Groundwater Hydrology and Management
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Lecture 31
Artificial groundwater methods for India

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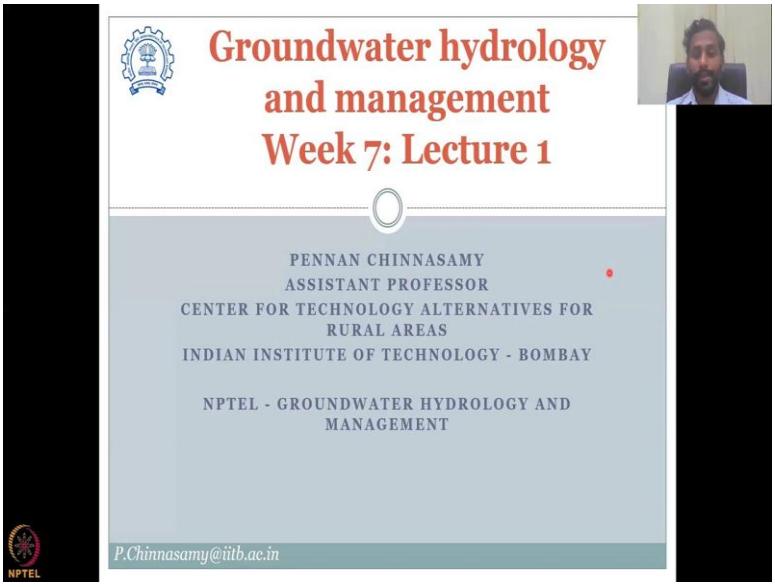

Hello, everyone. Welcome to Groundwater Hydrology and Management, Week 7. This is Lecture 1. The past weeks, we have looked at how groundwater recharges into the system, what are the key factors that influence recharge and what is the condition of groundwater recharge in India.

Using the several metrics, we found that both the WRI and CGWB metrics, we found that the groundwater is depleting. Even though many studies say that the development is around 60 to 70 percent, in most important locations, it is more than 120 percent, 110 percent, which means we are using groundwater more than it is recharging.

There are locations where groundwater is not needed and not used much. For example, the Ganges plains, the hilly areas where groundwater access is less. So, we should not be counting them in the overall budget and overall average. If you look at very focusly where food is grown, where food is exported out of the country and between states, you clearly see that the groundwater is depleting.

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So, there is a good report by the government of India, CGWB, which has a manual on artificial recharge of groundwater. I will put the link here, so that you can download it. It is a free book. And it is very very informative for this course. Let us quickly do a recap of Week 6. And I am trying to link it to Week 7, where we will be looking at specific manual recommendations from this book.

And we also will be looking at the pros and cons which are not discussed in detail in this book. But through my field experience and the literature review, we will be looking at, why one system is better than the other, and what are the precautions you need to take. More importantly, we will also look at type of beds.

So, in the Week 6, we looked at groundwater recharge and discharge, basically lowering of groundwater table due to discharge and then raising it up through recharge. We looked at the different estimation methods. And the most important method was the Water Table Fluctuation method.

We looked at the groundwater recharge conditions in India, we also looked at if you do not have data, how do you estimate groundwater recharge. And then at the end of the day, we said, given the conditions in India, that most of the hotspots are in food growing regions, it is very important to add groundwater using Artificial Recharge methods. And this book, where you see on the screen, is very informative on the artificial methods.

So, what are we going to look at in Week 7? In Week 7, we will be looking at the type of Artificial Recharge systems, especially for Indian rural system, and the cities. We will not look at international standards because the availability of water, the groundwater hydrology, the geology is different. So we would focus only on the studies in India and the methods that can suit India, which is given here in this book also.

There is a plethora of methods, we will use most of the methods in this lecture. We would also look at government plans. This book itself is a government plan, but also how they use schemes to augment groundwater recharge. We will look at two types of groundwater wells and pumps in power. Since we are looking at recharge and discharge from Week 6, it is important to understand how you get water in and what are the key pathways or key methods in which water is extracted.

