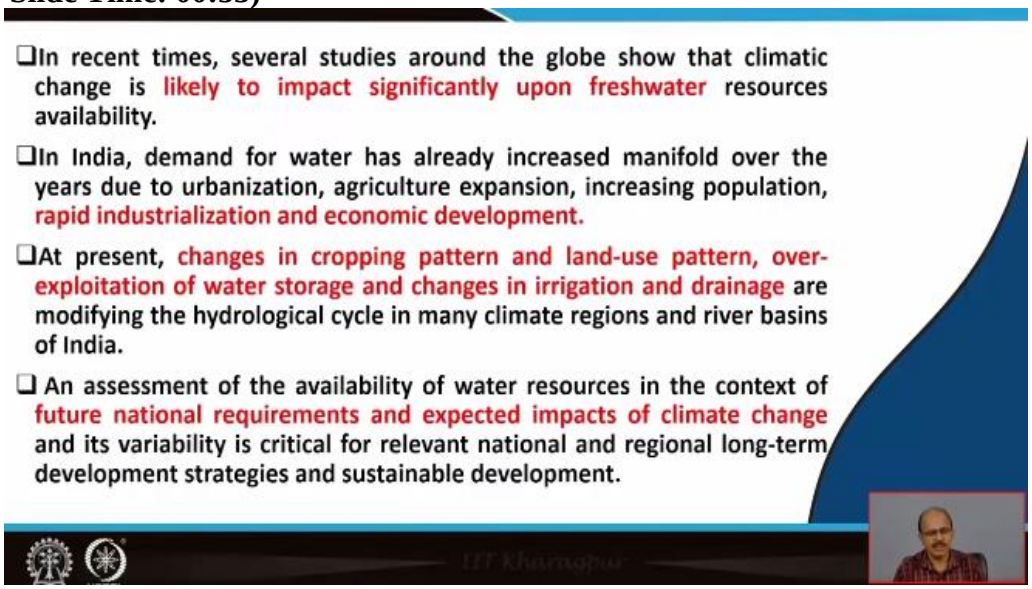

So, in recent times, several studies around the globe show that climate change is likely to impact significantly upon the freshwater resources and its ability. In India, demand for water has already increased manifold over the years, because of the increase in the urbanization, agriculture expansion, increasing population, rapid industrialization and economic development.

At present, changes in cropping pattern and land use pattern over exploitation of water storage and changes in irrigation and drainage are modifying the hydrological cycle in many climatic regions and river basins of India. If you can see at several places, generally the cropping patterns are changing. The cropping pattern which were earlier people were following, they are not following at the present time why?

Because for different purposes, the people are over exploiting the store water that is the from the aquifer. And therefore, the irrigation and drainage pattern of the area or you can say the hydrological cycle of the area have changed dramatically, because of the change in the climatic factors. So in different river basin, generally these patterns are very much clear at the present day.

An assessment of the ability of water resources in the context of future national requirements and expected impacts of climate change and its variability is very critical for relevant national and regional long term development strategy and sustainable development. That is why the subject topic has been chosen, because many people are knowing about the groundwater resources. These are the very good without any sort of pollution, groundwater resources the fresh water so it can be used that is true.

But it is ability what are the factors playing a role for making the water in a good rock agenda to forage remaining providing groundwater during the exploitation, many people are laying knowing less about the whole concept, the ability of water as well as management, that is why this course I mentioned here. The assessment of viability of water resources is very important with respect to the national requirements.

Every nation different nation are having a different nature of the ability of water resource within their surface area and an impact of climate change is different in different country, different

region. So, it is the ability also varies from place to place and it is important also, because of making the development strategy or sustainable development of any area.

