Availability and Management of Groundwater Resources
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Lecture – 60
Impact of Climate Change on Water Resources (Contd.,)

Welcome you all in the part 6 of the model 12 impact of climate change on water resources. So, in the last 5 parts, we have discussed about the precious water resources and its impacted on the impact of climate change on its ability and management.

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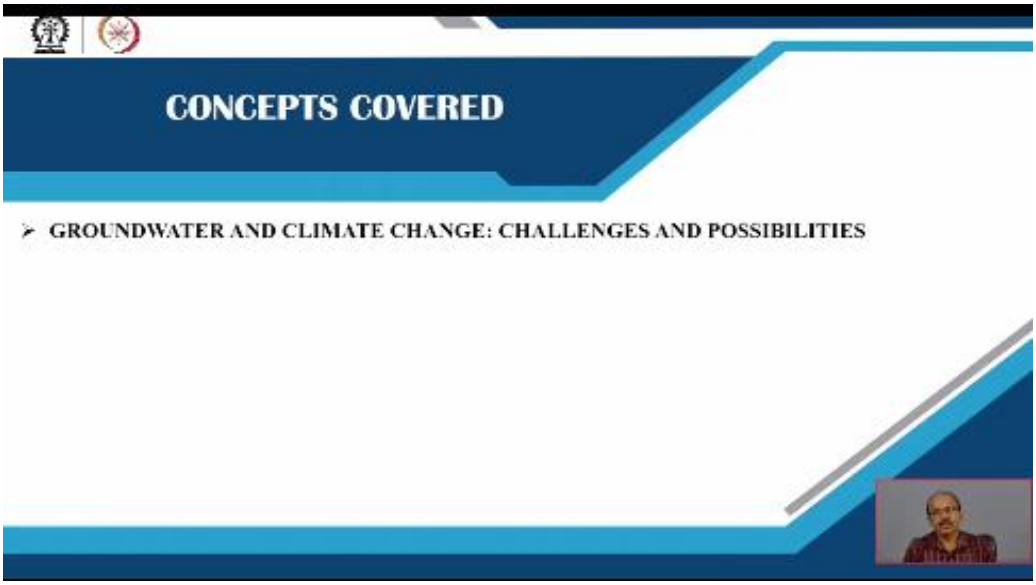

So, in this last part of the, your course, we will discuss about the groundwater and climate change, what are the challenges and possibilities.

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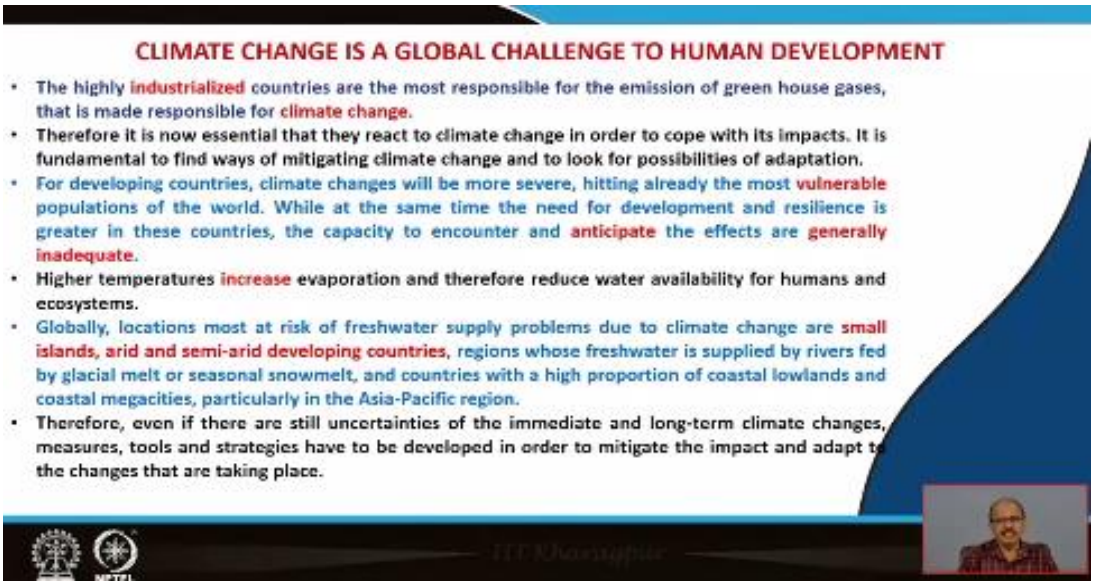

So, climate change is a global challenge to human development. The highly industrialized countries are the most responsible for the emission of greenhouse gases that is made responsible for the climate change. Therefore, it is now essential that they react to climate change. In order to cope with its impacts, it is fundamental to find ways of mitigating climate change and also to look for the possibilities of adaptation. For developing countries, climate change will be more severe, because it is hitting already the most vulnerable population of the world.

While at the same time, the need for the development and resilience in the greater is greater in these countries. The capacity to encounter and anticipate the effects are generally inadequate. Higher temperatures generally increase the evaporation and therefore, it reduces the water ability for humans as well as in the ecosystems. Globally, locations are most at risk of freshwater supply problems is due to the climate change are generally the examples are small islands, arid and semi arid, developing countries.

Regions whose freshwater is supplied by rivers and rivers fed by glacial melt or seasonal snowmelt and countries with a high proportion of coastal lowlands and the coastal mega cities, particularly in the Asia Pacific region. So, the locations are generally having the problem because of the climatic change. So, even if there are still some uncertainties of the immediate and long term climate changes measures, tools and strategies had to be developed in order to mitigate the impact and adapt to the changes that are taking place.

Therefore, still uncertainty of the immediate and long term climate changes measures are there. So, in that case, what to do some measures, some tools, some strategies, they have to be developed in order to mitigate sustainable impact and adapt to the changes that are taking place.