And that is why we have a session on type of groundwater wells, powers, pumps etc. And it is also necessary to look at alternative methods. Similar to recharge, we have alternative methods for increasing the recharge. We also have to find other methods to artificially give more power to these recharge systems and or discharge systems. For example, can we use solar power rather than electric and diesel power, thereby reducing the carbon pollution due to diesel pumps etc.

So all these things, we will look at given the time. And some of the methods we will also look at, in the next week. So in this week, mostly we look at artificial research systems for India given by this manual, we would look at the programs that support the funds for it. So in this book, you will not find the funds. So, it will just give you where and how this kind of recharge networks can be built, but the money and the fund has to come from somewhere. Types of groundwater wells pumps etc. we will discuss.

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Moving on, let us look at the planning for structures. Before we even get into the type of structure, it is very, very important to get into the planning. How do you plan, what type of recharge structure to build? Suppose I give you this book and say there are 10 methods. What are the methods that you will use in your location, let us say your village or your district or even your urban area?

And that comes from a fundamental understanding of what is inside the ground, what is the water availability and the demand. So it is very important to establish ground facts, as I put it the first point. You need to understand the reality in the ground before you propose these artificial recharge structures. Because many a times you would see these recharge structures, at least in villages, which are broken, not maintained well and they do not give much ground water, which means they are a failure.

And that happens because the underlying fundamental principles are not understood or these ground facts are not recommended or acknowledged. Let us look at some of them. Storage Capacity of aquifers. If you know the thickness of the aquifer, then you will know how much water, given the specific yield, can be stored. You can have a big aquifer, but if the specific yield is very, very high, like for example gravels, water will just move down.

So you are not going to store the water. So this is a very, very important aspect of groundwater recharge for using. So all these artificial groundwater recharge is not just to put water in, but to use it later for agriculture, for forests for bio life, etc., ecosystem services. So

it is very important to understand how much can we actually store. You cannot put, keep on adding water in a tank.

For example, if it is a 1000 liter tank, you cannot just put water 2,000 liter in the. What would happen? The water would just overflow the tank and only 1,000 liter would be stored. However, the money that is put to recharge the 2,000 liters is a waste. So, this is where you need to understand what are the limitations in your groundwater recharge, what is the ground facts, what is the storage capacity of aquifers.

Prioritization of areas, you cannot just randomly build ground water recharge structures everywhere, because in this exercise, in this lecture, I will be showing what are the key groundwater recharge methods proposed by the government. So suddenly, you should not go run to your village and do it or run to urban setting and do it. There are prioritizations needed. Not all areas are suitable. So that prioritization is given by this manual also.

Availability of source. Here, the source is your water. If there is no water, you can build as many structures as you want, but there is, no water would be stored. At the end of the day, as I said, you need groundwater in your system. Not you put money here and then the next 3, 5, 6, villages after the groundwater comes. It is okay for the nation.

But when the villager comes back to and says, I gave my land to do this groundwater recharge, but it is not helping me it is helping another village. So where is my money? Where is my water? What is my benefit, they will ask? And so some kind of package has to be given. Suitability of area is very important. The soil, land use, topography, climate, all these to be considered. We would look at these in detail in the coming slides.

The most important techniques and designs are Direct methods, Indirect methods and the combination of both, for artificial recharge. Remember, there is recharge and then there is artificial recharge. In the just recharge or the natural recharge, water hits a surface and slowly moves down through percolation, infiltration, gravity, specific yield etc.

Whereas during the artificial recharge, there has to be a push, there has to be something else that is adding to the recharge rates. And that is your direct methods, which include surface spreading subsurface methods, flooding methods. I am just putting the main points here, which are taken from this book. And the indirect methods which are induced recharge, aquifer modification, like bore blasting, fracturing of aquifers.

