Rural Water Resources Management
Professor Pennan Chinnasamy
Centre for Technology Alternatives for Rural Areas
Indian Institute of Technology, Bombay
Week 09-Lecture 03
Rural Water Infrastructures - Groundwater

Hello everyone, welcome to Rural Water Resources Management NPTEL course, this is week 9, lecture 3. In this week, we are looking at engineered structures that can help in rural water resource management, we found that in the previous week a lot of water is wasted or water is not captured and management is lacking. So, how can we increase these aspects there is natural based ways and engineering based in this week, we are looking at engineering-based methods to improve rural water resources. The last lecture we looked at dams and check dams. Now, we will continue to see how different models exist with check dams.

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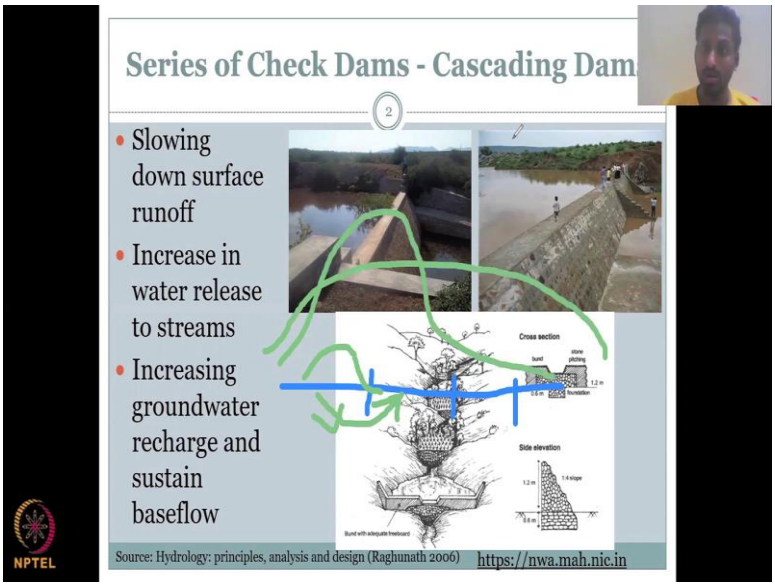

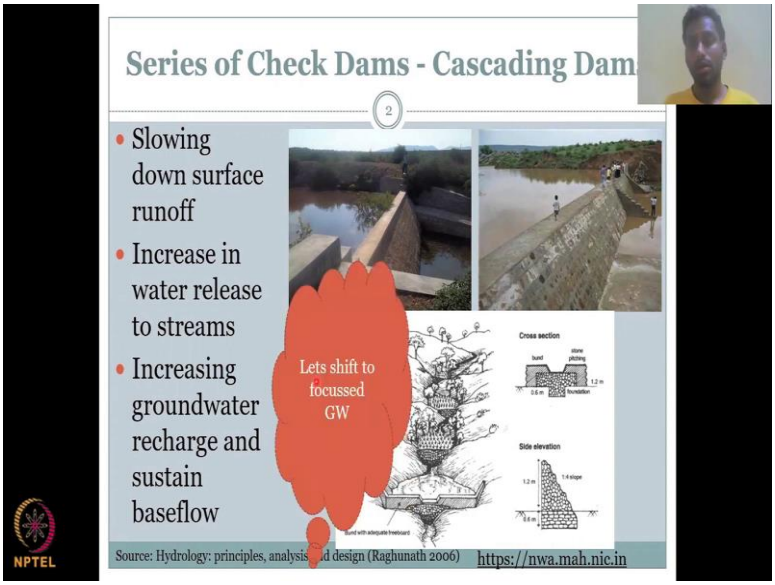

A series of check dams can also be built in the previous lecture I showed you how one check dam is there, water comes get stored and then the recharge happens. But there can be also cascading effect which means you can have one after the one after another very strategically placed to have a cascading effect. Let us see how that looks.

So, this is a single check dam and the check dam can have a kind of a water area that it is storing. So, it also looks like a tank, a tank should be all sides closed. But here you could imagine that water is coming and filling a tank and then it goes to another tank, another tank or one dam goes to another than goes to another dam.

