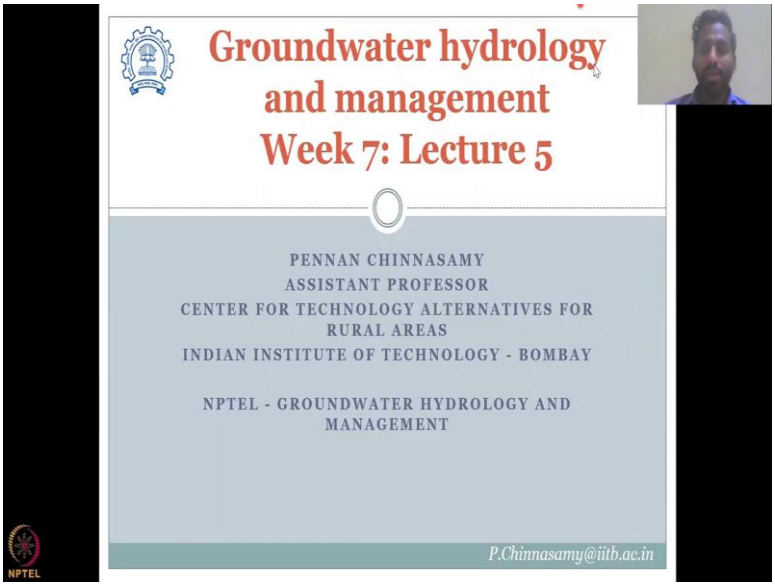
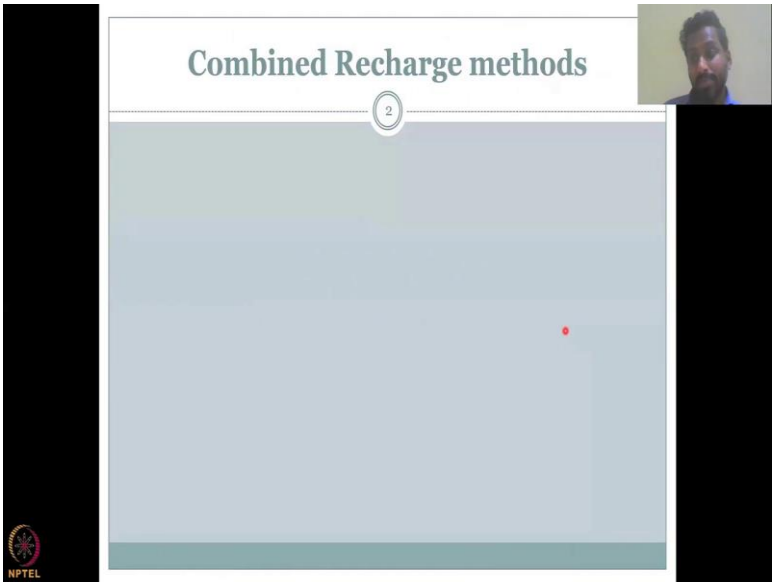
Groundwater Hydrology and Management
Professor Pennan Chinnasamy
Centre for Technology Alternatives for Rural Areas
Indian Institute of Technology, Bombay
Lecture 35
Groundwater recharge recommendations

(Refer Slide Time: 00:16)



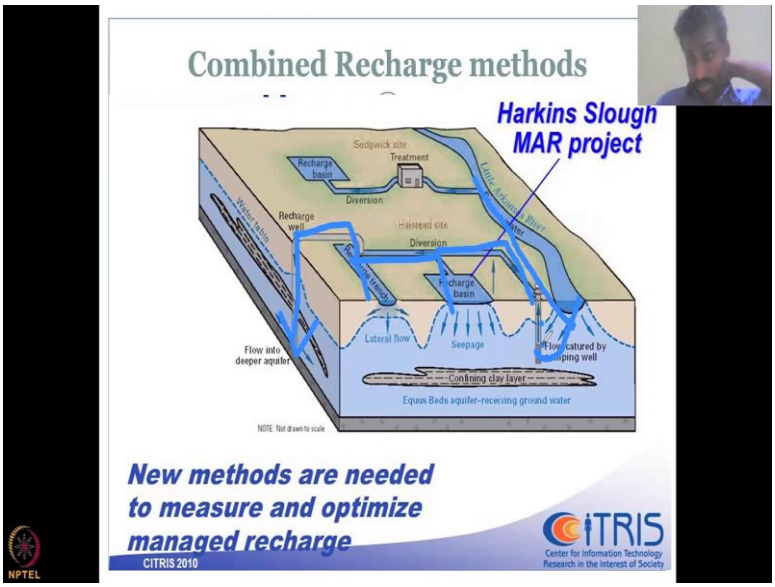
Hello, everyone. Welcome to NPTEL Groundwater hydrology and management course. This is Week 7, Lecture 5, In this week, we have been looking at groundwater recharge methods. Especially, the artificial recharge methods. And we have looked at the direct methods, the indirect methods, and also moving on, we will be looking at what are the specific methods that CGWB has recommended across India. And that is what we will be covering in today's lecture.