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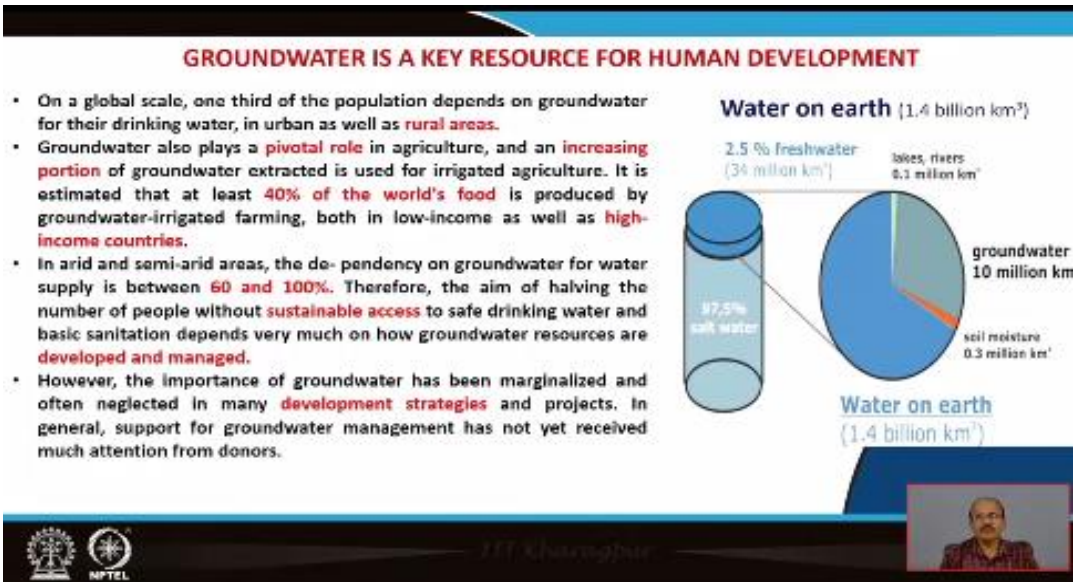

So, groundwater is a key resource, it is a key resource for human development. We have seen in the last few lectures we have seen that it is a key resource for human development. Not only we are using it, but it is also important because without water we cannot survive. So, on a global scale 1/3rd of the population generally depends on groundwater for their drinking purposes in urban as well as in rural areas. Generally, people are taking out the water from well, bore well, hand pump etc.

And then they are using it for their drinking purposes, cooking purposes, bathing purposes extra groundwater plays a vital role in agriculture, and an increasing portion of groundwater extracted is used for irrigation, that is the further irrigation of the agriculture. So, this groundwater also plays an important role in irrigating the crops in the field. It is estimated that at least 40% of the world's food is produced by the groundwater irrigated farming.

Both in low income group as well as by high income countries, low income countries or high income countries in both the country type of countries generally the 40% of the world food is

producing by the irrigation. This irrigated water is coming through the groundwater that is from the aquifer. In arid and semi arid areas, the dependency on groundwater for water supply is between 60 to 100%.

Therefore, the aim of having number of people without sustainable access to safe drinking water and basic sanitation depends very much on how groundwater resources are developed and managed. So, this is a very important point. However, the importance of groundwater has been marginalized and often neglected in many development strategies and projects. In general support for groundwater management has not yet received much attention from the donors.

In the diagram also, we can see the ability of the groundwater is only very few and its management is very, very utmost important at this stage, because already, because of the different formations we are having the different quantity of water, groundwater resources inside the surface, and because of this greenhouse gases and the global warming, because of the climate change, we are having the reduction in the your volume of the groundwater resource inside the Earth's surface.

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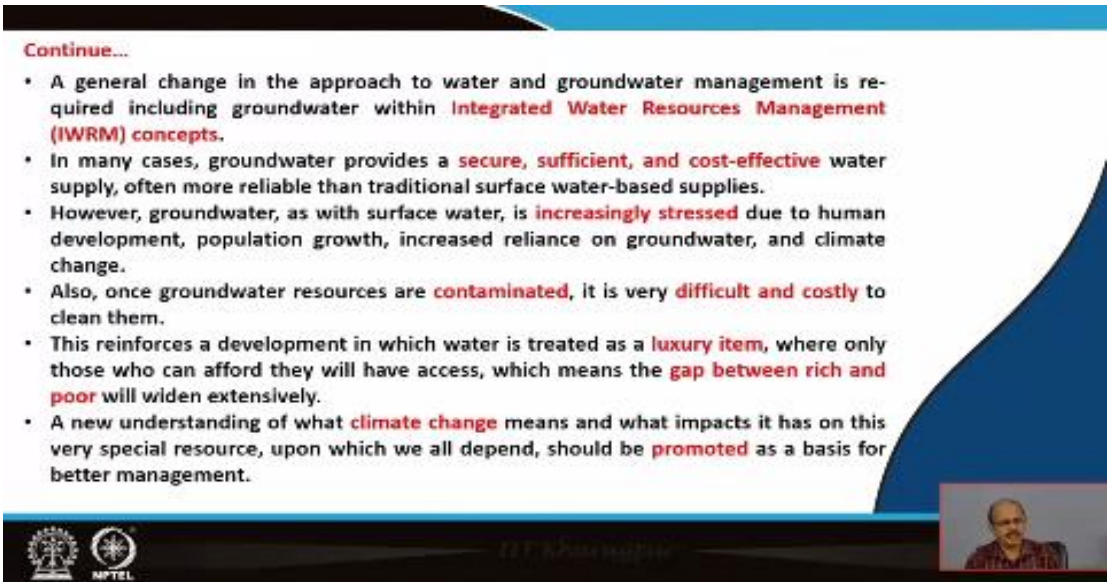

A general change in the approach to water and groundwater management is required. So, here an approach is required and this approach, including groundwater can be named as integrated water resource management concepts. So, it is very important now, we should follow the approach of the integrated water resource management. In many cases, groundwater provides a secure,

sufficient and cost effective water supply often more reliable than traditional surface water based supply.

