Rural Water Resources Management
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Week 04
Lecture No. 03
Groundwater Recharge and Discharge

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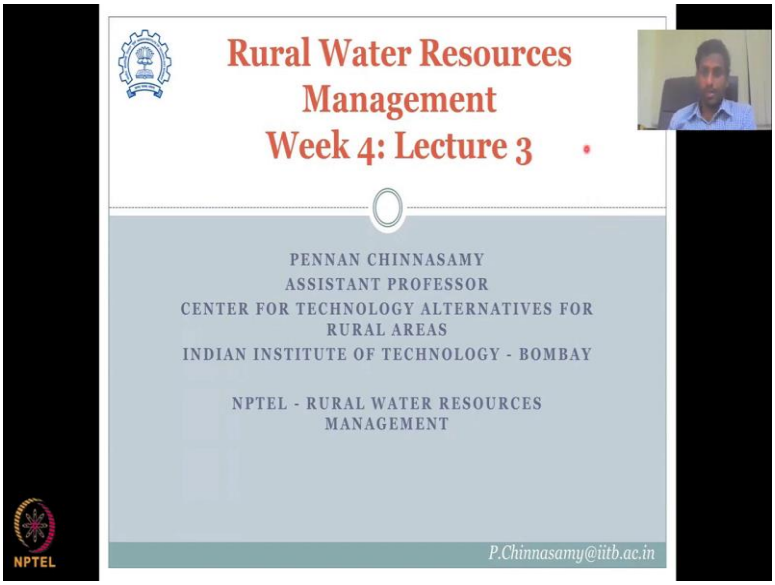

Hello, welcome to NPTEL Rural Water Resource Management course, week 4, lecture 3. In this week, we are focusing on groundwater hydrology. The past two lectures we looked at what constitutes groundwater hydrology. We also looked at the concept of aquifers, then unconsolidated versus consolidated, unconfined versus confined and saturated versus unsaturated.

So, we have seen different phases of aquifers, different places where groundwater can exist, what drives the groundwater storage and what drives the groundwater flow, especially potential difference. So, in the following lectures, we would like to see how ground water is recharge and then discharge or pump out used, etc. So now you have a better idea of managing the groundwater resource if we know about the recharge and discharge.

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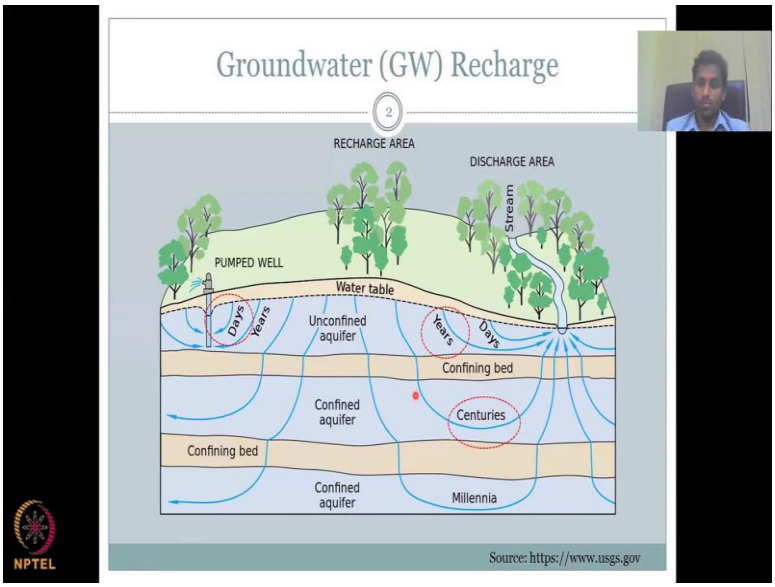

Let us start with groundwater recharge. So, the recharge area which you see on the top of the land is going to be the predominant phase, where you have water coming in okay yeah, water comes through streams and rivers, but it is much less compared to precipitation induce groundwater recharge. So, again visualize yourself as a water droplet, you will come, infiltrate and then get into the first unsaturated, then unsaturated zone.

Once you get into the saturated zone, and you have a confining bed it becomes an unconfined aquifer. Remember I was saying that you do not just have to have one confined aquifer there can be multiple, but you can only have one unconfined aquifer there cannot be an unconfined aquifer suddenly after a confined aquifer.