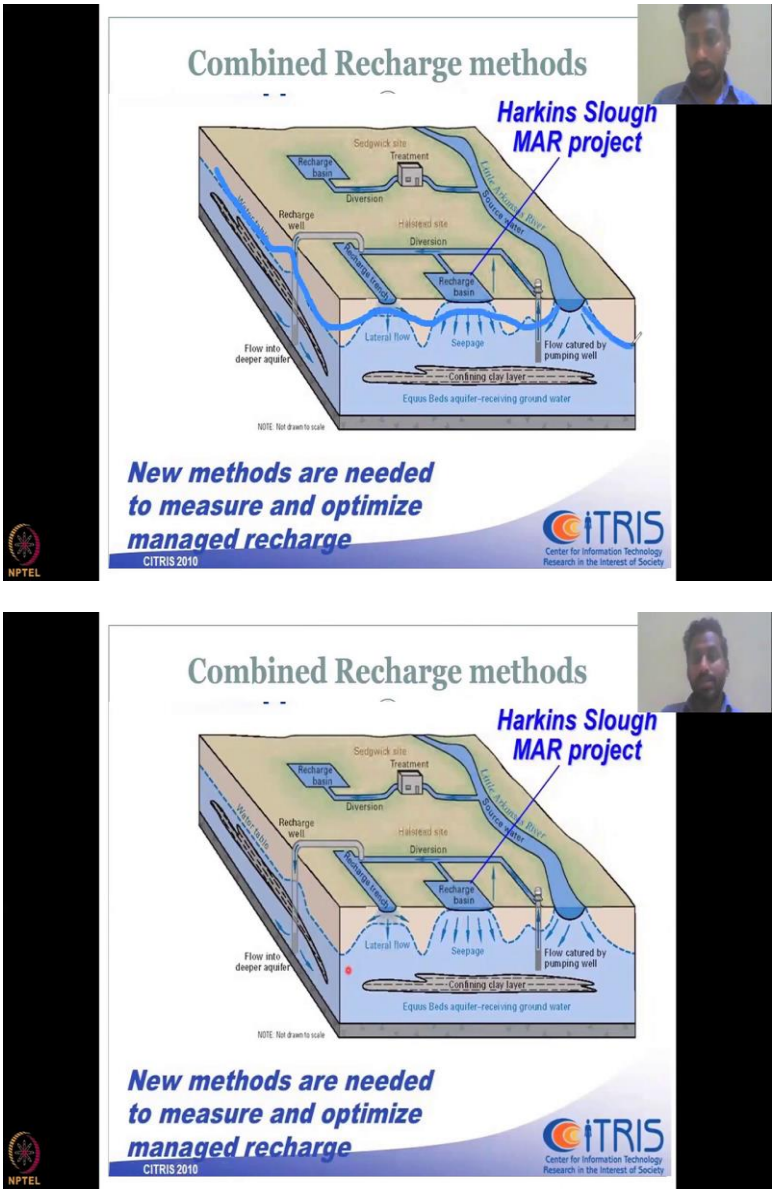
(Refer Slide Time: 00:57)



So, in the previous lectures, as I said, we looked at indirect method and direct method. The direct methods involved capturing surface runoff and then putting it into the groundwater recharge units, whereas the indirect method is to push water into the groundwater aquifer unit. Here, we will be looking at combined recharge methods.

(Refer Slide Time: 01: 21)





If you look at this land, this piece of land where you have a lot of water which is coming and it is been treated and put into recharge basins, which is a part of a direct method. And then you also have a recharge induced well, which is pushing the water in. So what you are seeing here is a combination of multiple method because, one method may not be just enough for your activities.