And then your Combination method, combination of both direct and indirect. What is needed is a good understanding of the differences between these methods, the cost, the time and the resources that are needed, like land, soil, etc., and then you can take a call which is best for you. Remember, I am using a groundwater book, which is the government's book.

So you can actually bring citations from this book saying that this book has recommended these, so I will be following this in my village, after considerable study, for example. So the link for the book is given below. You could see it as the dot pdf. It is free, and anyone can use it. And to be honest, there is a lot of citations inside the book, it can also be taken for future reference.

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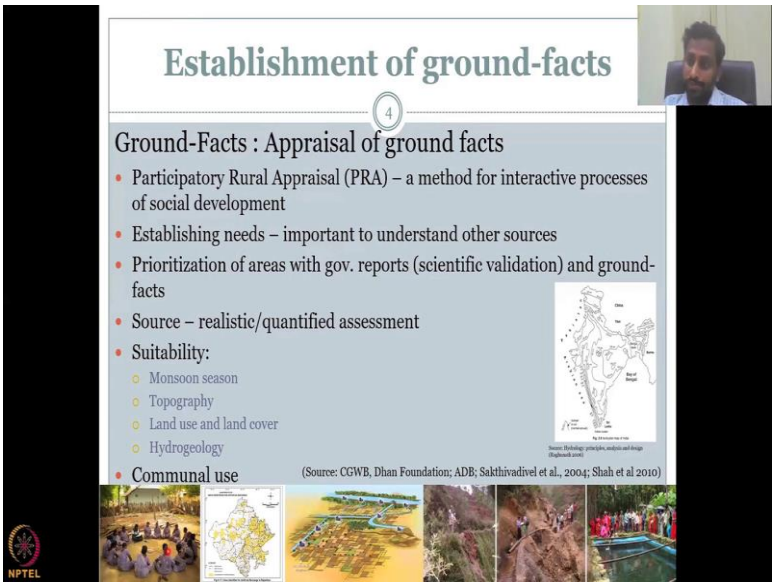

Establishment of ground-facts. This is very, very important. If you do not understand what is the reality, you could sit at your office, for example, I am sitting here in my office and I can put all these groundwater recharge plants, but it will not work. I can even run a model, hydrological model, mudflow, Groundwater model, but it will not run.

Why? Because there is a need for understanding the ground facts. So for that, what are the methods used? Participatory Rural Appraisal or PRA, as we call it, is a method for interactive processes of social development, wherein you talk to the people, you can see on the Ground, DHAN Foundation is doing it.

So you communicate with the people, you set multiple iterations, you discuss the issue, you discuss who is going to take care of it if these systems come in place. And also understand

the need for it, the actual need. Do you actually need a groundwater recharge activity or you can manage it without other aspects?

Establishing of need, as I said, is very important because you can also have water from channels, you can have water from rainfall, you can better use your demand estimates, you do not need to go to groundwater recharge because you may have enough water, you just do not know how to use.

The other aspect is understanding the other priority areas, priority needs in the village because if you have limited resources, you cannot put them into the groundwater recharge, money, time, etc., Prioritization of areas with government reports, scientific validation, because all these reports are thoroughly validated by science., here, if you can see.

It is a following scientific method, it is not they just took a map and colored, this area you can put groundwater recharge activities, there are a couple of steps that have been followed. And all these steps are given in the book. Every single state is given. I do not want to pick states and then give examples because overall is also needed to run through the books.

So these books, these methods have been scientifically done, validated with citations and methods, global methods etc. And then they put in a, for example, here, you could see that they have put in where the groundwater recharge activities can come, Prioritize such areas. You should go there and then check the ground facts because the area is big.

You cannot put all groundwater recharge in, for example, the west side of Rajasthan or the eastern, northeastern part of Rajasthan, you cannot just put everywhere. They say these districts are good, these blocks are good. Then you go into the block, into a particular plot because all these are small sites, and then choose which area works, for which you need to understand the report, how it is done.