So, no doubt groundwater supply is a very secure supply and sufficiently also available. However, groundwater and surface water is increasing stressed due to human development. So, due to the over exploitation of groundwater resources, now, it has come into stressed or a groundwater it facing increasing stress condition nowadays, because of the your population growth population has also increased, then the climate change has also taken place as well.

And also, once groundwater resources are contaminated, then it is very difficult and costly to clean them. So, generally, the groundwater resources are remaining fresh, without any pollution, free water groundwater, but once it will become contaminated, then it will take so much amount of money, as well as it is very tough, it is very difficult to clean it. So, generally groundwater resources are the freshwater resources.

Once it will become contaminated, then this reason enforces development in which water is treated as a luxury item, where only those who can afford, they will have access, which means the gap between rich and poor will widen extensively. So, reach now, this groundwater resources has become one of the luxury item why because Rich people are having money, they can do good scientific study, they can conduct goods and they can have the resource also they can just take out the groundwater, but if there will be poor.

So, since it has become costly, once groundwater is contaminated, it will become costly to clean them. So rich can do it, but poor care will not do it then what will happen, this will increase the gap between whom between the rich and poor, this gap will widen in new understanding of what climate change means and what impacts it has on this very special resource that is the ground resource upon which we all depend should be promoted as a basis for better management.

So, for better management for sustainable management, we should think over it because the whole factors we are having the knowledge about whole factors we are knowing that groundwater relying in some rock formations inside the surface. So, we are also knowing that the different formations

where is at the remains at different places. So, it is not your that each and every formation will hold the groundwater will store the groundwater.

Again, we are knowing that populations are increasing, so demands of the water increasing. So, exploitation will be more, once the exploitation will be more than there will be time will come, then maybe the groundwater level will go down. So, on the other side, we are also knowing that the climate change effect is there, global warming and greenhouse gases are gradually increasing. So, this climate change issues that are generated, you are declining the groundwater ability in the different parts of the region.

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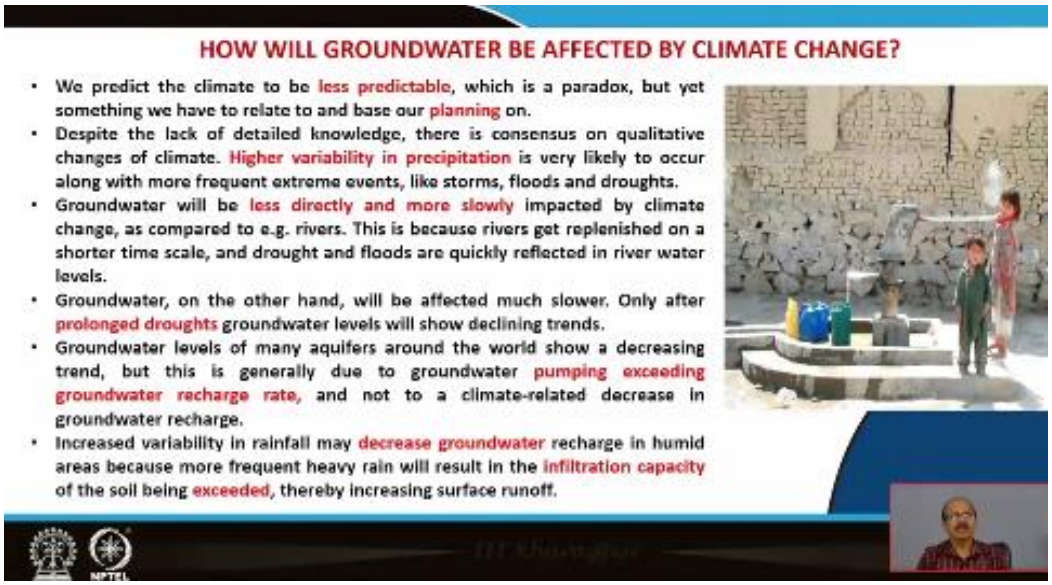

So, for this now, for this, we should think that how will groundwater be affected by climate change, we predict the climate to be less predictable, which is a paradox, but yet something we have to relate to and base our planning on. Despite the lack of detailed knowledge, there is a consensus on qualitative changes of climate. Higher variability in precipitation is very likely to occur along with more frequent extreme events, like storms, floods and droughts.

Nowadays, we are facing with the higher variability in precipitation, the precipitation will not remain same as in each and every place. So, groundwater will be less directly and more slowly impacted by climate change as compared to surface water that is reverse. So, this is because rivers

get replaced on a shorter timescale, and drought and floods are quickly related in river water levels. Groundwater on the other hand, will be affected much slower.

They are much slower, only after prolonged droughts, groundwater levels with so declining trends. So groundwater levels of many aquifers around the world, so a decreasing trend, but this is generally due to groundwater pumping, exceeding the ground water pumping which is reading the groundwater recharge rate, and not to a climate related decrease in groundwater recharge. Increase the variability in rainfall may decrease groundwater recharge in humid areas.

Because more frequent heavy rain will result in the infiltration capacity of the soil being seeded, thereby increasing surface runoff. So this is why the groundwater be affected by the climate change.