So, only when you dig it up yeah, if you dig up a well and you have open water coming in then it is unconfined, but it would call it as an aquifer because it is a longer time and space, you clearly see here where you have unconfined layer because you have a confining bed, impervious bed, all these terms we discussed.

So, recharge water comes in and it takes days. So let us say if you have a rainfall within a couple of days you will see it coming into here from well. So, the well is where water gets stored, you could see the water level rise. So, you know that recharge is happening because of the rainfall. If you put a well here, you can also monitor the level rise when water was flowing in this tree. So, that also gives you an idea about water level rise due to recharge from water from the spring, stream, springs can also give water to streams.

So coming back, let us look at this angle only for now. So rainfall comes in, recharges your groundwater and flows into your wells it takes a couple of days, anywhere from a day to a week. Then you have further away, further away water can come into due to precipitation, infiltration and then go into your well which will take years, depending where you aquifer is stored, depending where the point of water access is there, the water would have to move a long term, a long term and distance and groundwater flow is very, very slow.

So, please look at this because it is slow it will take years and why is it slow because there is a lot of obstacles on it, solid materials are there, so water has to go around it connected through another pore, those kinds of things and if there is already water it is less the high potential I am saying then water movements are balanced out. So it takes anywhere from years in the unconfined aquifers.

So, anyway you could start from days to years. For example, in the Ganges basin, you could see it within a days that a well start to recharge when there is good water flowing in the river and also good rainfall. It may not be the same in central India, it will take some more days to see the groundwater rising up and then somewhere in the drier regions you would see years. Let us get into the confined unit.

Now, here comes the lag, the delay. So, water can come, but when it sees the confining bed or impervious bed, it cannot straightly come into and recharge, it takes a long, long time, long time the water has to sit on top of the surface slowly infiltrate, or water comes from a longer distance, distance can also increase the time the water takes to come into the aquifers. So, I am looking at confined aquifer one, this is confined aquifer two.

For the confined aquifer water can come from a very far distance. And then move slowly, slowly, slowly into this aquifer or water can come from the unconfined but stay there for a long time and then infiltrate, penetrate through the impervious layer, whatever it is impervious layer still some leaks, it is not 100 percent impervious layer, it is not a steel put. So, that it just stops here water, it is a stone, it is a rock. So, somewhere it can happen. So water can move through. And that takes centuries, hundreds of years for the water to come there. So, that is how long water takes from the surface to come into that aquifer.

Then you have the next confined aquifer, which is at a much lower depth and it has two confining units to jump. So, water has to come, go to the unconfined aquifer, then jump your confining bed which means infiltrate come into the confined aquifer, here it can move faster

because it has four spaces. So, it can move much faster and then it goes into the confining bed again.

Now, again it has to infiltrate, wait slow down and then get into the confined aquifer, this takes a millennia, which means 1000 years. So see how the same water can move from days recharge to years recharge and also from centuries to millennia. So, it is very important to understand the time groundwater takes to recharge and this I hope has clarified to understand that path, so that we can put better rules and regulations for using the water.

For example, if you have a pump in the unconfined aquifer you are okay that even if you dry it out for example, I am pumping the all the water out and after rain, the water can be recharged in a day, couple of days a week or max by years, within one or two years good rainfall water levels will come up. So if you see right now, all the areas in India are getting good rainfall, so all the groundwater levels are recording high, so some wells are there.

But if your well is it the confined aquifer one and you pump out all the water. So for it to refill again, for it to come back to the original level, it could take centuries, not one but multiple centuries. So you are actually taking your future generations water or the water that has been given to you by past generations for you to save and to use wisely.

If you pull it out within 10 years, 5 years, which is happening right now due to agricultural expansion, people doing two rotation crops, three rotation crops in an area where only one rotation of crops should be done. If you are too much using the water, groundwater resource, you actually are taking from the past and the future groundwater demand. So it is as a much more important to conserve the groundwater.

Now coming, if you have a well so deep. So in some parts in the drier regions, you can see wells going to 400 feet, 600 feet. What does that mean? So you are actually tapping the very deep confined units. Once you take the water, it is gone, you are not going to wait for another 1000 years to come. And that is where people abandon the wells, same here. If you have a well here, the water is taken out and you see, you wait for a couple of years the water does not come, people just move on, they say okay, so some bad and well, I am going to go for another area and put another one.