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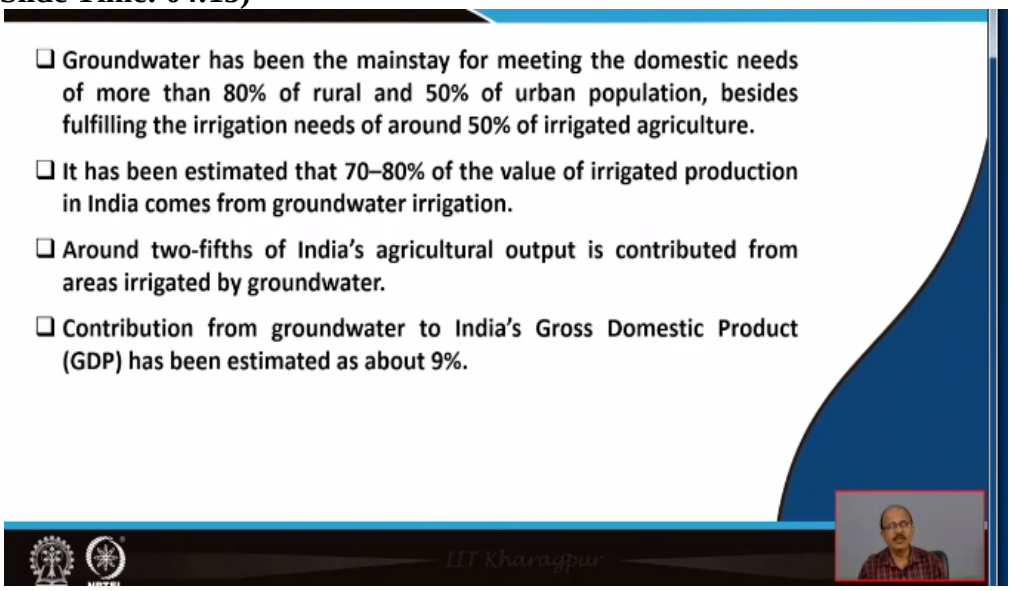

Now, groundwater has been the mainstay for meeting the domestic needs of more than 80% of rural and 50% of urban population. Generally, in the urban area also rural area say people are generally using the groundwater for their daily needs. Besides fulfilling the irrigation needs of around 50% of irrigated agriculture, so, no doubt the water groundwater regime are being used for the irrigation purpose.

But in rural area maximum needs are being fulfilled by the groundwater resources and urban areas also our own populations are also using. It has been estimated that 70 to 80% of the value of irrigated population in India comes from groundwater irrigation. So, people are just making a well or the bore well and through this they are just exploiting the water and then irrigating their fields so for the development of crops. So in India about 70 to 80% of the groundwater resources are being used for the irrigation purposes.

Around 2 fifths of the India's agriculture output is contributed from the areas irrigated by groundwater and contribution wise, if you will see contribution from groundwater to India's GDP has been estimated at about 9%. So, it is very clear that groundwater resources are being over exploited permitting the different purposes of the people who are living just either in the good ability of the groundwater resources area or the durability of the groundwater sources here.

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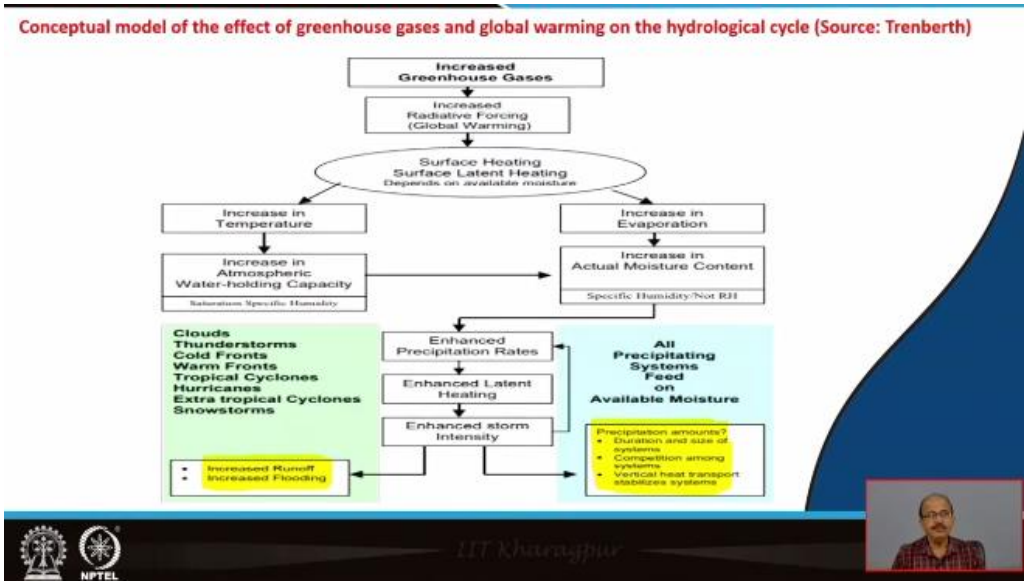