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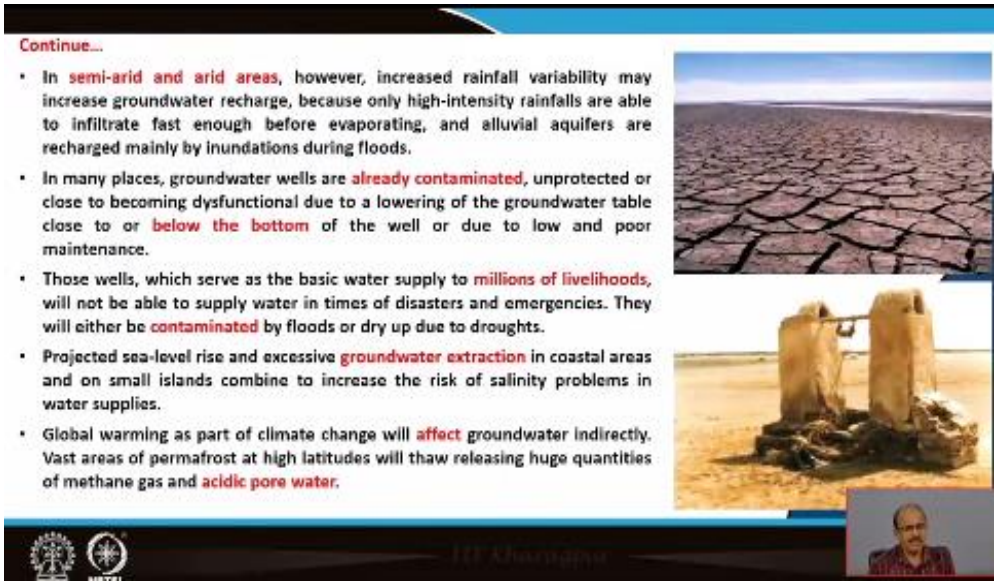

In semi arid areas, however, increased rainfall variability may increase groundwater recharge. So, increased rainfall variation will increase the groundwater recharge. Because only high intensity rainfalls are able to infiltrate fast only high intensity rainfalls, they are able to infiltrate fast enough before evaporating and alluvial aquifers are recharged mainly by inundation during floods. So, these alluvial aquifers are recharge, recharging only by mainly by inundations during floods.

In many places, groundwater wells are already contaminated, unprotected or close to becoming dysfunctional, due to a lowering of the groundwater table close to or below the bottom of the well or due to the low and poor maintenance. We can see that at several places groundwater wells are already remaining contaminated and protected or close to becoming dysfunctional by because of the closing of the groundwater table, which is very close to or below the bottom of the well.

And due to the low and poor maintenance so those ways we serve as the basic water supply to the millions of livelihoods they will not be able to supply water in times of disaster emergencies. They will either be contaminated by floods, or dry up due to droughts. Projected sea level rise and excessive groundwater extraction in coastal areas and on small islands combined to increase the risk of salinity problems in the water supply. So global warming as part of climate change will affect the groundwater indirectly.

Vast areas of the permafrost at high latitudes will thaw releasing huge quantity of methane gas and the acidic pore water. So this has been noticed and they generally these are just telling about the impact of climate change on the water resources.

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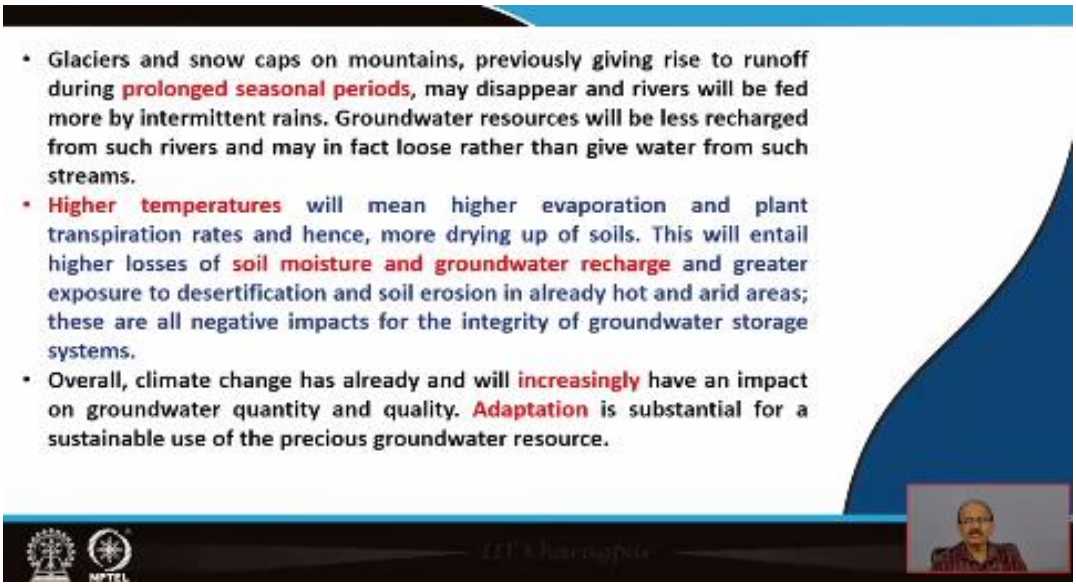

Glaciers and snow caps on mountains previously giving rise to runoff during prolonged seasonal periods may disappear and reverse will be fed more by intermittent rains, groundwater resources will be less recharged from such a reverse and may in fact, lose rather than give water from such

streams. Higher temperatures will mean higher evaporation and plant transpiration rates and hence more drying up of soils.

This will entail higher losses of soil moisture and groundwater recharge, and greater exposure to desertification and soil erosion in already hot and arid areas. These are all negative impacts for the integrity of the groundwater storage systems. So, this higher temperature generally increasing the evaporation and plant transpiration rate and hence more drying up of soils. So this whole will give the higher losses of soil moisture and groundwater recharge.

Overall, climate change has already and will increasingly have an impact on groundwater quality as well as quantity, quality and adaptation is substantial for a sustainable use of the precious groundwater resource. It is just for the substantial use of the groundwater resources, we should think for its improvement also. Now, what are the measures for adaptation as well as the mitigation.