Same here, if you pump out all the water that goes up, but that is not sustainable, because you use some water which was there for over a century. So this as a more important to conserve groundwater. I hope this actually brings in a lot of sensitization on using a groundwater,

understanding how deep your well is, so your depth of the well can actually give you a rough estimate of your aquifer.

So if you are tapping on water, let us say within 30 meters, you are well and good, you will say okay 13 meters it should be an unconfined aquifer technically your soil profile is there, water can come in okay well and good and this without talking about pollution, but then when you have your confined bore well is further deeper, when you push your bore well deeper then you are taking water from deeper confined unit.

And once your water level is coming down, which is this means you are using the water what was it running out, it is an alarming bell, alarming bell, that you need to start recharging, start doing some other practices to bring the water well back to a sustainable level. So, please understand that it is not the same recharge rate across, it differs and it differs at a big massive difference, years, days, millennia centuries.

So, you should not be using what water you took for a century to recharge within a year or two, so, as we conserve. Moving on, we can have days and years also in the same unconfined unit. But more importantly concerning the centuries and millennia water is important.

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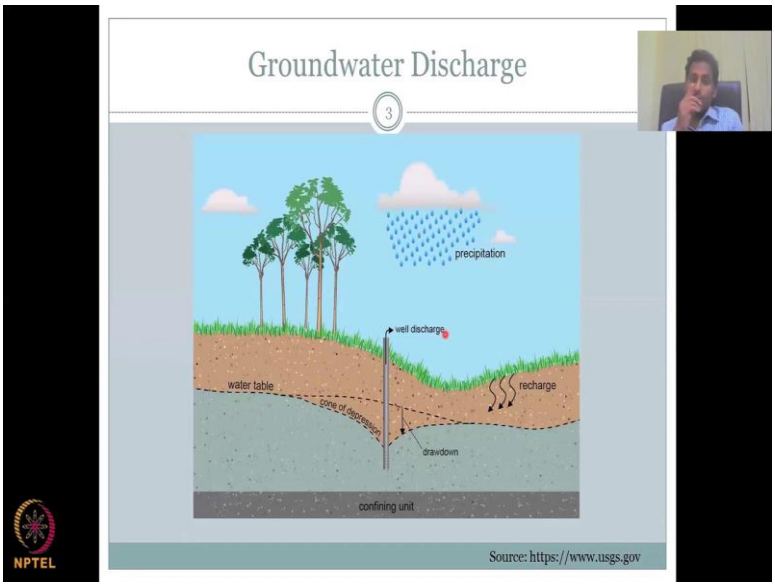

Groundwater discharge, now we are in a groundwater discharge slide where we talk about pumping, or you know water from the groundwater aquifer and that act is called discharge. Discharge can be of two types, one is forced discharge when you put a pump and you pull it out, to energy or manual labour, etc. Or by naturally groundwater can discharge into a system or out of the system.

Here precipitation happens, your recharge happens you have your aquifer form, your water table is there, then you start to pull water out, through the pump for agriculture, for domestic use for livelihoods industry, be it any, any use you want, but you are pulling it down. So once you pull, you could see that the water table is not the same and water table does not go down like this. First it goes as a cone of depression, which is means around the radial area of the well, suddenly the water level will come down because all the recharge that was happening evenly, evenly has created a even water table.

But your localized pumping is pumping at one point. So even though there is recharge happening on the sites, because of this pumping, all the water will go in as a cone of depression. So once you have the cone of depression, this is the worst part. If you have a cone of depression, then the water table which was almost stationary, because of a same potential, now starts to flow to your wells. So you are not actually pulling water from a different distance. But by the act of pulling you create a cone of depression. And once you create a cone of depression, there is a potential difference between this water table and the water table here.

So the water table here and the cone of depression here, there is a potential difference, high potential, low potential and because of that water will go naturally to the well. So you do not have to pump with more energy. So this is where farmers are using it, they think, so if it is recharging faster as I pump, then there is a lot of water, no, because the cone of depression is forcing the water to come in.

Think about you have a glass of water, you are putting a straw and you are taking water out. Initially you have less energy but when you go down further try to spend more energy to bring the water out. And because there is no water coming in, if it is pouring in more and more water than it is the same.