So, that is what is called a cascading dam. This involves many small dams in along the same river or stream network. And after one feel, the other one feels. So, here by you are not letting the water go escape out of the watershed, especially into the oceans and big rivers where the volume does not matter for the big river and ocean, but it does matter for the local pumping. So, as I said, if water flows out, it is a loss to the watershed. And this is very important when the watershed is leaving the water into a bigger water body, especially large rivers and oceans.

So, it is okay to store the water as a cascading effect. And when you have the cascading effect many important parameters get recharged. Let us look at some slowing down surface runoff. So, the major first goal is you slow down the surface runoff the water that flows on the top after you have precipitation and infiltration et cetera, the water which flows on top of the surface continues to flow along with other water runoff and then forms into rivers and streams.

So, this is being slowed down because of these check dams you are slowing down the water. Increase in water relates to the streams you are slowing down thereby not letting the water escape the system but slowly releasing the water into the streams. So, for example, this is your screen if runoff was coming very fast it will escape the stream look and go. So, in 3 months all the flows gone. However, if you stopped it at periodic intervals, the water gets only slowly, slowly miss in the stream, thereby increasing the longer activity or the long activity of the stream.

Most importantly, it lets in to recharge base flow groundwater, aquifer recharge et cetera. And those water would come back to the stream as river flow through base flow which actually increases the flowing period of the stream. It increases government recharges and sustains base. So, this is what I mean as, once the water goes in to the ground and then goes out as base flow. The stream gets more water. Let us have a quick diagram of how it works. So, you have your stream and along the stream you have check dams.

So, if the check dams were not present what would just flow out fast because you have the check dam, the water would go into the ground and then come back out into the ground and then come back out this causes a delay in the water leaving the stream. Thereby going in is called recharge and then coming out to the stream is called base flow contribution.

So, by this process, what going into the ground and coming out you are slowing the flow of the water in the stream thereby increasing the period over which the stream flows for example, in the stream was flowing like this just 4-5 months because it went into recharge and comes out base flow, it will flow like this.

So, all throughout the year, you will see groundwater flow. Is not this the way the initially on the water bodies were? Yes, initially, all the water bodies would be flowing. Every major water body, the rivers streams will be flowing throughout the year, you would have heard stories from your grandparents or even your parents that some of these water bodies, rivers streams were having water throughout the year, but now it is not happening.

So, there is a series of check dams can be built to increase the water industry. That is one method that a lot of studies have promoted. And especially one person has done a lot of these works in Rajasthan, Mr. Rajendra Singh, and he was awarded the Stockholm water prize, which is considered as the Nobel Prize for water kind of that high, highly regarded price for creating these check series of check dams to revive, revitalize the streams and rivers, he woke

up a lot of people to get into this series of check dams. And many, many rivers and streams have been benefited.

However, so here is where I am going to stop with the engineered aspect for rural water management for surface water, because you can do it in less amount of surface water interventions, it is not that easy to make multiple interventions for example, you cannot cut a channel and then bring the water out to your house and stuff which is not allowed in many, many aspects, you can put a bump and take it as lift irrigation even that is not allowed in a canal system.

So, think about all these regulations and that is where people have been not much abusing the rivers water bodies et cetera. But where most of the abuse is happening is the groundwater for rural systems. India is the chief groundwater extractor and there is a big need to conserve that resource.

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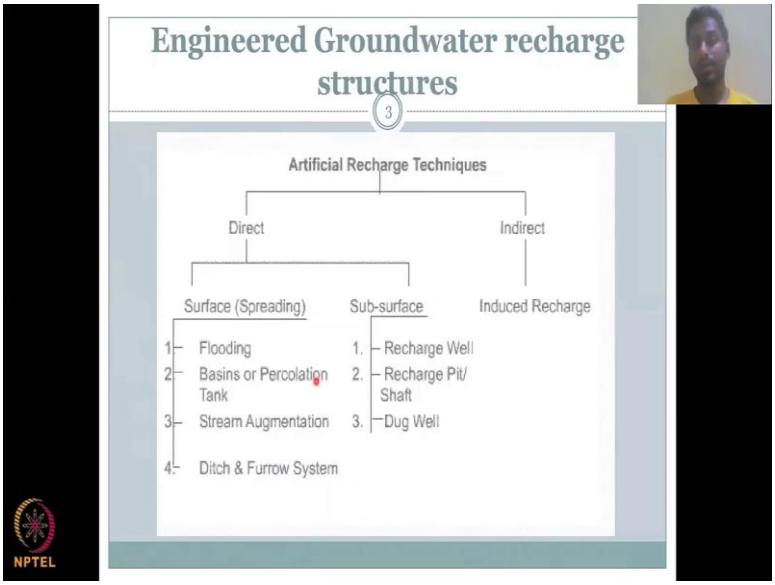