This conceptual model is showing the effect of greenhouse gases and global warming on the hydrological cycle. We are very well aware about the hydrological cycle, the major components were the precipitation, then the evaporation, then the transpiration, your surface runoff and the groundwater runoff. So that time when we were discussing about the hydrological cycle, in the very beginning of this course, we have discussed that the precipitation is the only source of recharging the aquifer.

That is the precipitation is the only source which is providing the groundwater resources beneath any geological formations, which is storing which are having the characteristic of storage of the water as well as the ability to transmit the water from one rock area to other rock area from one aquifer to another aquifer, but what is the effect of greenhouse gases which is coming out in the atmosphere and global warming, this can be clearly shown by this conceptual model.

If the increase of the greenhouse gases then what will happen; increase your radiative forcing that is the global warming. If the global warming will increase and what will happen surface heating, surface latent heating will move high depends on the available moisture. So, this provides either because of the increase in temperature or increasing the evaporation. So, if the increase in temperature then what will happen increasing atmospheric water holding capacity.

So, temperature will increase the definitely the atmospheric water holding capacity it will increase and if the evaporation will increase the increase in actual moisture content. So, in this way in high temperature is increasing you can see that the atmospheric water holding capacity

is also increasing and if the evaporation increasing it gives to increase in actual moisture content. Now, this factor we can see that it gives the humidity temperature gives the humidity whereas this gives us specific humidity not relative humidity.

So clouds, thunderstorms, cold fronts, warm fronts, tropical cyclones, hurricanes, extra tropical cyclones, snowstorms, they are also the some of the natural events which are taking place in the atmosphere. So, here we can see that the enhanced precipitation rates, this if the evaporation will increase the humidity specific humidity or not relative humidity, then what will happen it will enhance the precipitation rates once the residential rates will enhance definitely it will enhance the latent heating and then the enhanced storm intensity.

What is the result? All precipitation or precipitating systems feed on the available moisture and the result will be that the increased runoff will be there increased flooding will be there if there will be increased flooding and runoff then the what will be the precipitation will amount? Precipitation will amount the duration and size of the system the competition among the systems and vertical heat transport stabilizes systems.

So this because of the increase in the greenhouse gases and global warming on the Earth's surface, it is putting impact on the hydrological cycle. Once it is putting impact on the hydrological cycle definitely, the ability of the groundwater resources and its storage both differs from place to place, because their lead varies from place to place everywhere, we cannot get the equal volume of groundwater resources. So it varies from place to place, as well as with the different types of climatic factors. The different amount of groundwater will remain stored inside the Earth's surface.