But here because there is a potential of a cone of depression, because water is not it is not a river underneath, you still have soil materials in the aquifer. So that is where the cone of depression forms. If it is a river you pull, then the whole water table will go like this. Let us visualize you drinking water from a straw in a cup. If you drink it goes like this, the water level, it does not go like a pump pressure. Because it is purely water, here because of your sediments, solid materials, only the water is released. So that is why you see it is brown, if we take the water out it becomes brown, just no water.

So the cone of depression is kind of concerning because it actually pulls water from around your area into the well for easy access of your water. So, the water level does not increase, but the water coming into the well increases and you keep on pumping and discharging. So, here is where, if you are pumping cost is very low, if it is supplied by an alternative energy which is very low.

For example Solar Pumps and other things, what can happen is? If you do not have concern of pumping for the energy then too much water can be used, too much water can be extracted. So, it is always important to meter your pumps, understand how much water you are using, only use what water you need for your crops and then stop, otherwise its cone of depression would go bigger and bigger.

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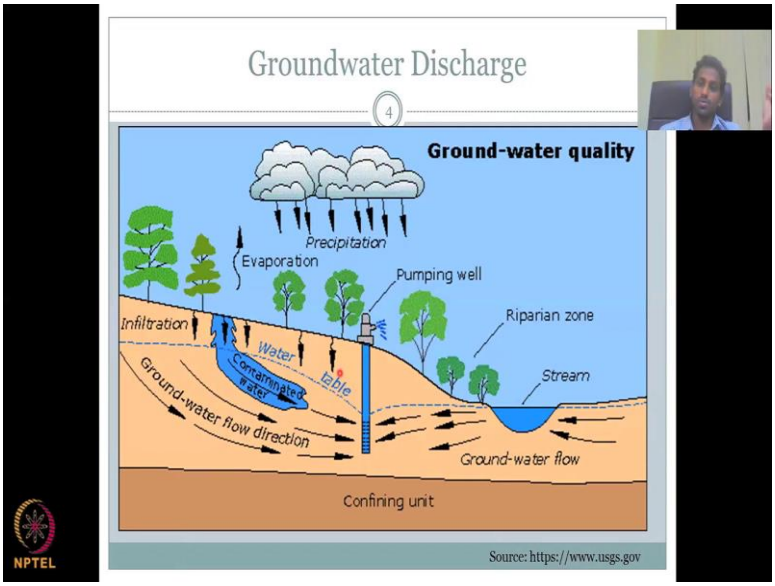

Another groundwater discharge diagram again, you can pull water from your groundwater aquifer and also you could reverse the sign of your stream network. So, initially the stream was getting groundwater from here. So, it was a gaining stream, but because you are pulling and because of the cone of depression, you have been pulling the water from the stream which is a surface body into the ground, then it becomes a groundwater and then back into the well. So the well is now pumping it out. So, the groundwater flow diagram is given. Infiltration happens near the contamination that is coming in, but evaporation losses, etc, etc, water comes in, goes into your pump because of your pumping.

And then you have cone of depression and because of that depression, a high potential, low potential gradient is formed and the volume of water is now full. So, where does the water quality come into the picture, because if you have a contaminated source, for example, in

landfill or a septic tank, which is broken and a lot of waste, solid waste is here, and it is standing there, because of the high water potential.

But when you pump too much and the cone of depression is formed, then you actually start pulling the contaminated water which was initially not moving. So, it is always important not to put groundwater wells near contaminated sites, sewage lines, and then over pump it. So, if you over pump it, the cone of depression forms and even though the polluted water did not want to move initially, because of this cone of depression it starts to move.

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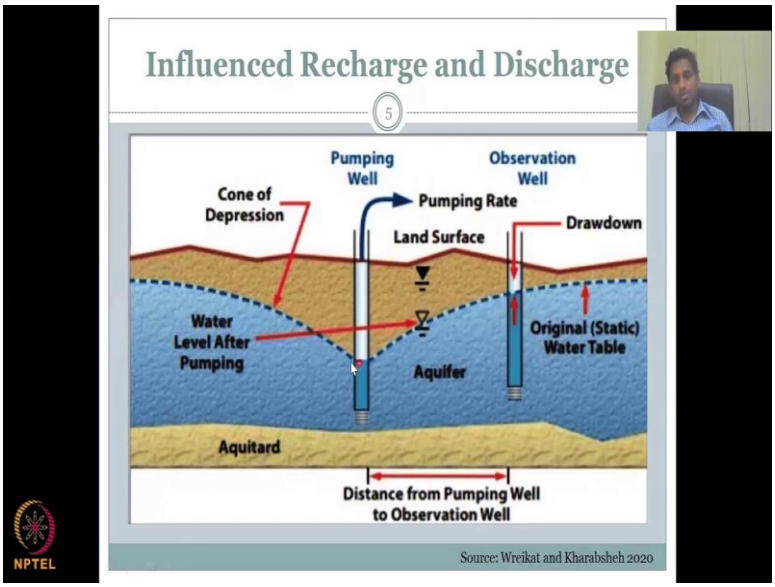

