Rural Water Resources Management
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Week 04
Lecture No. 05
Recap of Groundwater Hydrology

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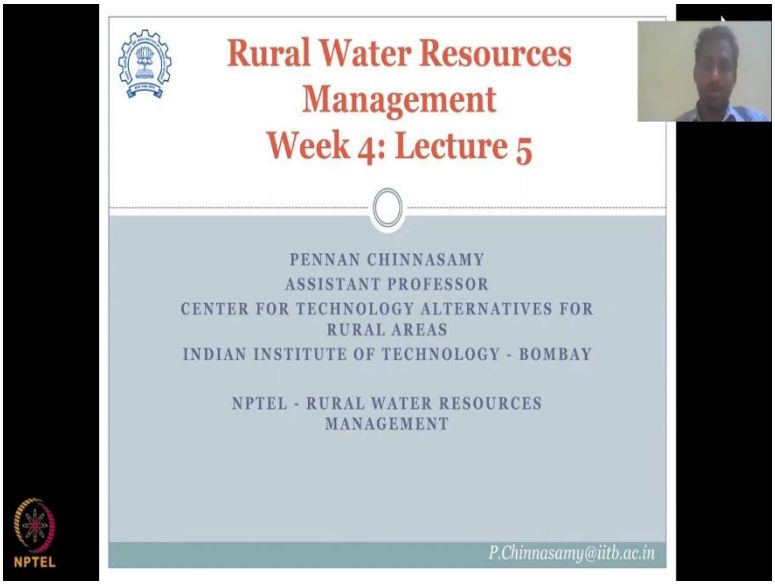

Hello everyone, welcome to Rural Water Resource Management NPTEL course, week 4 lecture 5. So, this will be the last lecture for week 4. And so, we will do a short recap after some materials in groundwater.

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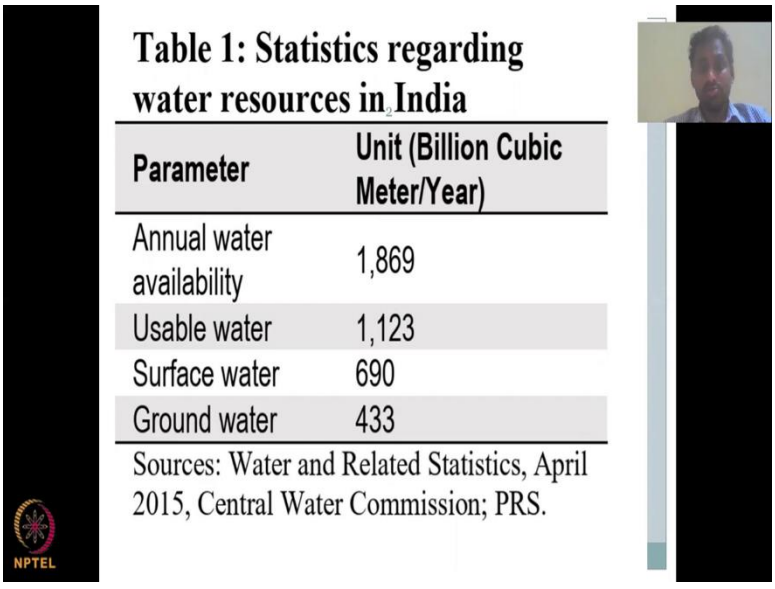

First, let us look at the statistics for water resources in India. We have gone through this and the initial classes, where we looked at the annual water availability as in billion cubic metres

per year, we have around 1800, 1900 goes to 8 cubic metres, of which usable is only 1100, 1,123 billion cubic metres of which surface water is 690 and groundwater has a very good shade of 433.

So, what this clearly tells you is that of the usable water 433 billion cubic metre is supplied by groundwater. So, given all the rainfall, the storage, the pit dams still the groundwater usage is a very considerable amount in the annual groundwater use in India, it is also a very decentralised water, wherein you do not need a channel, you do not need a dam to store and then do it but everyone who has access to wells and pumps can locally source the water. So, because of the ease, because of the access and technology, the stress on this water has also increased.