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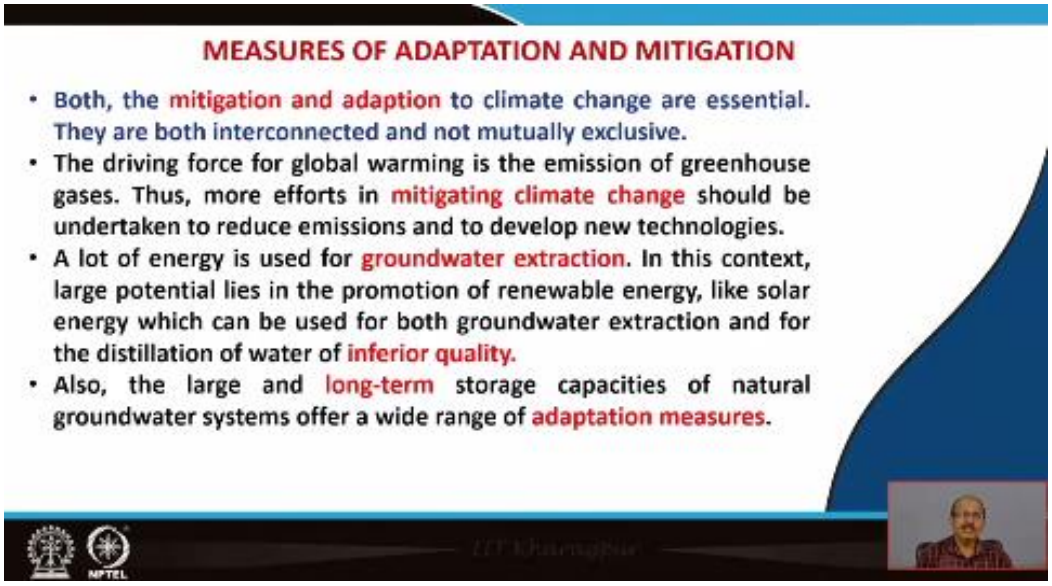

So, both the measures and the mitigation and adaptation to climate change are essentially they are required, they are both interconnected as well as not mutually exclusive. The driving force for global warming is the emission of greenhouse gases, it is the emission of greenhouse gases. More efforts in mitigating climate change should be undertaken to reduce emissions and to develop new technology. So a lot of energy is used for groundwater extraction.

In this section, they also need certain energy lots of energy are used. In this context large potential lies in the promotion of renewable energy, like solar energy, which can be used for both groundwater extraction and for the distillation of water of inferior quality. So the large and long term storage capacities of natural groundwater systems offer a wide range of adaptation measures, it is offering the wide range of adaptation measures.

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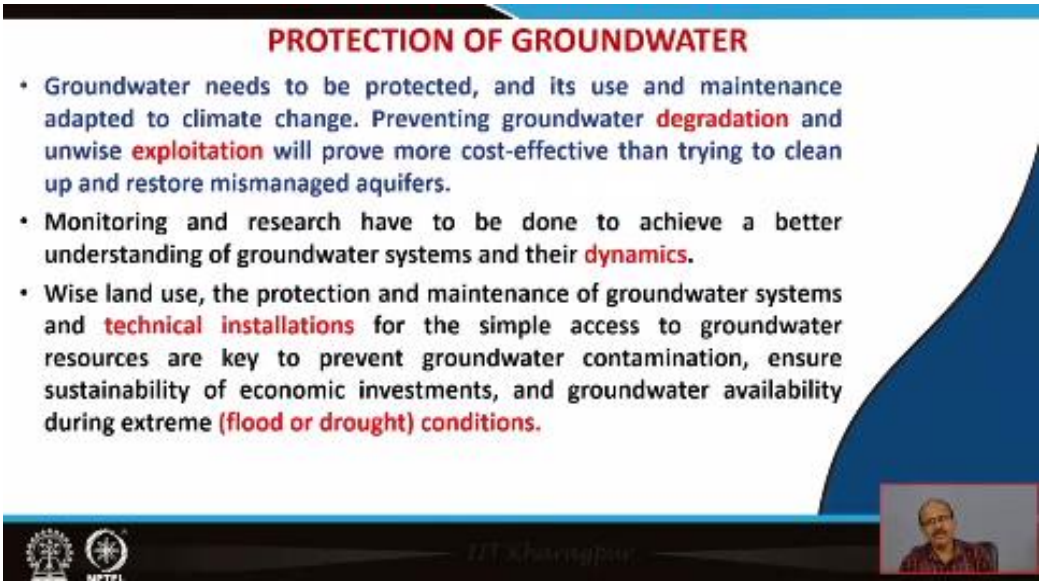

Now, how to protect the groundwater? Protection of groundwater is needed at the present state because groundwater needs to be protected and it is huge and maintenance adapted to climate change, preventing groundwater degradation and unwise the exploitation will definitely prove more cost effective than trying to clean up and restore mismanage aquifers, so monitoring and research have to be done to achieve a better understanding of groundwater systems and its dynamics.

Why the land use the protection and maintenance of the groundwater systems and technical installations for the simple assist to groundwater resources are the key to prevent groundwater contamination in ensure sustainability of economic investments and groundwater ability during stream conditions that it flood or drought conditions. So, in this way, the groundwater can be protected.