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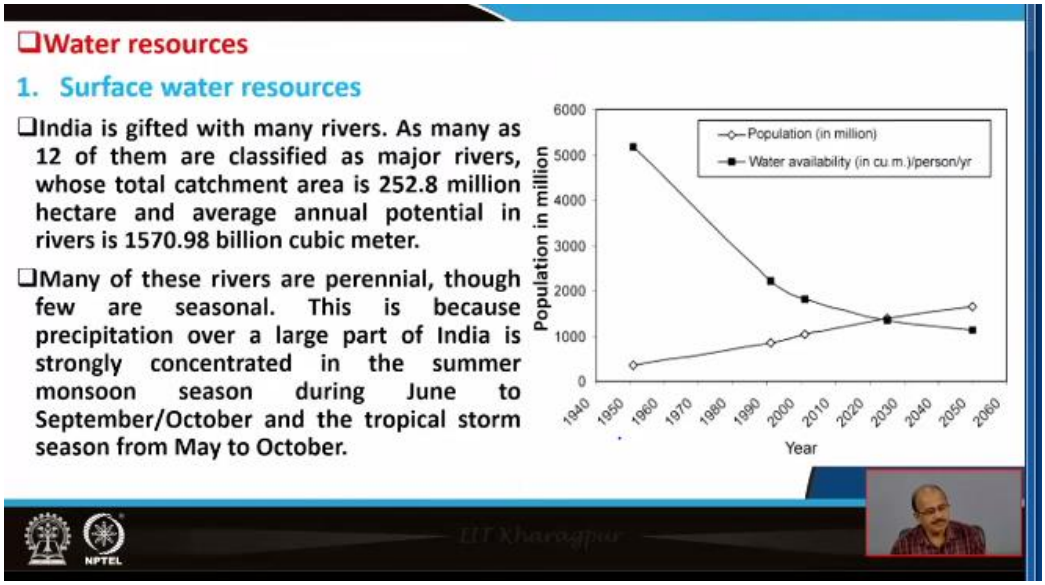

Now, we in water resources generally we are considering the 2 types of water resources one is the surface water resources other in the groundwater resources. So, for surface water resources India is gifted with many rivers and as many as 12 of them are classified as major rivers whose catchment area is 252.8 million hectare and average annual potential in river is 1570.98 billion cubic meter. So, this is the average annual potential of the rivers.

Many of the rivers in India many of the major rivers are perennial throughout the year you may get the water though few are seasonal, in which only during the monsoon, you will see the water is remaining in the rivers. This is because the precipitation over a large part of India is strongly concentrated in the summer monsoon season during June to September, October and the tropical storm season from May to October.

So, that is why many of the major rivers are perennial and few are seasonal also monsoonal also when during the monsoon only you can see the water in the river. So, you are different amount of water in different rivers are because of our precipitation pattern in Indian subcontinent. We are strongly we are getting the monsoon, the rainwater during the monsoonal season after summer and it lasts till September October and some tropical storms also we are getting from May to October.

So, in this way, if we will see the ability of the water resources in the graph from the year 1940 to 2060 you can see the population in million it is increasing the graph is in the increasing pattern whereas the ability of water when the year 1950 -1960 we are having so much amount

of water the you can see 50,000 population we are there. So 50,000 population we are there, 5000 population we are there but gradually you can see the water ability is just decreasing.

So, the water ability is just decreasing per person per year it is just decreasing in the year 2050 it has come to near about 1000 meter, you can see here per person per year. So, in this way what we have seen? We have seen the populations are increasing whereas the water ability is gradually decreasing. So, we must think over for the conservation of the water resources the proper management of the water resources.