Source. Be realistic. We have to be very realistic of how much water is available. It comes from rainfall, it comes from channels, it comes from other groundwater resources, etc. Think about the water balance. We have precipitation coming in, we have channel flow coming in rivers, streams, etc., and we have groundwater coming in, all these three. So these are the sources, and we should be aware of how much are these to support groundwater recharge.

Quantified assessment. We need numbers. Quantification means putting a value. We cannot say our groundwater is good. That is qualitative. Then we do not know how much is good. Does groundwater good means good productivity? We do not know. Which means how much area, is the question. So Suitability is a very important aspect, we need to understand.

Suitability, monsoon season, for example, the groundwater recharge, if it is to capture the rainfall and then put it into the ground, we need to understand the monsoon period. The monsoon period is very short, one month, two months, for example, the peak monsoon period. Is that enough to get just the groundwater in? No.

So you need to augment more and more. So think about suitability in the terms of water availability, resource availability, the topography, you might have all the water you need, but if the topography is like this, high slope, undulating land, then all the groundwater will just go down. It will not stand there. It is not a tank. Groundwater is not a tank, it is not a river. It is connected through pores and so it can move.

The land use and land cover is very, very important. For example, you cannot go and say I am going to recharge groundwater, I am going to demolish the forest. No. Because you have to preserve nature also. Yes, you need groundwater for your agriculture, protecting livestock, etc. But then if you want extremes, then the rainfall itself which was supposed to happen will not happen. You do not disturb the hydrological cycle too much.

The other aspect of land use and land cover is, suppose all this area you see here in Rajasthan, are good for groundwater recharge, however, they are placed in a agricultural field. Do you think it is going to be easy to take a farmer's land to put there groundwater recharge? No, it is not. Then what will happen?

Farmers should come together and say, five farmers, one farmer should sacrifice, but the profits and other aspects should be shared mutually among five. For example, if I am going to take a well and a well is taking 10 percent of my land, I have to sacrifice the 10 percent for the 90 percent to get water. So same ideology, you need to have here.

The same, if you build a house in a village. They will put a land for the well. You cannot say I will build the whole land full of house, and then inside the house I want to put a well. Anywhere, you need land for it, and that land, if it is agriculture, it is very hard, because you have to convince a farmer to get it. So that is the reality, that is a ground-fact.

And the Hydrogeology. What is underlying in the aquifer, what is the aquifer condition, is the quality good, is there geogenic contamination, arsenic fluoride, iron, so these are very, very important. You can put water in, but if it is polluted, there is no use. So these are where ground-facts are very important.

So another factor is, here, the image you see is a static image, which means you may not have this updated often because it is based on hydrogeology, the aquifer type, the rainfall etc., etc. So you need to make sure the ground facts are updated often. The monsoon is changing, climate change, topography may not change, land use land cover is changing, hydrology, geology does not change, land ownership changes, the prioritization, what is the priority for the village changes? For example, in some villages you had agricultural fields.

Now all the agricultural fields in a particular village could be converted to plots, housing plots. What happens? The water budget is going down because agricultural use is much higher than domestic use for drinking. So your recharge will come up. So does that mean it is good, because you lost your agricultural land?

So think those terms. So the priorities are there etc. So the rainfall is not a common across India. So that also is given here in the suitability, and where to put the ground water recharge, is it forest, all these have to be taken. Most importantly, it should be viewed as a communal use. Groundwater is a common man's resource, common woman's resources, it is everyone's resources, it is not one person’s.

So, the communal use ideology should be kept in this groundwater recharge activities. Otherwise, one farmer will take all the groundwater and recharge and they will get more benefit, whereas the others would lose it. So it is very important to understand these factors.