So while I was discussing the pre pros and cons of these methods, I mentioned that depending on your location, just one method may not be enough. So it is always good to look at multiple options for groundwater recharge. And how do you tackle these different resources and different units, different resources as in is it a shallow aquifer, deep aquifer or unconfined, confined aquifer, and how do you route water through these networks to get into the recharge.

Please understand that each method has its own positives and negatives, has its own land requirement and also energy requirement. In this picture, you could clearly see that the water is coming from your surface water. And let us look at the common ones that is there. Then, there is recharge from the stream. This is a natural recharge. You do not have to do much unless you wanted to do in-stream modifications.

We talked about in-stream modifications wherein put levees inside or you take more of the channel and make it wide so that you have enough water spread along the bed. So we did look at those aspects. Then there is a water loop divert. You divert the water, treat the water, and put it in the recharge basin. And from the recharge basin, water will go into the groundwater.

You could see here, water is going through the groundwater through seepage and infiltration, percolation, through this recharge basin. We also looked at contour trenches and ditches where water can be diverted and put in the trenches. And along the trench, there is recharge. You could see that water is laterally flowing into the groundwater the recharge. Then you have an injection well. So you take the water and push water inside thereby injecting groundwater recharge flow into the deep aquifers.

And so, here in both cross sections, you could see that there is a confining layer, which is a impervious, highly impervious layer. Water cannot pass through. So, what this integrated method has done is, it has taken the tube and pushed through the impervious layer and then pushed the water through. It is drilled through the impervious layer. And then there is energy spent in pushing it. So this is indirect, kind of pushing the water in. However, you are not, indirect, as in, the energy use, because normally, other methods, you do not supply energy.

Whereas here you have to push the water through indirect means, but it is not an indirect method. The indirect method would be here, where you pump water out and because of the pumping, there is induced recharge. That induced recharge is what we call as an indirect method of groundwater recharge in our topic in the last class. So you have water coming, and the water can be recharged naturally.

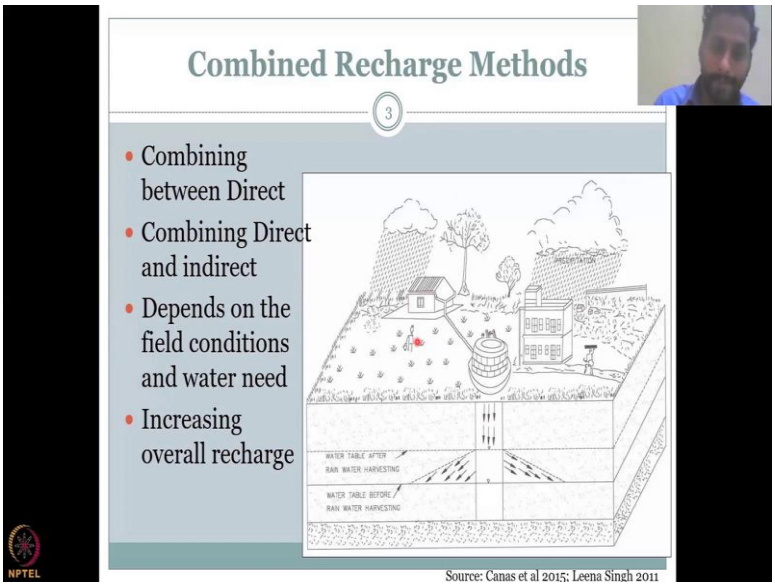
Or it can be pulled through induced recharge. You are inducing the recharge, you are pumping water, and then use it. As I said, in some locations, this pump water may not go to waste. It can be spread out into multiple areas, and multiple areas are going to get recharged now. So you are lifting this water and putting it into other areas where recharge can happen.

So, what is constraining factor here, is the energy. If the energy is enough, you could actually do this by yourself

Otherwise, so for example, in Western countries, where energy is not a constraint, people do use pumping a lot. So they pump the water and spread it across so that multiple areas gets recharged and because they pump horizontally, you are using the surface water by inducing recharge into the earth. So, all this water can be now used. And when you draw the key water of pathways, so water is coming, recharge, and because there is pumping here, water is going to be pushed into the well. This is induced recharge.

And pumped water is actually being used in multiple locations to recharge and also push water into the deep aquifers. So now you could see, a shallow water is taken and pushed into the deep aquifer, which is also good for one of those locations where there is a need for water table to rise. You could see that the water table does rise eventually on top in most regions. And this is good for the groundwater recharge.