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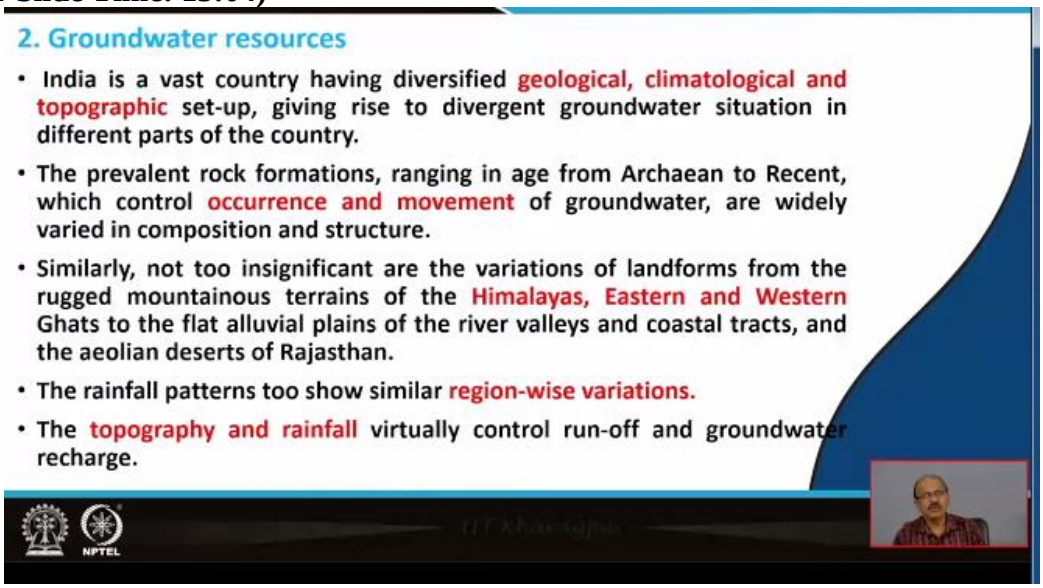

Now, the second is the groundwater resources. India vast country having diversified geological, climatological and topographical, set-up. So Indian subcontinent we are getting the different types of geological formation throughout the subcontinent. In the north, south, east and west everywhere the types of the rock formations underneath the surfaces are vary even, not only the geological conditions but climatological and topographical set-up is also varying a different part of the country.

What these are giving? These are giving rise to divergent groundwater situation in different parts of the country. So, in different parts of the country, we are having the different amount of groundwater storage inside the surface. The prevalent rock formations ranging in age from Archaean to recent which control the occurrence and movement of groundwater are widely varied in composition and structure.

So, this is very important because we are having the formation from Archaean to recent period and in the different type of rock formation the occurrence and movement of groundwater are varying because of its composition and structure. Similarly, not too insignificant are the variations of landforms from the rugged mountain terrains of the Himalayas in the north eastern and western Ghats to the flat alluvial plains of the river valley and coastal tracks and Aeolian deposit deserts of the Rajasthan.

So, we are having a variety of landforms also from the lofty mountains in which is present in the Himalayan region to eastern and western Ghats we can clearly see and the flat alluvial plains of the river valleys Indo-Gangetic plains we are seeing a desert in the Rajasthan because etcetera. So, the rainfall patterns too show similar region wise variation. So, since we are having the different types of rock formation all across the subcontinent of the varying age also, we are having the different types of landforms in our country.

So, rainfall patterns are also varying and it is not remaining similar in different region. So, variations are there in the pattern of the rainfall or also. The topography or rainfall virtually control the runoff and groundwater recharge. The groundwater recharge is being controlled by the topography and rainfall.

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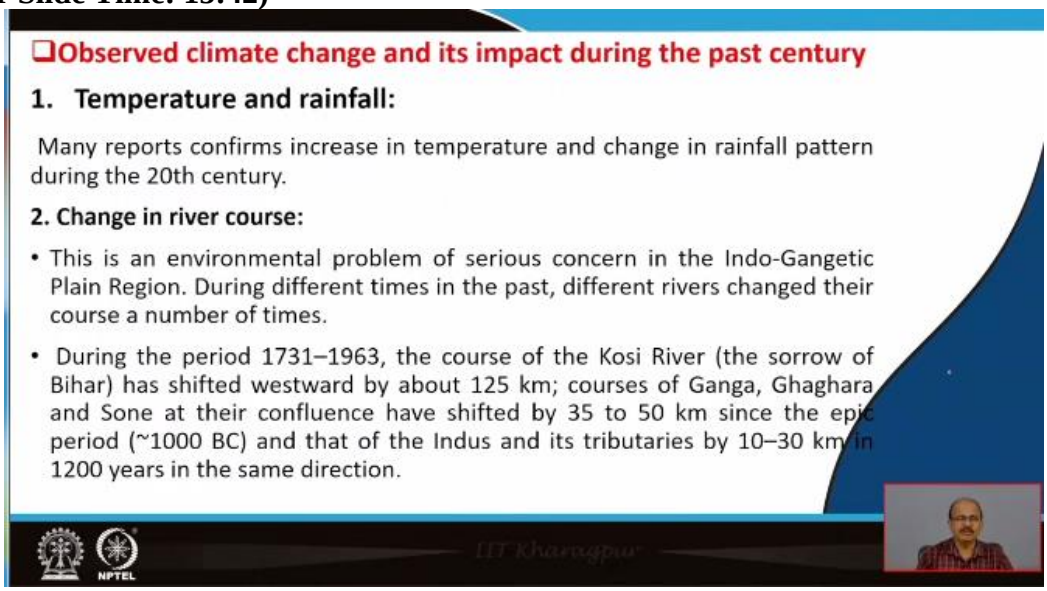