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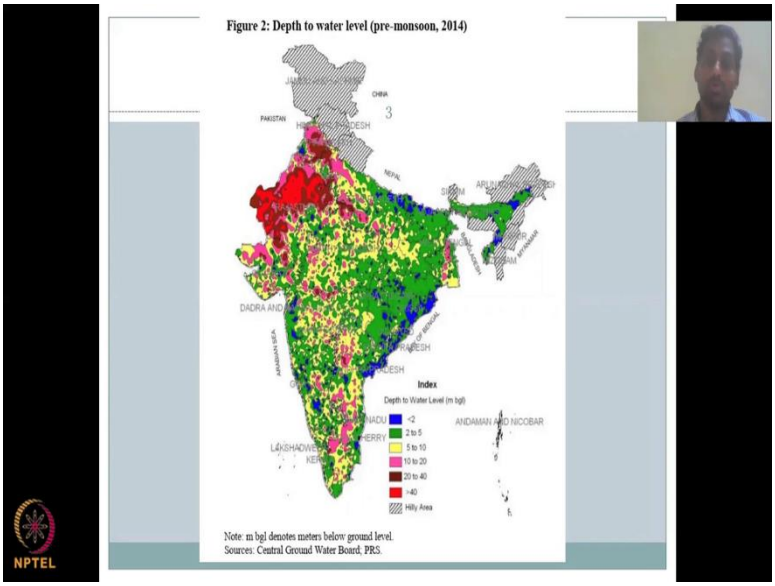

And this been captured by different groundwater maps, especially the pre-monsoon, because that is the peak summer. So, after all the rainfall, after all the recharge happens, you extract water, and it is reflected in the pre-monsoon season maps. So, if you look at 2014 and you could see that the pre-monsoon levels are really concerning in central India, where it goes to 5-10 metres a yellow colour and pink colour 10 to 20 metres but most importantly Rajasthan, Punjab, Haryana those regions have drastic groundwater levels depleted. The levels are on-going depleted and you know that what is the key livelihoods in those regions, it is mostly livelihoods are supported by agricultural activities.

So, agriculture has been a biggest consumer of groundwater and annually the water levels are decreasing in these regions. So, it is not that okay, you deplete it and then it comes back again

and, but it is not. So, there has to be some measures, some stringent rules on groundwater use and abuse and more progressive thinking on groundwater.

Also a lot of people react later very, very late. So, by that time the water depletion has hit a level that it is almost irreversible. So, it is more proactive measures are needed. Wherein visualising the groundwater use, visualise the groundwater demand, we need to understand and develop methodologies that can recharge faster or limit the use of groundwater.

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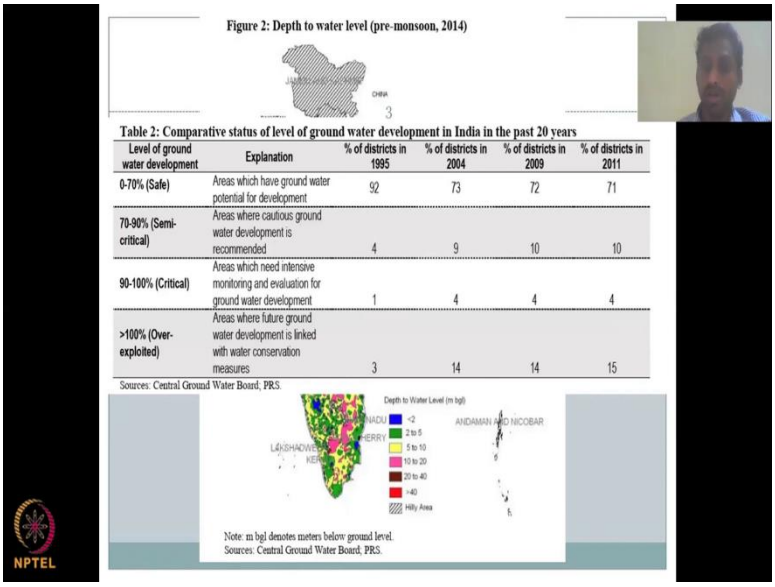

So, table of comparisons as I mentioned earlier, center groundwater Board characterises the blocks as safe, semi critical and over exploited based on the groundwater use. In the use 0 to 70 percent of the annual recharge, it is so you can still use some water and 30 percent could be given to ecosystem services, base flow, stream flow generation, etc.