(Refer Slide Time: 07:03)



Let us look at one more method before we jump into the recommendations by the government. So in the combined recharge methods, it may not be only indirect and direct methods, which is induced recharge and subsurface or percolation tanks etc. It can also be within the direct or within the induced method. So let us look at one example where direct methods are coupled together and recharges happen.

In this study, you could see that rainfall is being harvested, is being captured on the rooftop settings, and then routed through a canal into the dug well. Once it gets into the dug well, water is being recharged. Also, along the canal there could be water recharge. And that can also help the groundwater recharge in the network. Also, there is good land management practices, where the land has been tilled and more recharge is happening.

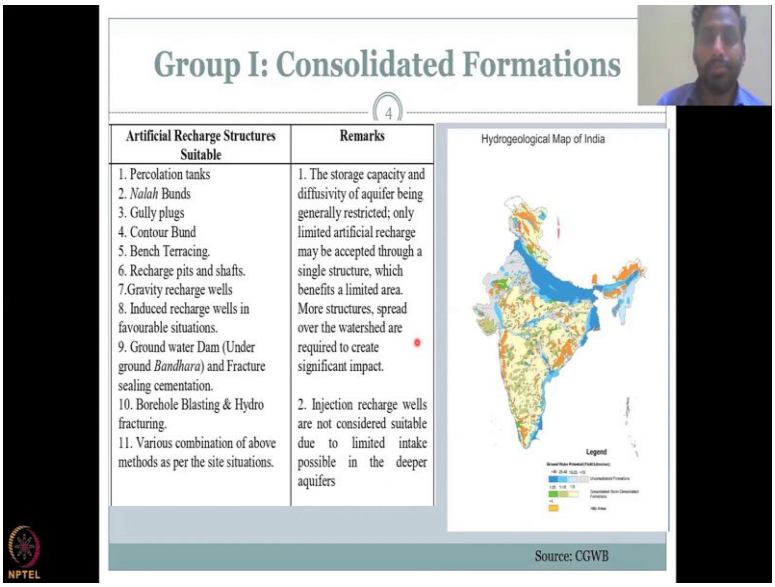
So it need not be just construction of a piece of well or recharge to tubes etc. You can also manage your groundwater resources by managing the land. So, combining between direct methods is also possible, combining between direct and indirect methods is also possible. Depends on the field conditions and water need. If you need more water, you have to use all the water that is coming to your location, both rainfall, your surface runoff etc, then you should do this field conditions assessment.

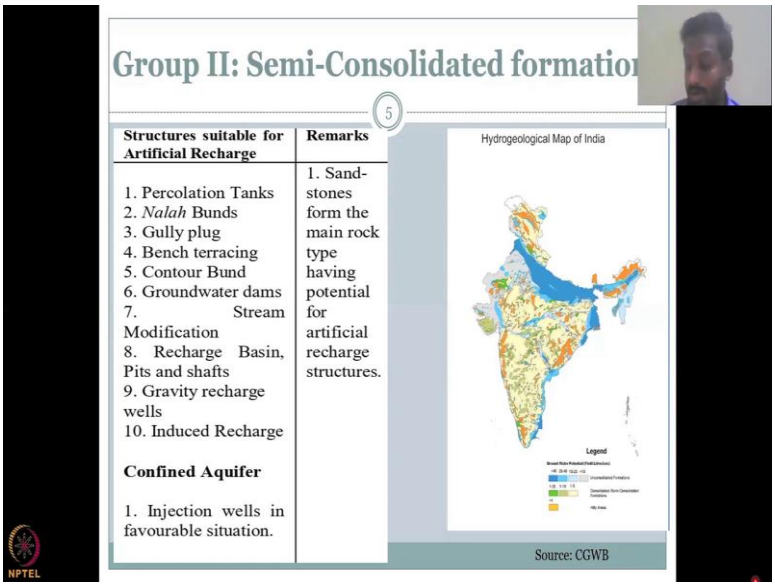
Then you assess the water conditions, water need, and then you do this on these methods combined. What needs to be very carefully understand, is are you overdoing the recharge thereby taking others' waters and putting into your groundwater. So that, you need to be careful.