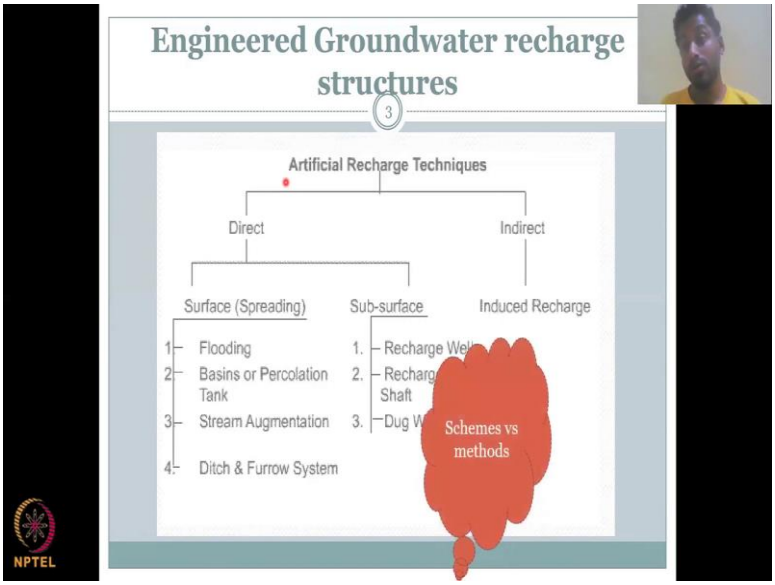

Let us see how you could do groundwater recharge activities in rural villages. So, since it is not natural base, it is called artificial recharge techniques. If it is nature based it is like forest and then you have more infiltrated soil percolate and soil where you have multiple nature-based solutions to increase the recharge. However, the speed is still low. So, for that there is a lot of artificial recharge techniques, which involves a lot of engineering aspects. Let us look at some of them in this class today.

So, first artificial recharge techniques are divided into direct and indirect methods. In the direct method, you have surface spreading techniques where you increase the time of the water in connection with the land. So, if water is flowing very fast on land, then there is the time of connection between the water the connect you know, between the water and the stream is very less the water in the land body and that causes less infiltration time. Less percolation time, thereby less groundwater.

So, how can you increase this connection between contact between the water and the land? The contact time you could increase that by flooding you flood the area let the water pond up. a thickness of water is on the land and that time is given to the land to infiltrate the water and take it to the groundwater. Multiple methods are there, those are basins or percolation tanks stream augmentation, ditch and furrow system.

We have seen this in the previous lecture also the ditch and furrow system, but here we will look at it, how it is in the groundwater network. In the subsurface we have the recharge well, the recharge pit shaft and the dug well, where most of these are wells and those wells have to be built inside the ground, whereas the surface techniques are on top of the ground,

subsurface techniques you have to dig and then put it in for the action to be taking place. The indirect is induced recharge which is mostly by pumping water into it, which is not a very commonly used method.

So, we will focus on the direct method, a lot of schemes versus methods. So, these are the techniques which are shown here sometimes cannot stand alone because the problem is complex, groundwater recharge is complex. So, let us look at some schemes where they take multiple methods and then work on the net groundwater recharge.