Then you have an influence recharge and influence discharge. So what we saw in the initial stage is if you just pump and the water level comes down, there is no influenced discharge, but when a cone of depression is formed, there is a influence discharge. So water level after pumping is here, it recovers, so water recovers but still the cone of depression is there and your initial water was here, but because you pulled water out, you could see.

So now let us take two wells in tandem and this is where the well monitoring I was talking about of representativeness, etc, etc. So you have a well here, let as call it well A and then well B, well A is used for your irrigation, for applying water to the crops. So you put a pump, you pump the water out and you apply the water.

And then what happens the water falls on the surface and you are irrigating. But meanwhile, you are creating a cone of depression. There is a well B, which is a little bit farther away and no pumping is happening, there is no pumping here. So what happens watch closely that

when you are pumping in well A, the cone of depression is formed and the actual water level from your well B is falling.

So now visualize this as two farmers. This farmer is an ethical farmer who says no, I do not want to grow crops in summer because there was not a good rainfall, I am not going to use groundwater. But this greedy farmer says no, I want to use no water, all the groundwater and then grow, he, she is not only using their groundwater but also the water levels of here.

So even though this farmer, farmer B did not put a groundwater pump and use the water, his, her water levels is also coming down. So here is where a communal source, a water which was for the community, for general public has become one persons property because they put in a pump, they did not talk to others, they start sucking all the water out because of the cone of depression.

And because of this, there is a induced discharge, the water level comes down that is a discharge, it is induced because of the pumping from a different well, here we can say pumping in observation, but hypothetically it could be two farmers nearby each other and pumping a lot.

So, think about even houses, you can have a flat system, an apartment and right next to it a single house, the single house can have a well and they can take water their need is very less, you know, maybe five people are using it for drinking. But the flat, the apartments need is big, if they pull too much water, they will eventually pull the water of the neighbour also. So, this is the important part about induced discharge.

What could be the induced recharge, same as you have water discharge being induced, because of the pumping, if there is a recharge happening here, it would recharge more here because of the cone of depression. Why would water go into a place where there is high potential, where it wants to go into the low potential and where there is more space? So, because of this pumping, induced recharge can also happen.

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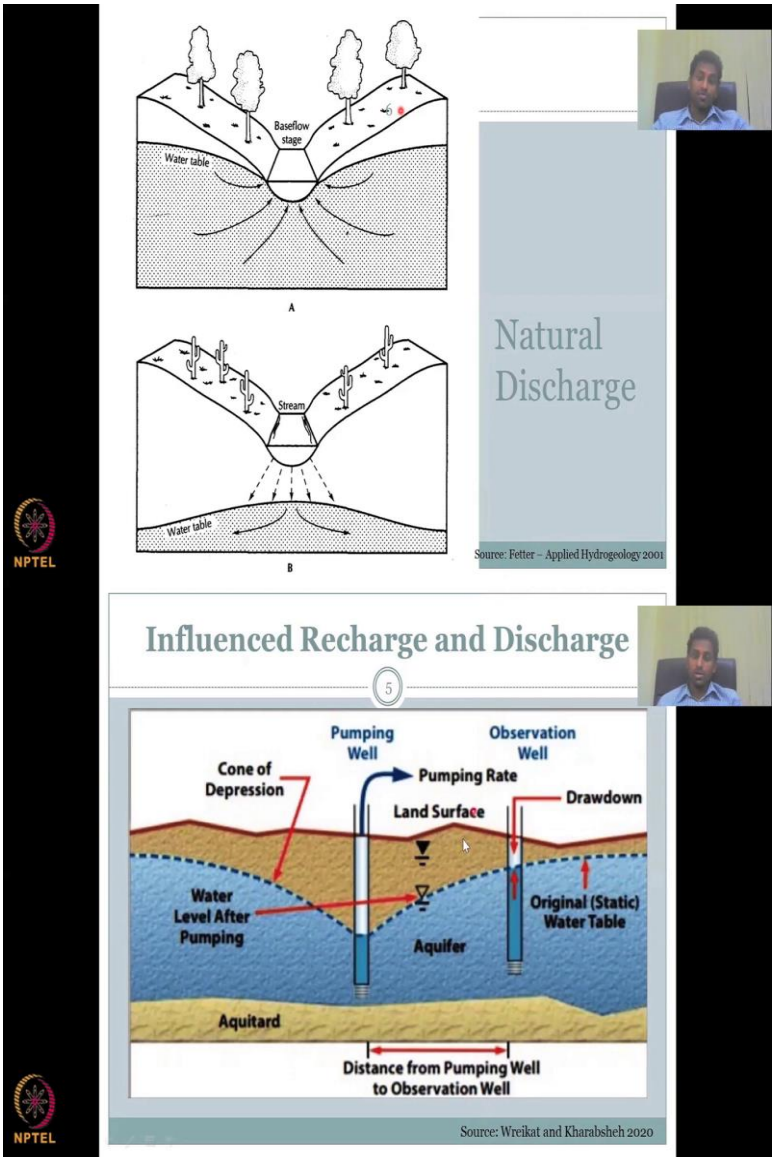