70 to 90 percent is semi critical and anywhere 90 to 100 percent which means you are using the annual replenishable water in the groundwater every year you are using it, so think about your bank account analogy again, if you have 1000 rupees coming in or 10,000 rupees coming in per month as a salary and by the end of the day, end of the month. If you have zero balance, then that is critical because if anything happens you do not have water, you do not have money, but 70-90 percent of semi critical, 0 to 70 percent is safe.

Over 100 percent, which means you are using past recharge water or someone elses water. So that means it is over exploiters that is the concern, so over exploit is the concern. And critical is also a big concern, because critical stages can easily jump into the over exploited. So, think about a bank account, we have 10,000 coming in every month, and at the last day of the

month, if you say no, I need more, I have exhausted my 10,000 rupees, I use a credit card or a loan and I take more, it adds up as a debt, so you are actually eating into your future water, or you are taking some savings and then using your water.

So, over-exploitation is bad. If you know the water levels, why would you go and use more water is the question, if you know you are going to get 10000, you should have your demands and also your needs within the 10,000, so that you are safe, otherwise it is over exploited. And that is not sustainable. How long can you do that? At one point you need to stop, maybe you will say okay, I want to spend after some time, I will stop but water is not there, every year you need water, every year the trees need water, every year the streams need base flow.

So, overexploitation and critical stages are very, very important and groundwater board and government agencies are working on arresting these groundwater falling levels by putting in more infrastructures or mapping them for the government records, and sensitising people on not doing these kinds of activities. The rules and regulations are not yet stringent, because it is very hard to understand where the pumping is, who are pumping, etc, etc.

So, 0 to 70 percent areas have groundwater potential for development. So, you still can extract more and if you look across the years from 1995 to 2011, the percentage of districts in the past 20 years shows clearly that the safe level blocks and districts have come down. So, 92 percent to 71 okay, so look at 90-95 it was 92 were districts will safe. 2011 71, which means your safe districts are coming down. Whereas you are over exploited and critical are increasing, especially you are over exploited which was 3, it jumped to 14, 14 and 15.

So within 10 years, you have 14 districts over exploited. Same in the critical stage also 1444. So, what you see clearly is the safe and semi critical have been converted as critical and over exploited. So, this is why I am trying to say that critical blocks, critical districts have to be managed with utmost care, because they can any day become over exploited.

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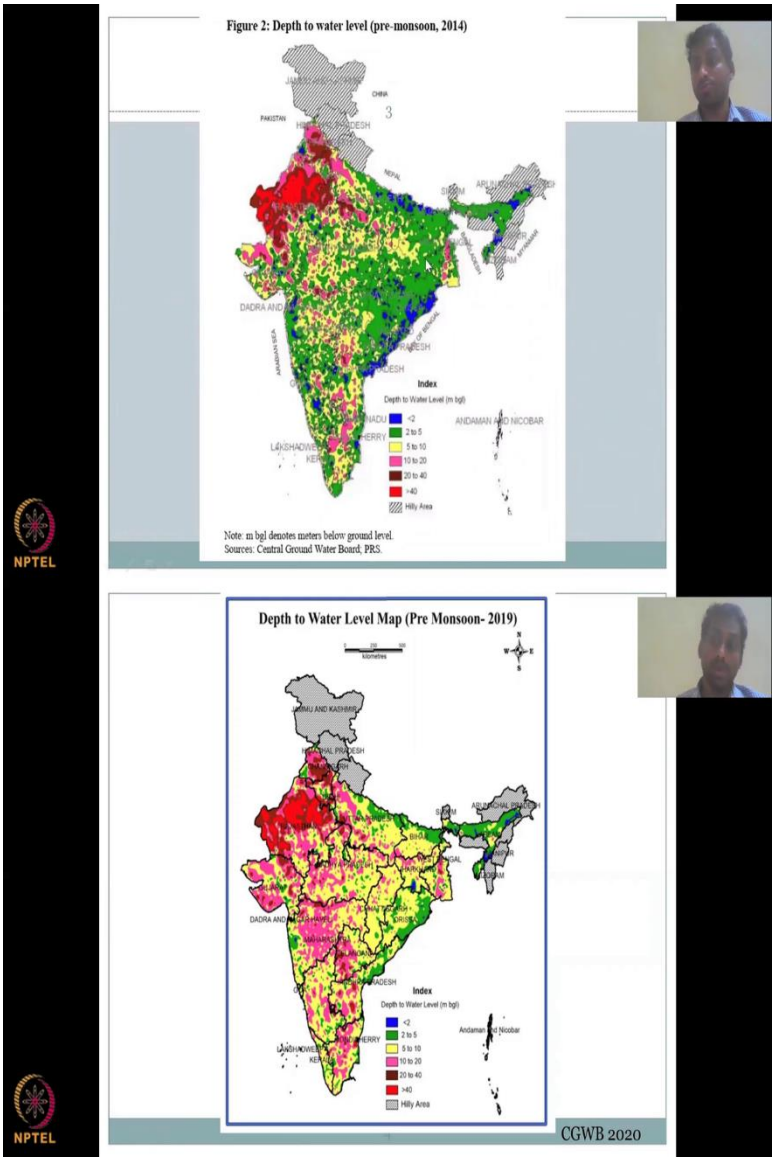