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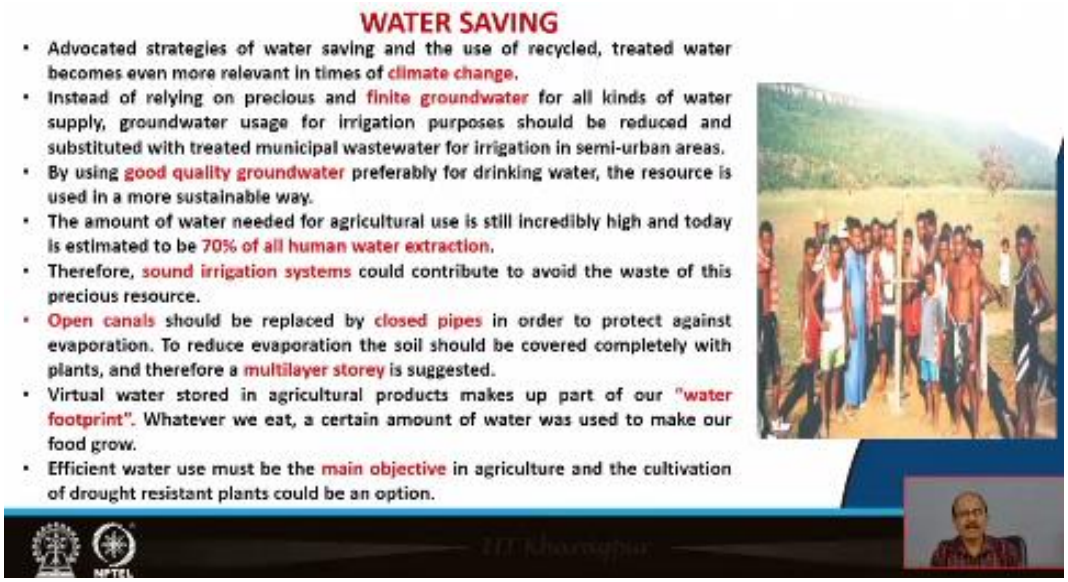

Now, the second aspect nowadays, it is a very popular word water saving, advocated strategies of water saving and the use of recycled treated water becomes even more relevant in times of climate change. So, water after its treatment can be used, you can be used for different purposes, instead of relying on precious and finite groundwater for all kinds of water supply. Groundwater uses for irrigation purposes it should be reduced and substituted with treated municipal wastewater for irrigation in semi urban areas.

So in this way, we can save the water we can save the groundwater resource, if we can use the your wastewater after its treatment for the different purposes, then for then, this water can be used for different purposes, then definitely there will be the lesser exploitation of the groundwater resources from the surfaces and in this way we can save the water also. By using good quality groundwater preferably for drinking water the resources used in more sustainable way.

The amount of water needed for agriculture use is still incredibly high and today it is estimated to be 70% of the of all human water extraction. Therefore, sound irrigation system, good irrigation system could contribute to avoid the waste of this precious resource. Open canals should be replaced by closed pipes in order to protect against the evaporation to reduce evaporation in the soil the soil should be covered completely by plants.

And therefore, a multi layer story is suggested virtual water stored in agriculture products makes up the part of our water footprint. Whatever we eat at a certain amount of water was used to make our food grow. Efficient water use must be the main objective in agriculture and the cultivation of drought resistant plants could be an option. So in this way, in this way we can save the amount of water groundwater resources.

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What are the strategies for policymaking? Many principles applicable for the sustainable management of surface water is equally valid for groundwater management also thirst capacity development, good governance and transparency by are the key stones which have to be promoted or which have to be considered. Often the insufficiency of supplying drinking water and sanitation is driven by insufficient or inefficient supply of services rather than by water shortages.

Investments in building home human capacity and physical infrastructure contribute to the development. For decision makers the available data and information concerning the water balance and changes due to climate change have to be comprehensive and easily accessible. Still, not only knowledge should increase and the data collected but it is absolutely important that data is comprehensive and easily accessible.

Due to increasing investment in the global water market governments should support strong regulatory systems which are based on monitoring data collection and sharing of knowledge by national water authorities.

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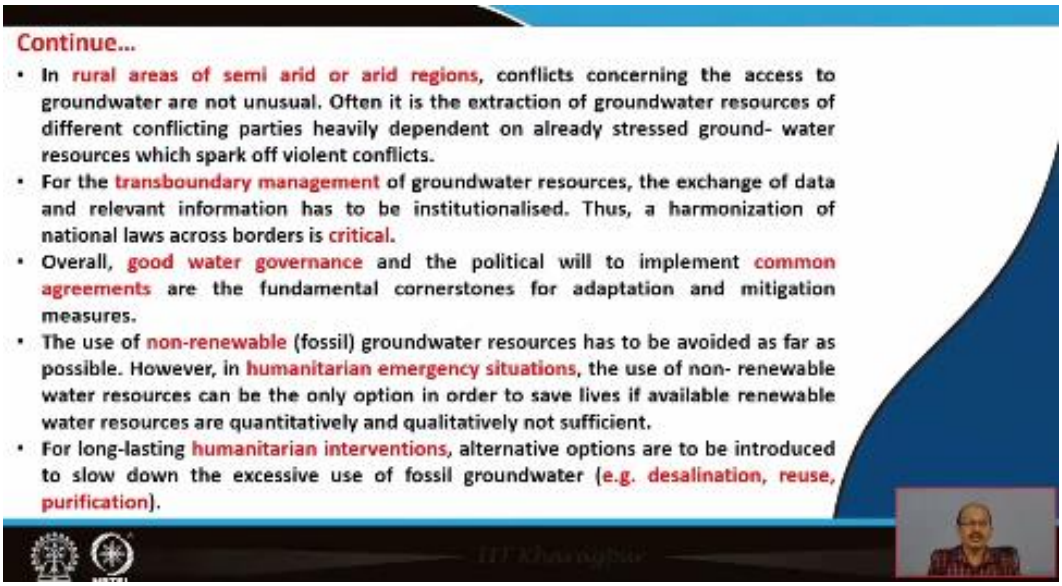

In rural areas of semi urban rural areas of semi arid or arid regions conflicts generally arising that is regarding the concern to access the groundwater and they are not unusual. Often it is the extraction of groundwater resources of different conflicting parties, heavily dependent on already stressed groundwater resources, which spark of violent conflicts. For the transboundary management of the groundwater resources, the exchange of data and relevant information has to be institutionalized.