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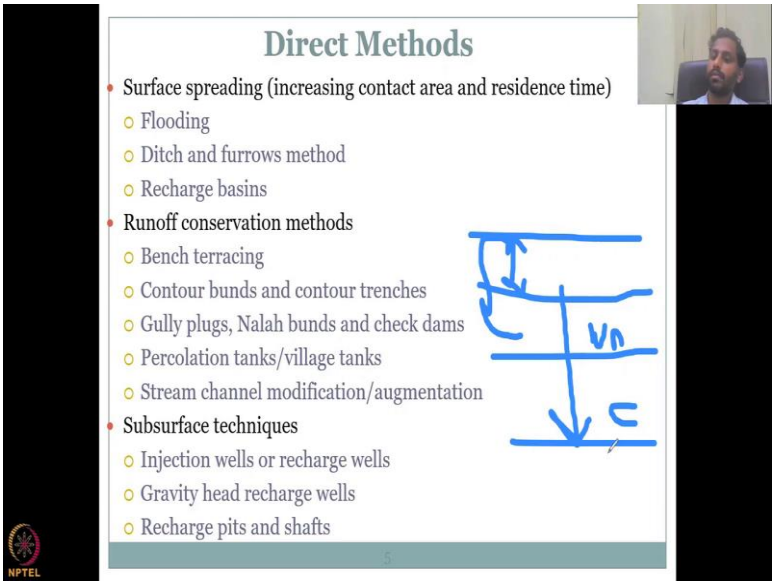

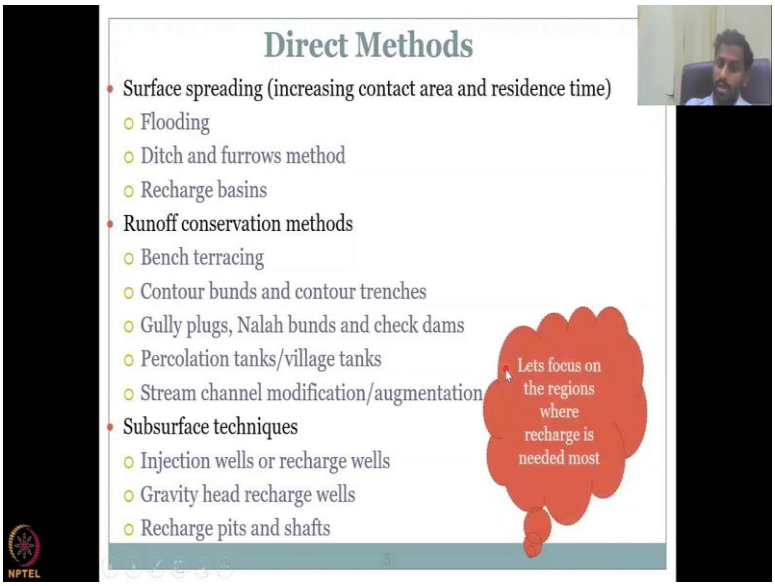

Let us look at some other methods. The most important is the Direct methods, directly applying water. Whereas an indirect is you do a particular method for something else. However, the ground water gets the recharged. For example, forest cover. You increase forest, but by increasing forest also the groundwater recharge increases, because the infiltration increases, percolation increases.

So let us start with Direct. In the direct method, you are increasing the contact area and residence time of water, so that water and land have more time to talk to each other and then recharge. So that is the problem now. If you do not give enough time for water to talk to land and then say I am going to infiltrate and percolate, then recharge will not happen.

That is what is happening in highly sloppy land. Water touches and goes down. So the Surface Spreading method actually increases the contact area. I am going to directly apply water on a land and then recharge it. And of that, there are three important methods for India. Flooding, Ditch and Furrow method, and then Recharge basins. In the flooding method, as the name suggests, it is more like you are flooding the entire land, and then you are looking at how recharge happens.

In the ditch and furrow method you are constructing parallel sequences of land burrows so that water can run through, and wherever it is running through it will recharge, whereas flooding is just applying throughout. I will show you some examples. And there are something called Recharge basins which are more engineered, more specific for groundwater recharge and has some designs etc., more construction.

Then in the other direct methods, you have runoff conservation methods, basically arresting your runoff. You are stopping your runoff, which is your rainfall runoff, I have showed you in hydrological equation, water flows in, and then this water flowing out of the basin is stopped periodically somewhere and then recharged.