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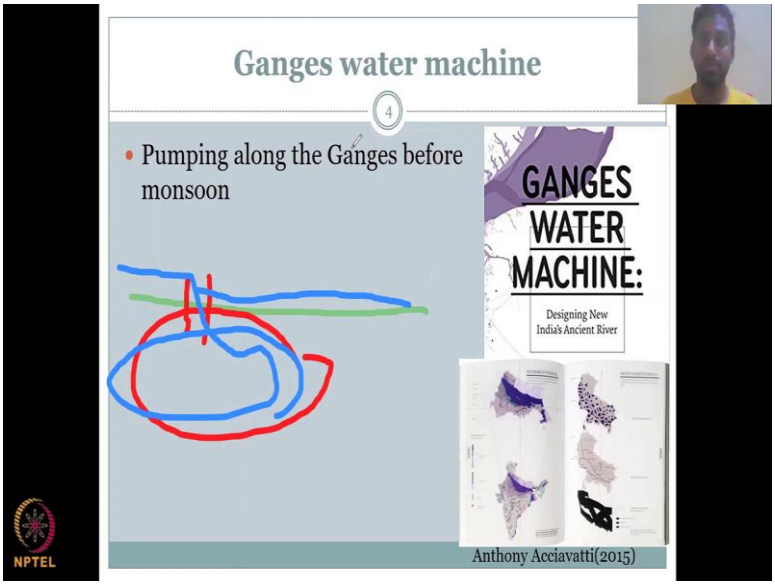

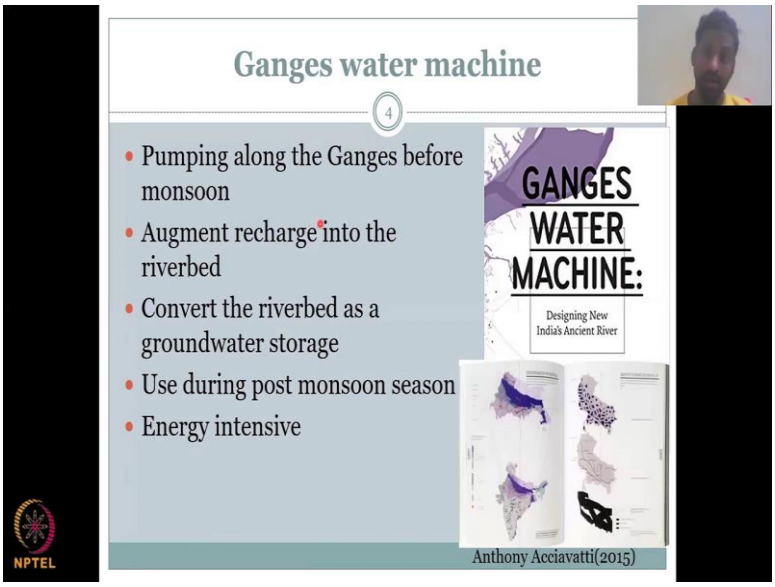

The first one is the Ganges water machine, which is thesis as I mentioned from an Indian student at MIT, Stanford, Harvard, where they worked on these topics for inducing groundwater recharge along the Ganges it was a very old thesis and now a lot of people are

working on it, is a book by Anthony in 2015 of this against water machine, please see if you could look at it and what they talk about, I will give you some examples of what it is.

What does Ganges water machine mean for groundwater? The Ganges has a lot of water as surface water, but in recent years along the Ganges the rural areas the groundwater has been depleting. So, what the Ganges water machine concept thinks about is if you pump along the Ganges before the monsoon, along means along the riverbed where you can put a big pump and pull out the water, if you take the water out before the monsoon, which is the time when you need more water for irrigation and agriculture.

So, if you take the water before the monsoon, then what happens is when a big flood of water comes in the Ganges during the monsoon, then there is space for the water to recharge, which can be taken out later. So, I am going to draw how it should look like so you have a land. And what they are asking claiming to do is you pump before the monsoon, you take out the aquifer volume, so basically empty that cover and when water starts to flow in the monsoon, so when water flows, it goes inside and recharges.

Thereby, the water level might come down in the Ganges, which means the floods might come down. Still all this is a thesis a theory. So, there is a lot of experimental methods that needs to be done to prove it. But what I am trying to tell you is by these methods, you can actually recharge as per the science and the book which has explained. So, you bump before the monsoon along the Ganges and then you have recharge of water in the riverbed.

So, basically the flood comes in the monsoon, it goes into the riverbed and recharges the soil. So, even if you pull it out in before the monsoon the water, it does not affect the groundwater use because you are actually recharging it every year. Convert the river bed as a groundwater storage. So, initially the riverbed is always full of groundwater because no one is putting a pump and taking the water. No one is actually using the underground of the riverbed where there is good aquifer storage, mostly only the river is used and the banks of the river where the groundwater is there, they use it.