Let us look at how it looks now compared to 2011 images. So, in 2011 images, you saw a lot of green colour here. Let us go back and show you quickly, so you saw lot of green colour which is 2 to 5 metres depth to the water level which is still safe and 5 to 10, 10 to 20 are really bad, blues are okay, but when you come to 2019 which is the latest year 2020 report image, you see clearly that okay the borders of the green are still, but the central India is actually coming in groundwater levels, it is the same legend, so the colouring is the same.

So, 2 to 5, which were here, all the green colours, all the green colours along this region, central India are now in the 10 to 20, not even 5 to 10. So, you have jumped approximately 15 metres from your 2011 level. So, within 8 years or even 9 to 10 years, your groundwater has fallen by 15 metres and that is not sustainable, multiplied by the area, you would

understand how much volume that is, which is very, very big compared to the water volume available.

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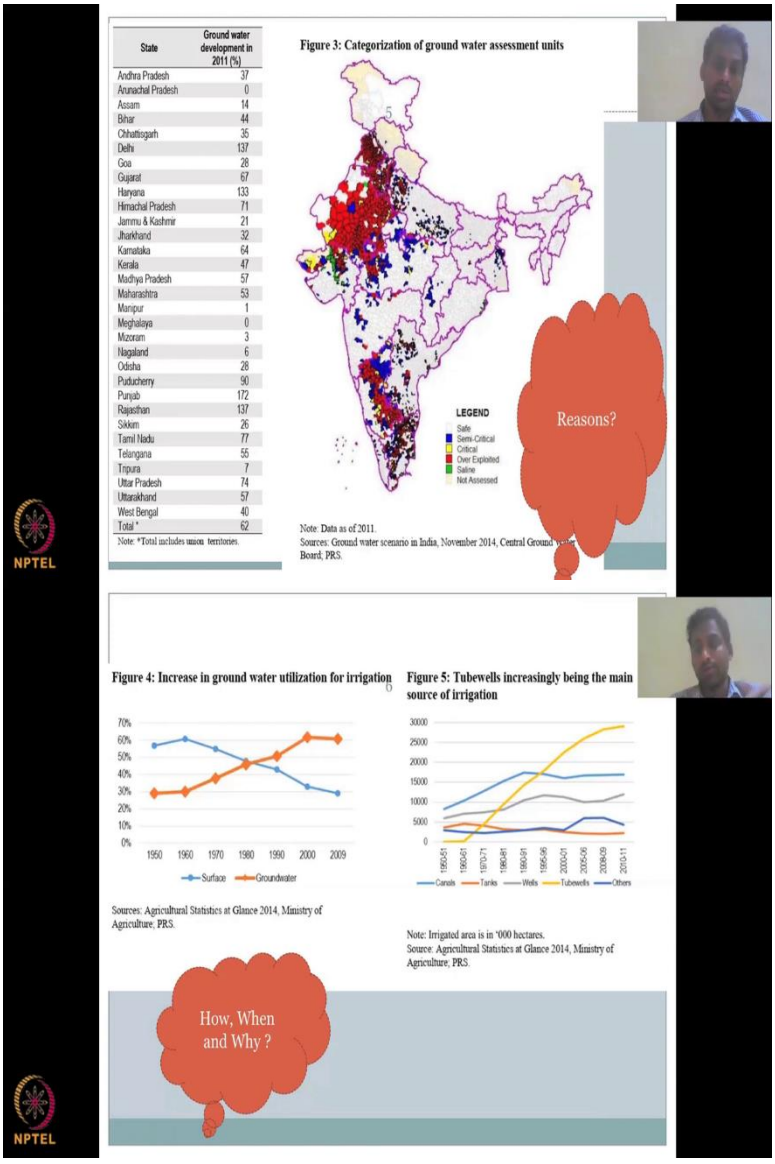