So some of the methods are bench terracing, contour bonds and contour trenches. Gully plugs, Nalah bunds and check dams, very, very famous word, check dam, because it has actually helped a lot of locations in India. Percolation tanks, village tanks. So percolation has a very particular condition that it has to increase the rate of water moving through the soil profile, and it can happen anywhere, land, in terms of rural, urban, peri-urban etc.

Whereas village tanks are mostly for agriculture and for village use. Then you have stream channel modification and augmentation, where you alter how water flows in a stream or a river. Basically, as it is runoff water, all these are, the source is runoff whereas here it is runoff, it could be rainfall, either way you are getting the water to talk to landmark, whereas here you are stopping the runoff.

You are trying to add some features to the runoff, either stopping it or even making sure that passes through the stream channel find, so that at one end it goes it and recharges. And then there are subsurface techniques. The subsurface techniques include the subsurface region. I will draw here, you have your land and then you have your subsurface, then your unconfined aquifer, confined aquifer, confined, unconfined.

Then the subsurface which is just a small thickness under the ground where it is not under the ground too much or not the surface, it is sub-surface, where you can put wells like injection wells, recharge wells. Injection, as the name suggests, you inject water, recharge it slowly. Recharge water, gravity head, recharge wells, recharge pits and shafts.

So this subsurface can go anywhere until you're unconfined, whereas the recharge pits and shafts goes much, much deeper. So these techniques have their own positives. All these are positives for groundwater recharge, but they have their own challenges and why it is not working in India, which we will cover, which is very important to understand why a system works and why a system does not work.

So in due course of time in this course, we will focus on the regions where recharge is needed most because if you remember the CGWB map of where the critical zones are, etc. The Punjab-Rajasthan belt, places in Gujarat, Karnataka, Tamil Nadu, in the west regions of Assam, you have a lot of critical to semi-critical locations, but more importantly, you have overexploited locations. Rajasthan, Punjab, Haryana, Delhi, all these are red, which means groundwater is extracted more than the recharge.

So we will be focusing on, even though there are so many methods, as you see here, we will be focusing on the methods where recharge is needed most. And that will be handpicked from the CGWB's report, and then we will discuss it in the following lectures.

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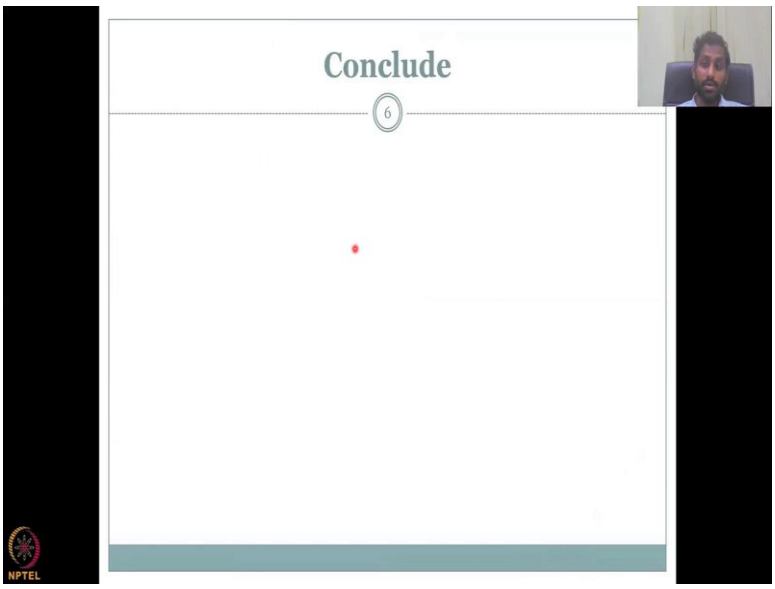

With this, I would conclude todays lecture. I will see you n lecture 7 of Week 7, Lecture 2 in the next class. Thank you.