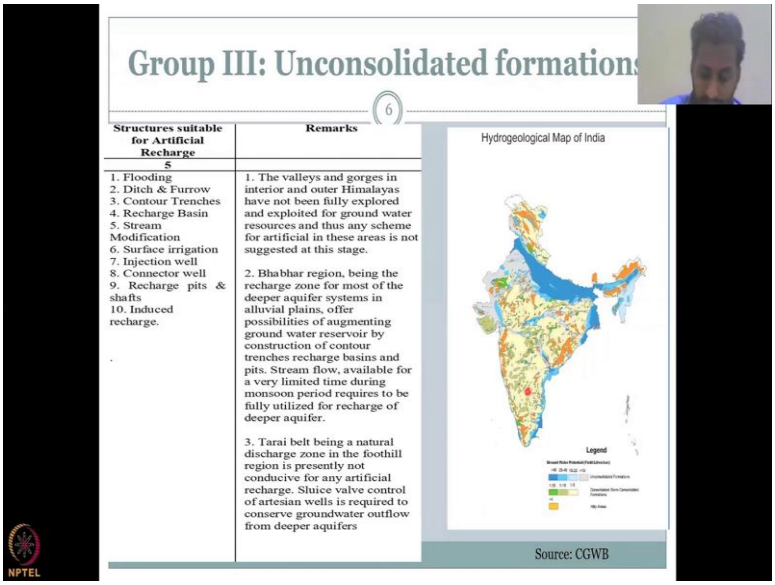
And increasing the overall recharge is good, but is not usable, because a lot of these methods, as I said, have energy component wherein you need to supply a lot of energy. So please make sure if the energy is used wisely, and all these groundwater is necessary, because what is happening in reality is all these recharge networks are there to recharge groundwater, but groundwater is used in a very unsustainable way.

For example, excess water application for crops, flood, sheet irrigation, which is not needed. You could have used better conservation techniques for water. Because there is a groundwater access, there is a subsidy for groundwater, you may have used groundwater, but the cautious nurse should come to use it wisely. Even though it may be free source for you, you need to use it wisely because it is not an unlimited supply of source. So that is the big difference between groundwater and surface water.

(Refer Slide Time: 10:13)

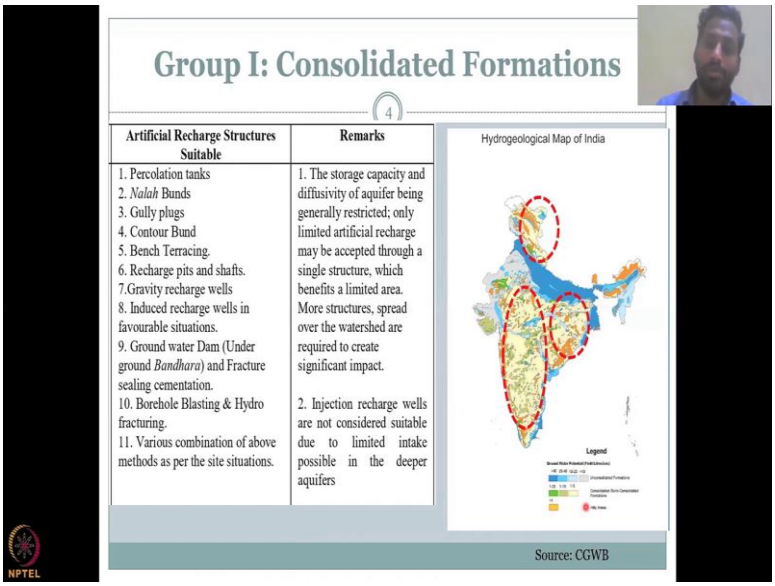






Now, let us look at the different recommendations by the government of, for artificial managed aquifer recharge. And they have divided it into three sections, consolidated, semi-consolidated, and you have unconsolidated formations. What we will do now is, we will look at the consolidated formations first, and then we will go to semi and then unconsolidated next.

(Refer Slide Time: 10:41)



So, consolidated formations, the consolidated formations, the recommendations are given us progression tanks, Nalah Bunds, Gully Plugs, Contour Bunds, Bench Terracing recharge, all these we have seen in the lectures before, expect borehole blasting and hydro fracturing, which is kind of excessive energy and also, I personally do not know much if it is useful and

how the impact is in a long term. The others, yes, these are more nature based solutions, which is okay. But then blasting, I do not know.