Let us see, which are the states, you the districts now let us see the states, which are the states that are using very high amounts of groundwater as personal development. And I said anything about 100 is bad, but we will still put a ballpark around 90 percent which is low, so 90 and above is not acceptable because it is very, very harmful to groundwater aquifer.

So, you can come down to Delhi, Delhi's water is, groundwater levels are above the recharge. So, the use is above the recharge and the government is working on a lot of methods to bring back the water by recharge and other mechanisms, but the population is very high. So, there is a lot of groundwater use.

Coming to Haryana, which is an agricultural state, you could see the groundwater uses above your groundwater recharge because 100 is equal groundwater recharge is equal to groundwater use, but here is 133. So, 33 percent above and when you come down, another Pondicherry, and very small state, there is a lot of agricultural activities there and also, urbanisation. Punjab is purely driven by agriculture, and you could see a lot of agriculture activities supported by groundwater. So, groundwater has to be managed as much as in Rajasthan and other states.

So, all these states in 2011 have performed kind of on the critical or semi-critical levels and the handful which are on the over exploited, but in recent years, the levels are not promising because everyone is now having easy access to groundwater. And so, these are the characterizations of the blocks of semi-critical, critical, and over exploited, over exploited are in the red colours.

And you could see in 2011 most of it is in Haryana, Punjab, Rajasthan regions, and there are some blocks, so compared to districts there are some blocks, within the district, the image might not be that helpful, because part of the district is urban, part of the district might be a desert, part of district might be a forest.

So overall averaging a district might not be that helpful, but a block image actually shows you where the water is being used more than the recharge and now you could see more southern states have blocks that have high demand in groundwater, Bangalore, Chennai, all the big cities are there Hyderabad, etc, etc.

The reasons, the urban reasons let us look at the big, big states and big, bigger blocks, what is the reason? It is agriculture. So, increase in groundwater utilisation for irrigation has tremendously increased over the years, if you look at the Agricultural Statistics you could see that the groundwater component in agriculture has increased from 30 percent to 60 percent, whereas the surface water has come up to 60 percent or 30 percent. So almost it is exchanging their responsibilities.

So, now groundwater has been promoted as the key resource in the regions where surface water irrigation was happening. And that again, as I said, surface water is a more centralised approach where you have a dam and the dam resists water to farmlands only to the farmlands where it has access to channels. Whereas groundwater is you just have to put in a pump and then suck all the water out.

So, coming back, so groundwater has overtaken surface water in some regions, but more importantly, the pattern is exchanging between themselves. So, the role, the responsibilities have been taken out by groundwater, and more and more areas are coming under groundwater irrigation.

The other finger shows another story, tubewells have increasing, so, that actually is an indicator of groundwater being the source of irrigation. So, if you look at the source of irrigation, canals, which have surface water related have almost stagnated from 1950 to 2010-11. Tanks also is the surface water storage unit has also stopped or even come down in recent years.

Whereas wells have increased and most importantly, your tubewells have just skyrocketed, it was 0 in the 1950s to 1960s, technology was expensive, there was not much development on groundwater pumps. But then slowly science and technologies have become prolonged effort in bringing up the groundwater pumps, electric pumps, diesel pumps, those kinds of things. And you could see skyrocketing increase in the number of tubewells. Even the easy access and easy installation of tubewells has big impact on the groundwater use for the irrigation.