The riverbed members mostly less affected. And that is where the study is saying use the riverbed to take water out and use during post monsoon season where you can recharge the groundwater in the monsoon and then post monsoon, you can take it out and use it there by emptying the space again. So, it is a machine. So, you are converting the Ganges River bed into a machine where water comes, you recharge it, and then the flood is reduced.

But then after the water flood season is gone, you take the water and use it for agriculture, keep the water aquifer empty, another annual river water comes in goes inside, it keeps continuing like a cycle. However, so these are the benefits, let us look at the practical problems. That is why I am saying it still needs a lot of testing, the energy consumption is intensive, a lot of energy is needed to take water out of the riverbed and then where to use it how to spread the water out is a concern.

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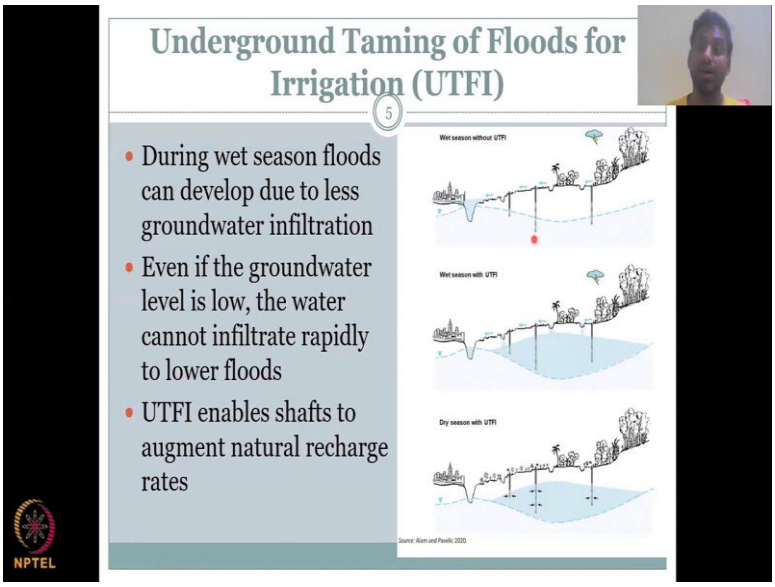

Please understand that against riverbed and Ganges area already has a lot of water resources. So, why would someone put energy and pump and then use it for agriculture is a question. So, all these still have to be done. A lot of big agencies are working on it. As example me who does not have funds from big banks to work and test this system because once they test it, they can actually use it for groundwater recharge and taming of floods, which is what this second team that we are going to look at are the scheme. This scheme you see Undergone Taming of Floods for Irrigation UTFI.

So, you are having the flood water coming on the surface, which is washing away the rural areas and stuff not much agricultural benefit, it is not stored in the aquifer. So, there is a lot of loss of the floodwater, what this scheme does, if you look at it, this is the wet season or the monsoon season without UTFI scheme in without UTFI scheme there is a rain all the water comes as runoff, it goes into the rivers and streams and floods the cities and rural villages.

Whereas, in UTFI what happens is there are these long shafts, groundwater recharge shaft, where water is stored in these small, small recharge ponds and pushed into the groundwater

through the recharge shaft thereby increasing your groundwater recharge. Now, your flood volume is much, much attenuated in the streams and rivers before the city and also the rural villages.

More importantly, your water can be used in the dry season which is the next season. You can see that the groundwater is being pumped and agricultural activities are happening. So, this is with UTFI. So, all UTFI does is it captures your monsoon rainfall. Even the floods push the flood water into or before even the flood happens because you are capturing the water before the flood happens and pushing it into the groundwater storage through recharge shafts and this water is available in the dry season for agricultural activities.

During wet season floods can develop due to less groundwater infiltration also because the soil is very wet and so the infiltration is very slow. However, if you have this long recharge shaft, I will show you the figures of how a recharge shaft looks like. It is an engineered product, where you can push water into the recharge faster and thereby actually not in the shallow aquifer it goes directly to the deep aquifer. So, there is a lot of volume which has already been depleted by rural activities, especially agriculture.