So, what are the observed climate change and its impact during the past century? So, during the past century temperature and rainfall, this is the important point because many reports confirm increase in temperature and changes in rainfall pattern during the last century. Temperatures of the surface is gradually increasing and the rainfall pattern is also just changing

we are having the erratic type of rainfall pattern not same in every years. So, the variations we are getting in that nature.

Second change in river course, this is an environmental problem of serious concern in the Indo-Gangetic plain region. The during different times in the past, different rivers change their course and number of times, it will see in the past also the river were moving in different directions and gradually they are changing their course of flow. During the period 1731 to 1963, the course of the Kosi river, which is known as the sorrow of the Bihar has shifted westward by about 125 kilometer.

You can see in the 70 years, the Kosi river has shifted its path and it has moved to our west courses of Ganga, Ghaghara and Sone at their confluence accepted by 35 to 50 kilometre since the epic period 1000 BC and that of the Indus and its tributaries by 10 to 30 kilometre in 1200 years in the same direction. So, these your richer source that the river course has also changed in the past. They are changed because this river is also a very good source of the surface water resource. Because of the change in the climatic factor, they have changed the river course also in the so many periods of time.

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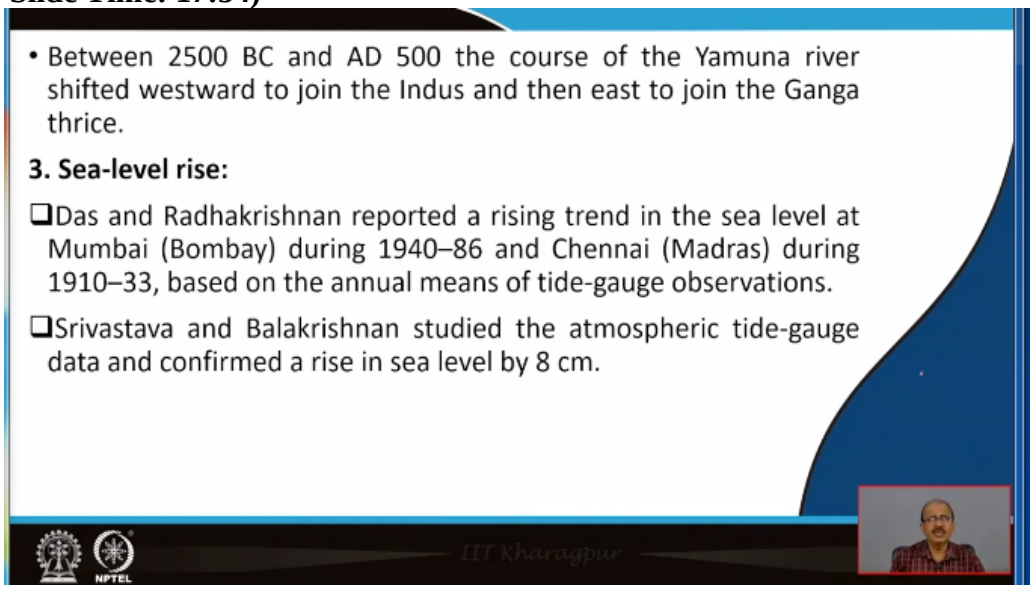

Between 2500 BC and AD 500 the course of the Yamuna river shifted westward to join the Indus and then east to join the Ganga thrice. So, this is a very important fact that Indus Yamuna has also shifted westward and join the Indus and then towards east to join the Ganga. So this is the facts related with your change of the course of the surface water resource that is the river.