So, all this is not sustainable, because initially one village would have two-three wells, I could imagine in my younger age, when I was travelling in the villages, we could see only a certain number of wells for irrigation. But now every small plot has its own well, because there are some funds, there are some subsidies given and water is just being exhausted, but there is less and less groundwater recharge activities happening.

So, how, when and why, what is the reason for this tremendous increase? Because there is a lot of stress on farmers who produce more food, the population is ever increasing, and the weight falls on the farmers shoulders, because they have to feed the people and also if they cannot allow the land to go fallow, because of the technologies and hybrid products, so, they will just put in more and more crops, fertilisers, all these things have actually converted the land from a single crop rotation land into two or even three crop rotation lands. And with this rotation, there is more need for water and groundwater is being used, because always you do not have rainfall for your kharif season.

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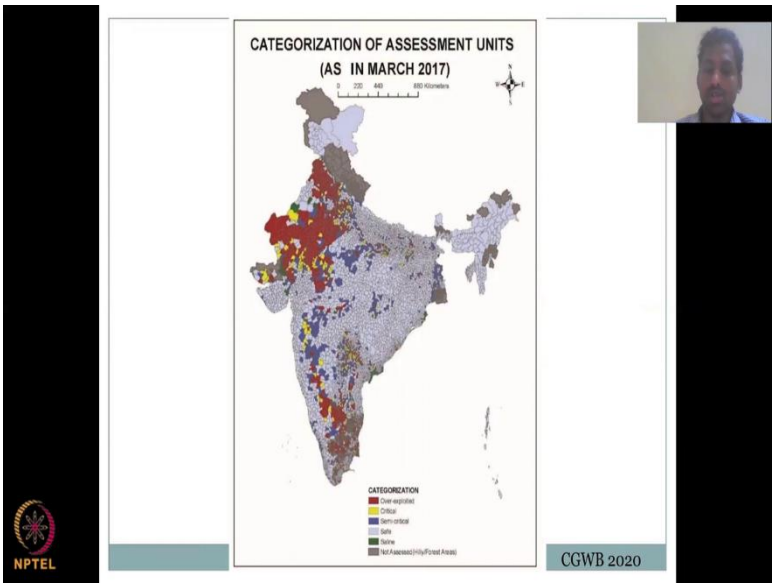

Because of this, compared to your 2011, you will see more and more red blocks over exploits, especially in the northern regions. But I would say that the ground reality might be much, much bigger because if you go back to the issues and concerns, I mentioned for groundwater monitoring, some of the wells are not representative or some of the wells are not pumping wells, it is monitoring wells.

And if you come to your central part of India, this is where we tie up all the learnings from these two lectures on groundwater hydrology, what did we find in the central part of India it is sort of hard rock aquifers. And hard rock aquifers are not well connected, because it has fractures and some of the wells would not be replying together, it would not tell the same story.

So, if you have one well which is from for farming and right next to it a well which is not being pumped, the water level will be always the same. So, when you do a block estimation, you might be misguided. So, there is a more, more need for augmenting groundwater data with other data to understand the reality of groundwater use.

So, if you look at the papers and other things that will be shown in the case study approach in the following lectures, you will see remote sensing images and also land use and cover use data, all these combining to give a groundwater estimate, not just a groundwater level. Because at the end of the day, if you have a land full of crops in a non-rainfall season, how did the crop grow, you should have given groundwater. So, that is where you link groundwater level with rainfall, with your land use and cover change to understand what is the reality on the groundwater.