So it could be dangerous, it could be short sighted also. So you have to be carefully looking at long term sustainability. In the remarks you could see that the storage capacity of aquifer is generally restricted, because in the consolidated formations, you could see, here the locations are in the yellow region. In the yellow region, what you find is the water yield is very low. If the water yield is low, the recharge is also low, because less recharge goes and less water yield it comes.

So these are mostly in regions where it is aligned with a hilly region, the hilly region is there and part of the hilly region which has been weathered is where the consolidated formations are. And consolidated is more hard rock, those kinds of types, where the recharge potential is low, and the recharge storage is low. The storage capacity is very restricted. Only limited artificial recharge may be accepted through a single structure.

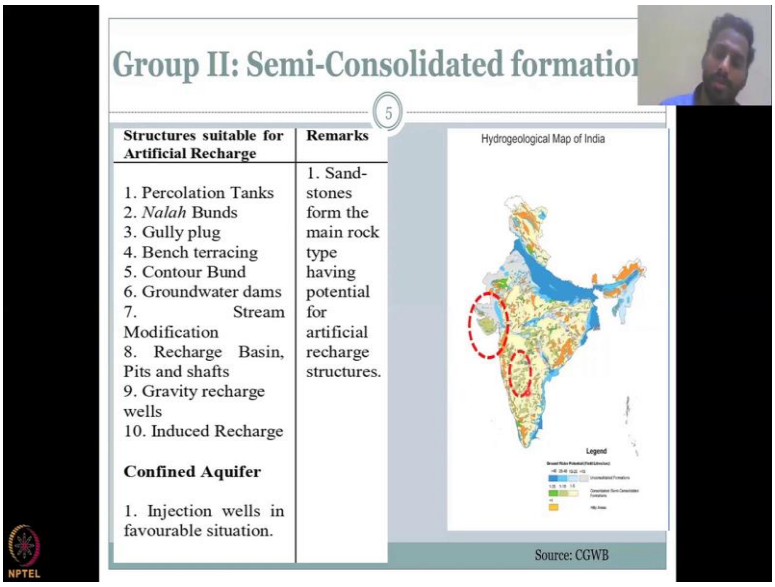
So this is where the government has also said, do not use this one structure, use multiple structures to enhance the groundwater recharge. More structures spread over the watershed, are required to create a significant impact. You cannot just put one unit and then say no, the recharge is not happening, it is a waste of money. You have to spread the recharge structures across, and then wait for the recharge should happen.

Injection wells are not generally given in this because we do not know how much storage is there in the deep aquifers, because these are cracks. So if you start pushing a crack, that is when you are actually overloading the crack, fracturing the cracks, or it will lead to undesirable solutions. Also, we do not know the water quality. Throughout all these lectures, we only seen water quantity not water quality. I will have one week for water quality to just go through what are the basics, but since this is a water quantity management course, I will stick to water quantity.

This is how in the consolidated formations we could see the recommended artificial structures. And mostly, these are the ones that Check Dams, Contour Bunds, and Nalah Bunds, percolation tanks, are formed across these central regions and South regions. The water holding capacity is low in these aquifers, and also recharge potential is low. These are hard rock aquifers. However, this is the maximum acreage covered by aquifers in India. So, hard rock is the type which is the maximum in India.

So, we will have to choose and play with all these different recharge structures that are recommended by the government. The most important factor is, as I mentioned, you just cannot use one method and aim for full satisfaction. So, all these, throughout pan India, you have multiple locations where this groundwater recharge is slow through hard rock aquifers are consolidated formations. Moving on, now, we are going to look at the semi-consolidated formation.

(Refer Slide Time: 15:11)