Thus, a harmonization of national laws across border is critical. Overall, good water governance and political will to implement common agreements are the fundamental cornerstones for adaptation and mitigation measures. The use of non renewable will groundwater resources has to be avoided as far as possible. However, in humanitarian emergency situations, the use of non renewable water resources can be the only option in order to save lives.

If available, renewable water resources are qualitatively and quantitatively not sufficient. For long lasting humanitarian interventions alternative options are to be introduced to slow down the excessive use of fossil water that is desalination, reuse and purification.

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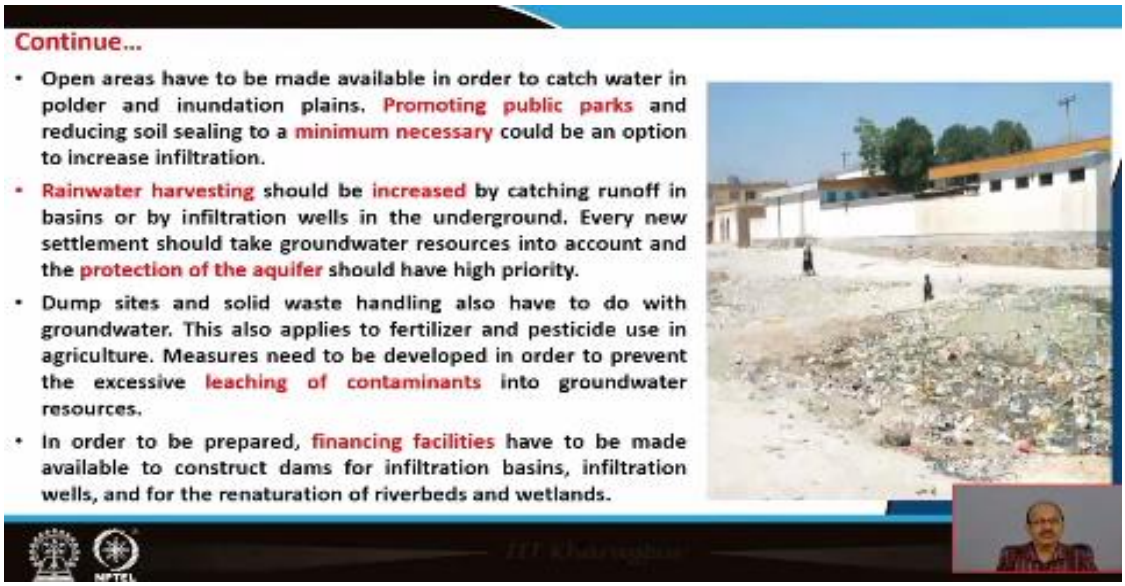

Then, open areas have to be made available in order to catch water, in polder and inundation planes. Promoting public parks and reducing soil sealing to a minimum necessary could be an option to increase infiltration. Rainwater harvesting should be increased by catching runoff in basins or by infiltration wells in the ground. Every new settlement should take groundwater resources into account and the protection of the aquifers should have high priority.

Dump sites and solid waste handling also have to do with the groundwater. This also applies to fertilizer and pesticide use in agriculture. Measures need to be developed in order to prevent the excessive leaching of contaminants into groundwater resources. In order to be prepared financing facilities, have to be made available to construct dams for infiltration basins, infiltration wells, and for the renaturation of riverbeds and wetlands.

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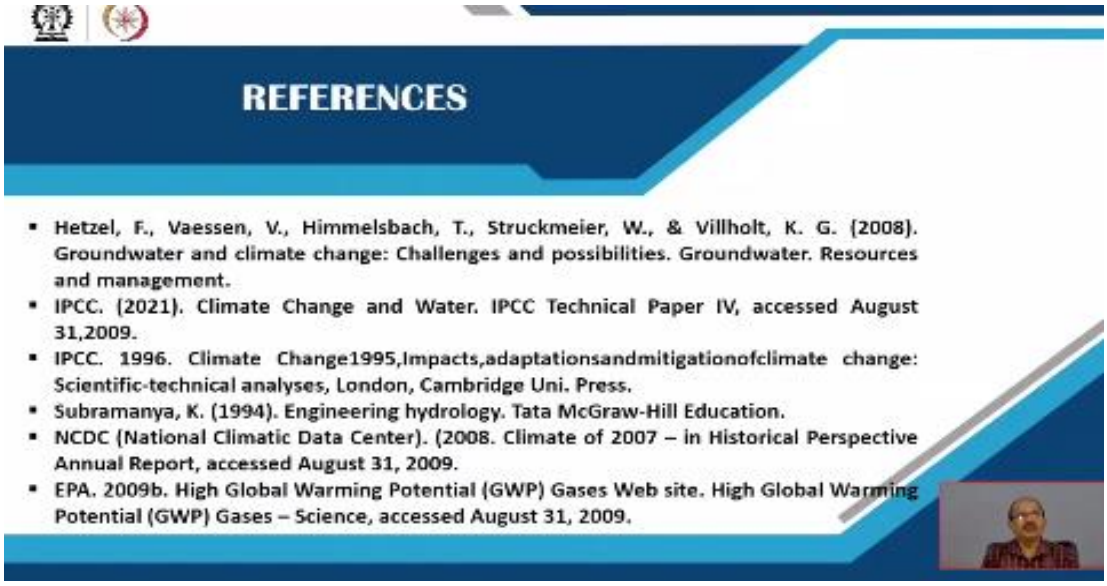

So, these are all about the your subject that is the impact of climate change and water resources. These are references I have taken for the formulation of the 5 6 different parts of the content my impact of climate change on water resources, you also go through it.