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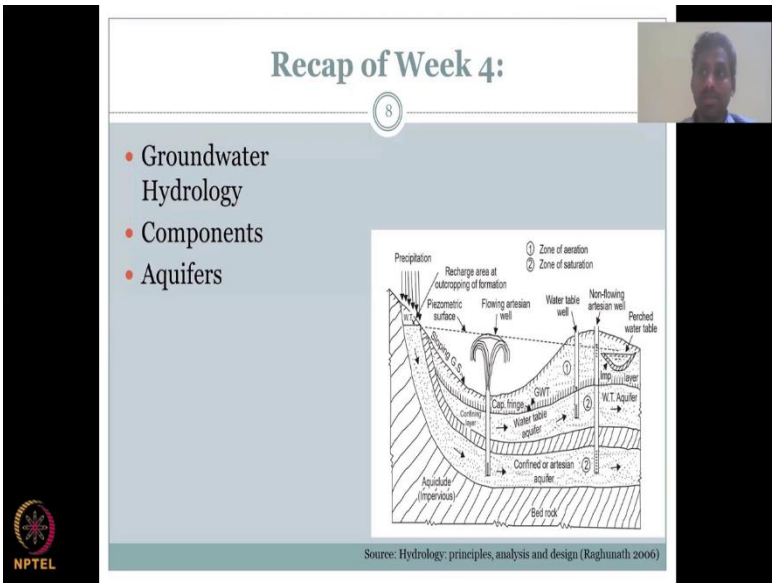

So, with this let us do a recap of week 04, we did, do a very focused discussion and learning on groundwater hydrology, where we focused on the overall hydrology only the components which are necessary for groundwater hydrology, we looked at the most important components of precipitation, infiltration and then how water moves down in the soil profile to different compartments in the aquifers, etc.

We also looked at the very important material and material properties for groundwater hydrology, which is basically your sediment and soil materials, along with the porosity the pore space where water can enter and store. So, these components we looked at many illustrations and we understood that if there is a confining unit or impervious layer, in between the aquifers then the aquifer is divided as an unconfined, and confined aquifer.

The unconfined aquifers have the top surface the open to infiltration precipitation coming in, whereas the unconfined are having a confining both at the top and the bottom. So, any system can have only one unconfined aquifer, but the confined aquifers can be multiple. And depending on the placement of your wells and the depth of the wells, the wells get different names.

So, if you put a well in your shallow aquifer, you will mostly be dug well or you will have a well with the 30 metre depth, so you just annually recharge, shallow aquifers or annual recharge or even within a couple of years, we looked at residence times, we looked at recharge times, etc., when we discussed about aquifers.

When we have deeper aquifers, this is the bigger concern, your deeper aquifers are going deep into the system like here and it is screen so, it does not take water from the shallow aquifers, it takes only from the deep aquifers. And that you are using water which has been stored there or taken time around 100 years or even a millennia 1000 years for the water to come there. So, if you deplete it, you will have to wait another 100 years for that full aquifer recharge to happen which is not possible in one's lifetime.

So, with utmost care and concern aquifers should be used especially the deep aquifers. If the shallow aquifers are depleted, then multiple opportunities are there to enhance their groundwater recharge, which will be looking at in the coming weeks. But more importantly, we will be looking at how water structures, both natural and artificial can aid in groundwater and surface water hydrology for rural development.

We also looked at zone of aeration versus zone of saturation, whereas zone well it has the soils, has pore spaces still without water or void spaces without water are called zone of aeration, because air is still present. Whereas zone of saturation is the zone where the void spaces are filled up with water.

So, all these things we looked at and we looked at the sloping nature of the land which helps in groundwater movement laterally. And we also discussed the stage where your groundwater recharge happens and it goes until your last impervious layer, which is your Aquitard or your bedrock and after that water even though gravity is acting on it, water does not move down but laterally and once it goes laterally there is a natural discharge.

So, discharge can happen in multiple ways, you can put a pump and take the water out that is your artificial discharge. But naturally discharge is when groundwater goes and at one point comes out of your lithology or the Earth's crust into the streams, rivers or springs. We also looked at perched water table which is very less in number and artesian wells which are less in number and whatever reasons through which it happens.

We looked at central groundwater board data, how it is collected and other measurement devices and the driving force here is the data is present but to have more understanding and more management plans, there is a need for augmenting these observation data with remote sensing and other data like farmer, crop data, yield data, etc., or even power use for groundwater pumps to estimate the amount of time the pump was running, which is also related to the amount of water it was pumping out from the aquifer.

So, all these data can be put together to better understand, groundwater block characterizations which is critical and semi-critical, etc. So, with this I would like to conclude the groundwater hydrology lecture. And look forward to meeting you in week 5. Thank you.