So, what the scheme says is already the groundwater is defeated. Why do not you take the flood water push it inside and then use it for post monsoon activities. These are still being tested for recharge rates, water quality, quantity and once they get tested and scientifically validated then big schemes can be implemented in India. So, this study is also been tested in India where there is a lot of engineering aspects, artificial engineered products to enhance the groundwater.

Even groundwater is low the water cannot infiltrate rapidly to lower floods, because floods happen at a very fast state's speed, whereas, the infiltration is a much slower process. That is where UTFI smartly enables shafts to augment natural recharge rates. Augment means add on or faster than the natural recharge rate.

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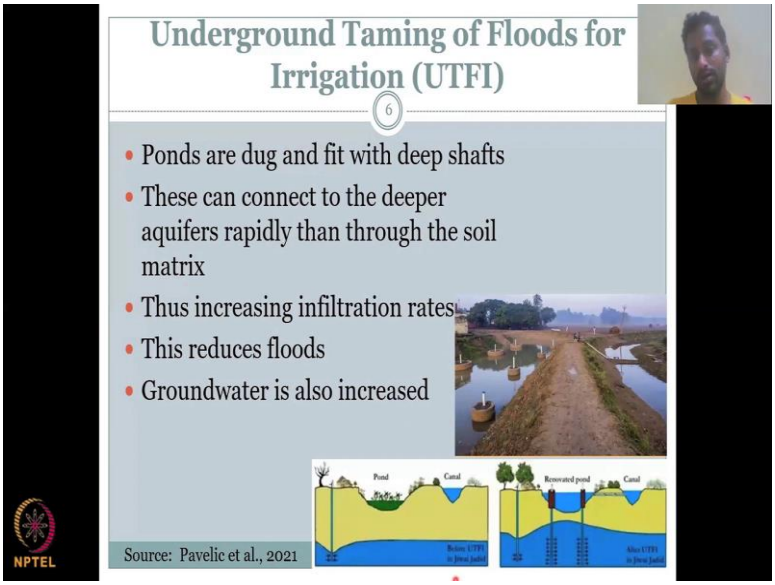

Let us look at how it is done. So, you have here the recharge shaft as I mentioned, and you have a canal where the water is flowing canal stream or river network water is being shunted into a renovated pond. Initially, all this area does not have groundwater because groundwater is very deep, nothing is growing the villages are not having water for agriculture, the pond has no water because of climate extreme and nothing is growing along the banks of the pond. So, it is just wasted water resource and water body look at how deep the groundwater is.

So, now what they claim is if they canal water is added and this canal has nothing to do with the pond, there is no recharge happening. So, now what UTFI scheme does is take the canal water diverted into the pond part of it not all canal water is lost only part of it. So, there is first a diversion of water and that water is put into these recharge shaft people see the recharge shaft and groundwater goes faster, much faster into the shaft and to the deep, deep aquifer.

So, you can see that the deep aquifer is getting all the water which then recharges the entire aquifer. So, from here, it has gone up to here in during the UTFI scheme. Ponds are dug and fit with deep shafts. So, the ponds getting the pond lag is a concern. But if you already have river and upon nearby, then you can easily talk to the villages and see how the scheme can work. That is how they have done a testing site in the Ganges they have identified a farm pond which has not had water.

They have said, let us take some canal water through permission and put it in the pond. If we just leave it in the pond the recharge rate is slow. So, to augment it to increase that these

recharge shafts have been built, engineered so basically, they are a column which goes into the deep aquifer and water being pushed in to these recharge shafts to go faster and then recharge.

So, you will see the faster recharge is happening compared to the recharge here from the pond. These can connect to the deep aquifers rapidly then through the soil matrix. Because of water has to go through the soil it is very slow process. What they do is they put gravel and other layers of soil and rock in the recharge shaft. Put the water on it so that the water moves slowly and all the impurities are kept on the top then water just goes faster into the pipe.

So, this pipe there is no soil so water can just go faster. Once it goes faster, it recharges the deep aquifer, thus increasing infiltration and percolation rate. To be honest, there is no percolation rate needed because the infiltration just takes the water straight to the deep aquifers. You are bypassing the percolation path. This can reduce flood because you are quickly catching the flood water and putting it in thereby reducing the flood peak and more importantly, you will also recharging the groundwater.