Sea level rise some of the scientists they have reported that a rising trend in the sea level at Mumbai during 1940 to 86 and Chennai during 1910 to 1933 based on the annual means of tide gauge observations. They have found that the sea level hydrolysed to a certain extent. Srivastava and Balakrishnan also studied the same point and the most varied tide gauge data and confirmed they rise in the sea level by 8 centimetre. So, they have studied the atmospheric tide gauge data and then they have confirmed that the sea level is definitely rising and they confirmed that is rising sea level is by 8 centimetre.

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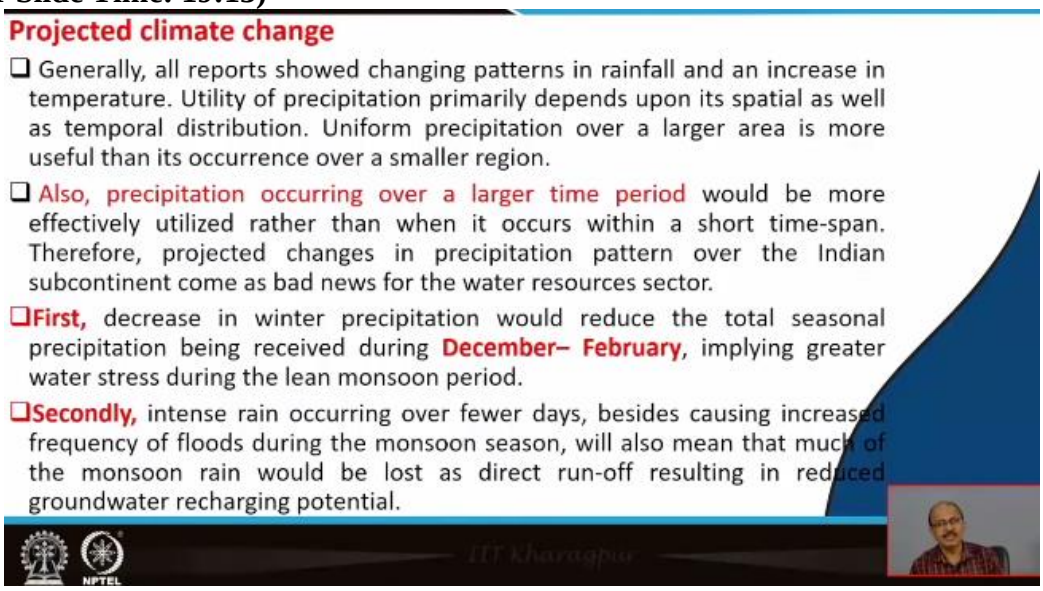

Now, projected climate change generally all reports showed changing patterns in the rainfall and an increase in temperature. Utility of precipitation primarily depends upon its spatial as well as temporal distribution. So, uniform precipitation over a larger area is more useful than its occurrence over a smaller region. Generally, all report are showing this thing that rainfall pattern is changing and increase in temperature you are also getting all across the surface in the subcontinent.

Precipitation occurring over a larger time period will be more effectively utilized rather than when it occurred within a short time span. So this type of presentation is very important because it is occurring over a larger time period. And in these are if the presentation if a larger time period is definitely it will be more effectively utilized then the precipitation which is occurring for a shorter time period. Therefore, projected changes in precipitation pattern over the Indian subcontinent come as bad news for the water resources sector.