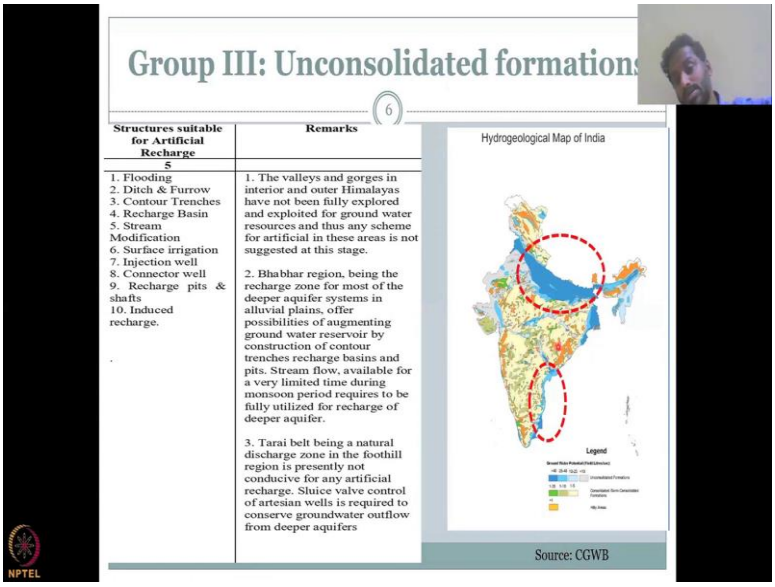
In the semi-consolidated formation, what happens is there is some extra water yield and water recharge. The structures that are recommended by the government are percolation tanks, Nalah Bunds, Gully Plugs, Bench Terracing, same or similar as your consolidated, recharge basins, shaft recharge, induced recharge, in the unconfined aquifers. For the confined aquifers, injection wells are used. So injection, you have to push water in. And those are recommended for the confined.

In fact, injection is only for a confined. Which confined you will use, is the question. If you want to use it in the consolidated formation, you cannot, because it is not wise to crack a hard rock. And also how much storage you have, is very less. So it is best to think of it as a single fracture unit and then send water very slowly, and recharge through the cracks. The remarks are, sand stones form the major type of rock in these semi-consolidated formations, having potential for artificial recharge structures.

So, these sandstone bearing aquifers are okay for groundwater recharge compared to consolidated, but we need to make sure that it has to be divided between unconfined and

confined, and then water being recharged as per need. So where are these locations found? We can look at it. It is mostly the greenish colour, and it is found in Saurashtra region and Gujarat, near the hilly regions in Kerala, Maharashtra and Rajasthan. Some central parts of India also have these.

(Refer Slide Time: 17:14)



Now, we come to the unconsolidated formations or the formations which are technically young and still evolving, and mostly occurs among these big, big river basin deltas. So what are the structures needed? It is flooding, ditch and furrow, contour terracing, recharge basins, in-stream modification, surface irrigation, injection well, connected wells, research pits and induced recharge.

What happens here is, as I said, these are based on large river networks or large river bodies. And these are mostly, so the artificial recharge is mostly aligned with the methods. For example, you have flooding. Flooding is taking the water and spreading it across. You need water. It is not just rainfall you are going to use for groundwater recharge, but here you are using a discharge from the river.

So in the consolidated, let me map it. In the consolidated, you did not see much rivers. However, in the consolidated formations, which is blue in colour, the yield is high, and the aquifer already has a lot of surface water interaction because big, big rivers and streams are here, channels are here and there is recharge.

On top of it, even though there is recharge, there is depletion. In the Ganges basin, for example, there is tremendous groundwater depletion. One-third of the basin is highly depleted. And we are using more than twice or three times the area of the aquifer, as per the lectures I gave in the beginning.

So it is very important to save these aquifers by recharging them through these methods given. And most of these methods are based on an in-channel method or taking the water and spreading it across. So it is kind of your surface water techniques, and or using small corrections of ditches, furrows, contours etc.

The valleys and gorges in interior and outer Himalayan have not been fully explored an exploited for groundwater resources, and therefore there is no need for groundwater in Himalayas. What they are saying is, in the Himalayan region the groundwater has not been much used. There has not been much need. There is no industries in the Himalayan region which are pumping water, or agriculture is not big.