And this is where two aspects have been satisfied because when floods come your rural agriculture has gone, a lot of fields have been washed away. Too much water is also bad. So, you are capturing the water, putting it into the groundwater and recharging and after the flood, after the flood season this water can be found through the deep aquifer pumps and used for agriculture.

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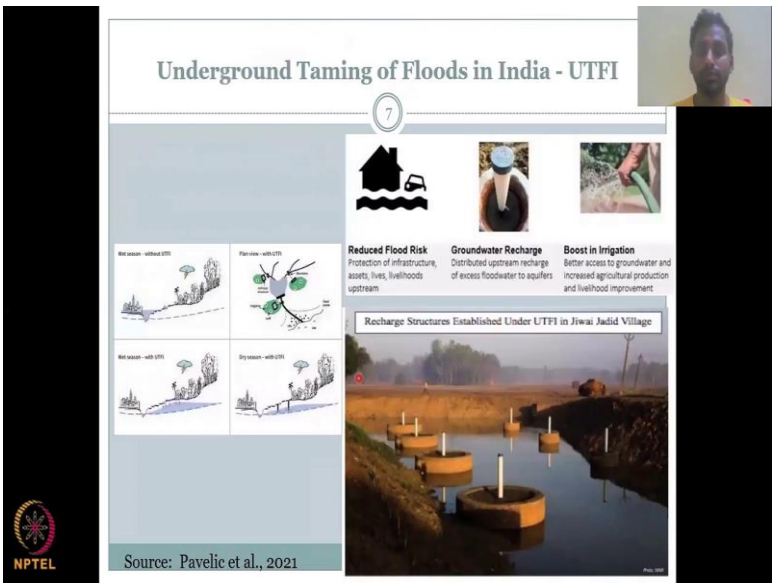

As I said this has been tested widely and still the results are coming. Just recently last year we have papers so look at the wet season without UTFI and wet season with UTFI you do not have groundwater recharge here there is a good groundwater recharge and most importantly the flood level has reduced. How does it look? Plan view with UTFI is you have these recharge ponds and around the recharge ponds or inside the recharge ponds. You have these recharge shaft, which actually pushes water faster into the groundwater. And during the dry season this groundwater is being tapped for agriculture.

So, it reduces the floods, protects the rural villages assess livelihoods, from flood damage and groundwater recharge happens distributed upstream recharge of excess flood water to aquifers, water is pushed into these because when the pond level rises, for example, now the pond does not have water.

But when water comes the pond level rises and can go into the brown space you can see here which has layers of materials that can remove the impurities or filter the impurities and the water cleaner water can go into the aquifer. This aquifer water can be used to boost irrigation during the dry flow season or the non-monsoon season, better access to groundwater and increase agricultural production and livelihood improvement.

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So, this is a win, win for everyone. But this is only the schemes that I have been talking about. Now, we will look at some of the methods I will introduce the book, please go through the book it is a free open-source book. I will discuss more about the methods in the next class. So, the book is called Managed aquifer recharge, where groundwater recharge is slow,

there needs to be methods to improve or increase the infiltration and that has been widely used by Manage Aquifer Recharge activities, which is called MAR where you manage your aquifer through artificial means and your recharge happens.

So, engineer or natural activities that are done to increase groundwater recharge rate, the natural activities I will discuss in the next week. In this week, I would focus on the engineered aspects. The book by Gale 2005 captures methods for rural India because there is a lot of examples from rural India, especially in semi-arid areas where rainfall is lesser than sound 50 millimeters or rainfall is only concentrated in a particular month, months, monsoon months. So, what happens if you are capturing the rainfall, you are storing the water in particular methods to recharge locally in the aquifer.

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As I said the book is free and open source it looks like this. Please go ahead and download and read it for better understanding about manage aquifer recharge in semi-arid areas because it was totally dry. There is no rainfall to capture and put it back. So, there is already a loss but in a semi-arid you have some rainfall. Let us not waste the rainfall captured it and put it in the groundwater is the concept. So, I hope to see you in the next class with some models and interesting aspects and how to test this in the field. I will see you in the next class. Thank you.