So, this is not good news, because precipitation pattern is gradually just changing erotically and first to decrease in winter precipitation, because, when during the winter time also some precipitation we are getting. So, decrease in winter precipitation would reduce the total seasonal precipitation being received during December to February, implying greater water stress during the lean period during the lean period just giving the greater water stress.

Secondly, when intense rain occurring over fewer days, besides causing increased frequency of floods during the monsoon season will also mean that much of the monsoon rain will be lost as direct runoff not going inside but it is just converting a general and this rain is just losing a runoff resulting in reduced groundwater recharging potential. If the more runoff will generate because of the monsoon rain, then what will happen it would not recharge the aquifer underneath.

So, it will ultimately reduce the groundwater recharging potential in the area. So, these are the some of the factors we show that groundwater recharging potential has also decreased in the past few years.

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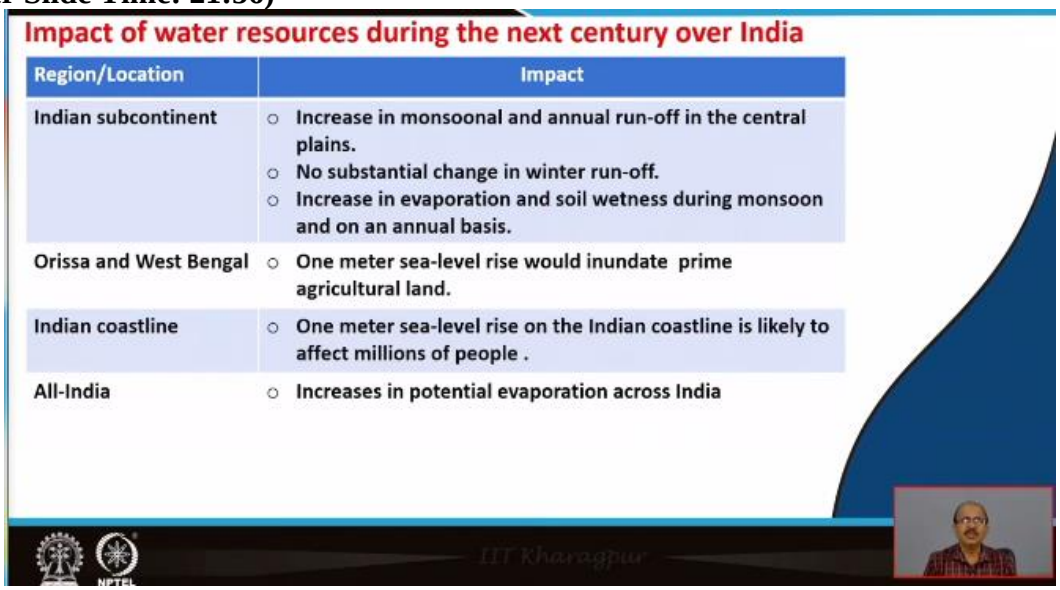

So, impact of water resources during the next century over India. Now, after knowing these facts, we can just see that what are the impacts of water resources during the next century over India? So, in Indian subcontinent increase in monsoonal and annual runoff in the central plains. So, this has been noticed that there is a increase in monsoonal annual runoff in the central plains. No substantial change in winter runoff. There is no change in the winter or not.

Increase in evaporation and soil wetness during the monsoon and on an annual basis. So, actually, if there will be the impact of climate change, then there will be increased in evaporation and soil wetness during the monsoon. In this is for the overall Indian subcontinent. Now for Orissa and West Bengal we can see 1 meter sea level rise would inundate prime agriculture land. Indian coastline 1 meter sea level rise on Indian coastline is likely to affect millions of people.

All India will see the increasingly will potentially operation across India. So, the point is that near your coastline areas also it is affecting by the sea level rise. Once the sea level will rise definitely the nearby agricultural land they will just summarized and coastline also legally it will reduce it. So, the increase in the monsoonal increase in the erratic pattern of the monsoon period or the rainfall period will definitely put impact on the water resources, maybe the surface water resources or the groundwater resources. So with this, thank you very much to all thank you.