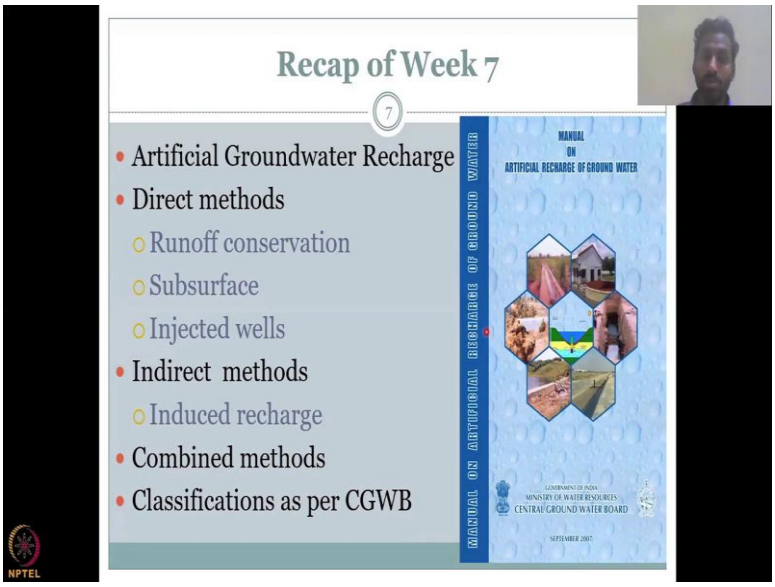
So for that reasons, the government is recommending do not, you do not need to put artificial recharge structures because there is no need for groundwater recharge. Groundwater depletion is not happening. Bhabhar region, being the recharge zone for most of the deep aquifer systems in alluvial offer possibilities of augmenting groundwater reservoir by construction of contour trenches, recharge basin and pits.

The Tarai belt is a natural recharge and discharge zone in the foothill region, and is presently not conducive for any artificial recharge. So, both the Tarai, the Bhabhar, all these valleys are hard rock because it also has the mountain regions. So if you look at the mountain regions, those are the least, or the hilly regions, those are the least water yielding zones, and water recharge zones.

However, along this unconsolidated formation, there are some locations of these hilly and valley regions. So the government is recommending, do not push artificially charged structures here. It is going to be not yielding well. You will not get much profit by doing such recharge activities. You also notice that it is not only in the hilly regions and Himalayan regions, but also along the coast because along the coast there is discharge of water into the oceans and rivers.

The last point where all these collected water across India escapes the system is through the beaches into oceans and rivers and seas. So these oceans, you could see here, in the diagram, and along the coast you have the bluish colour, which is having unconsolidated formations. So unconsolidated is kind of young and new, I said, because sedimentation is happening often. Every single day sedimentation is happening, and that sediment brings in an unconsolidated formation, a high yielding aquifer, a highly rechargeable aquifer.

(Refer Slide Time: 22:22)



So, with this, we are coming to the end of Week 7. We have crossed more than 50 percent of the course with this lecture. So in this lecture, what we have done is we have looked at the manual on artificial recharge and groundwater. I have given the link to this book, which is a free book, PDF book. Please go through it. And it has very clearly explained the different techniques with diagrams in some, and without examples.

But in my lecture, I have covered most of these topics with examples and pictures from notable publications. What we looked at is, the artificial recharges needed. First, even before we went into artificial groundwater recharge, is there a need? So we assessed the need, and we said that as per CGWB, 70 percent or 62 percent is the groundwater development. Still, the groundwater development might be much higher depending on the data availability.

So, there is a need for groundwater recharge. However, the groundwater recharge is very slow in the natural process. Therefore, there is a need for artificial recharge of groundwater. One point I would like to tell you is groundwater is a single word. When you separate ground and water, it becomes two words. And they may not mean the same thing. So either you

should use it together as groundwater as one word, or if you are using it as two word, be very consistent.

For example, CGWB uses as two words. Central Ground Water Board, so it C G W, G W is the Ground Water. But in most literature, it is written as one word. So direct methods involved runoff conservation, where you take the discharge, the river water and then you do some activities to conserve runoff and put it into, capture runoff, and put it into the recharge.

Then we looked at subsurface designs, where you had to dig some part of the land out and then put the water in for recharge. Then you have injected wells where you push water into the aquifers, especially your deep aquifers, or your confined aquifers. Then we looked at the indirect methods. And indirect methods include induced recharge, wherein you are pumping water at a high rate, and because of the pumping around the well there is a cone of depression form, and that cone of depression pulls the water from different resources.

Is one method enough? Not. You will need to use a combination of methods based on your water need and based on your budgets. You may not have an induced recharge method for allowing your watershed. What you could do is you can have runoff conservation in one end, and that water can be applied to injection wells and subsurface water tanks, example. And then you can also have induced recharge where you pull more water and that water from the rivers and stream reverse the direction and come into your well.

So, all these are good, and can be further updated with use of science and technology. The classifications are as per Central Ground Water Board. So my citations, everything for these two weeks are from CGWB. With this, I would conclude today's lecture. In fact, this week’s lecture. I will see you in the next week's lecture, soon. Take care. Thank you.