We also looked at the natural discharge and recharge, which is again we will have to go through it because of the terms of recharge and discharge, you have the gaining stream versus the losing stream. In the gaining stream which is on the top a river is flowing through good forested area and the water table is at a much higher level because of the forest, there is good soil and good soil can have more water infiltrate and keep and so the water level is high it can come down into the stream.

So that is a gaming river, the river again, so that is a recharge from the groundwater, but the groundwater is discharging into the stream. As a stream it is getting water, so it is recharged by the groundwater, as a groundwater I am losing my water to the stream. So, the groundwater is discharging into the stream okay.

The other diagram where we saw a losing stream, here, it is natural recharge not discharge because groundwater is not going to a stream. On the other hand, the stream is giving water to the groundwater because the stream is at a high potential compared to the groundwater which is at a low potential, this act of getting more water by the groundwater through the stream, through a losing stream is natural recharge. So, if you have pumps here, then it becomes induced, here we are only talking about natural process, once you put an engineer process inside, then a lot of induced processes can happen.

So, with this lecture, we have seen about the recharge and discharge mechanisms, we have seen the timeline that takes for these mechanisms anywhere starting from days to years in an unconfined unit, consolidated unit which is much more down deeper. And talking unconsolidated units or unsaturated units, water can move within days to years, whereas if you go beyond a confining unit, an impervious unit, then it can take years, multiple years, centuries and then furthermore, another layer, impervious layer can take you millennia.

So, it is kind of very important to understand the recharge process and the time it takes, it is a slow process because of the presence of sediments, rock and other materials. Once you know the recharge process at the time as per say, then you could look at induced processes because of pumping and induced discharge because of pumping.

And also we saw that in this lecture, your groundwater, which you claim because you are putting your well and saying no, it is my water, it is not just your water, but the water of the surrounding area also. So just because I am not putting your well in my field, does not mean you could take my ground water, because groundwater is a communal source. Maybe the farmer did not have money, cannot afford it. And that is where in the rural water resource management course, we will be looking at how to pull farmers to better manage this resource in one of my field works as a project scientist.

We looked at mobilizing farmers, sensitizing then saying not all farmers can have pumps, not all farmers can have tractors. So can we work together to conserve the groundwater. For example, if seven farmers say okay, you take the groundwater, I will not manage my land. I will not manage my land. I put cement on my land, will the another three ground water they will not.

Because he or she has to give the land for recharge, so that is very important again here, if this farmer is not pumping, but still he is recharging the groundwater. So this farmer which is

farmer A, he is taking all the water from farmer B and his hard work, his or her hard work in recharging the groundwater.

So, this is the concept which needs to be driven for rural water resource management, to make them understand it is not one persons utility groundwater, it is a communal source or a social, common source for everyone. And also the management has to be common. With this I would like to stop about groundwater recharge, discharge, communal use, etc. Let us see what is available for the next lecture. Thank you.