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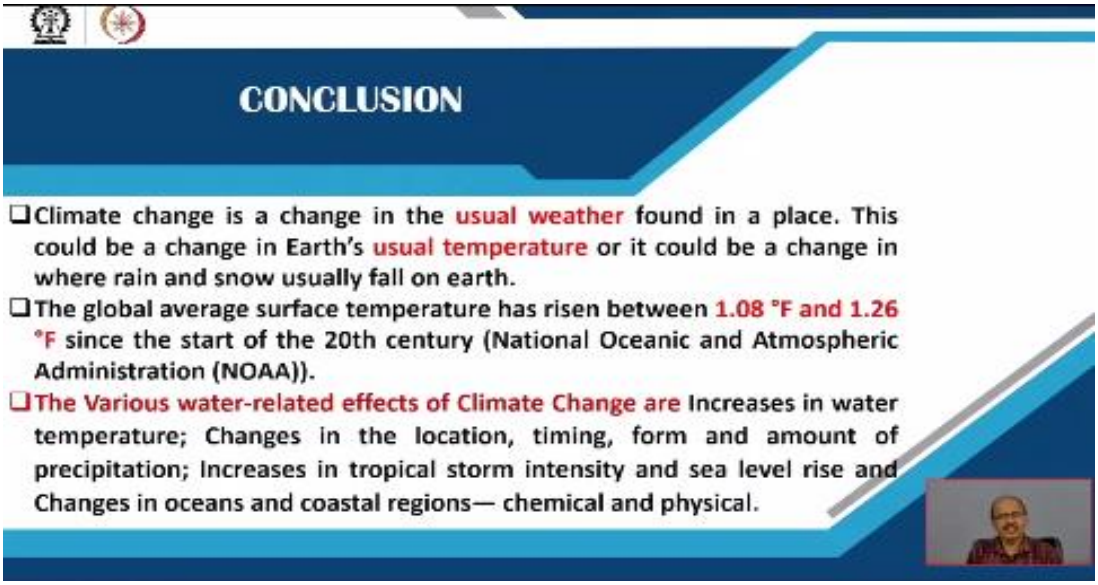

And you can make you can read many more points in here from they are also now conclusion of this subject the impact of climate change and water resources is that climate change is a change in the usual weather found in a place. This could be a change in Earth's usual temperature or it could be a change in the where rain and snow usually fall on the Earth. The global average surface temperature has risen as 1.08 °F to 1.26 °F since the start of the 20th century.

That is for the National Oceanic and Atmospheric Administration NOAA, the various water related effects of climate change, our increase in water temperature, change in the location, timing, form and amount of populations increase in tropical storm intensity and sea level rise change in the oceans and coastal regions chemical and physical.

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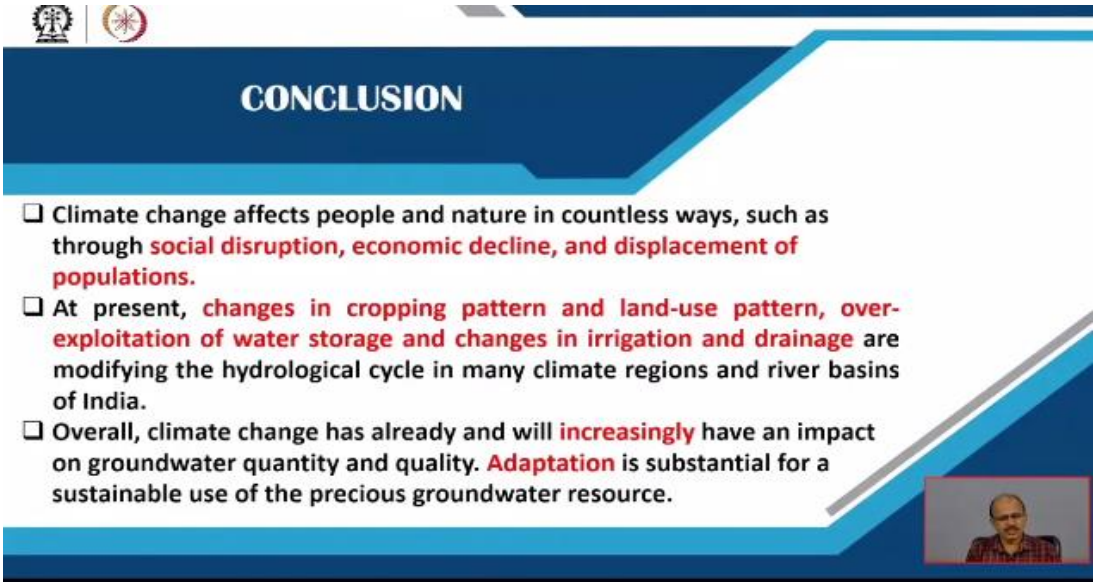

So climate change affects people and nature in countless ways such as through social disruption, economic decline and displacement of the populations at present changes in cropping pattern and land use pattern over exploitation of water storage and change in irrigating and drainage are the modification or the modifying the just the hydrological cycle in many climate regions and the river basins of India. Overall, climate change has already and will increasingly have an impact on groundwater quality as well as quantity.

Adaptation is substantial for a sustainable use of the precious groundwater ratio. So, we have seen the change in the details about the hydrological cycle we have seen the different parameters of the hydrological cycle also, in the very beginning of the course, we have seen that the precipitation is the only factor through which the aquifers are being recharged underneath the surface. Now, in this part, chapter 12, we have seen the impact of climate change.

Because gradually the because of the emission of the greenhouse gases and the global warming on the Earth's surface, gradually they are putting impact on the ability of the groundwater resources

also, because of the increase in temperature as well as the increase in the evaporation rate. Once the operation will increase definitely there will be some of the erratic pattern of the rainfall precipitation. And because of the erratic pattern of the rainfall, precipitation, definitely the recharge inside the earth surface will differ from place to place, and from season to season.

So, this is all about the impact of climate change on groundwater resources, or water resources. Thank you very much to all.