Rural Water Resources Management
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Week 09-Lecture 04
Rural Water Infrastructures – Managed Aquifer Recharge

Hello everyone, welcome to NPTEL course on Rural Water Resource Management, this is week 9 lecture 4. In this week, we have been looking at options to manage rural water resources through engineering ways. More importantly, we looked upon dams and check dams for the surface water and for the groundwater, we looked at manage aquifer recharge, especially, artificial recharge through engineered aspects. We looked at some schemes in general, but today, we will be looking at methods based from the MAR book that I have shared last time. I hope you could search the book and get it please use it for understanding about the Manage Aquifer Recharge programs.

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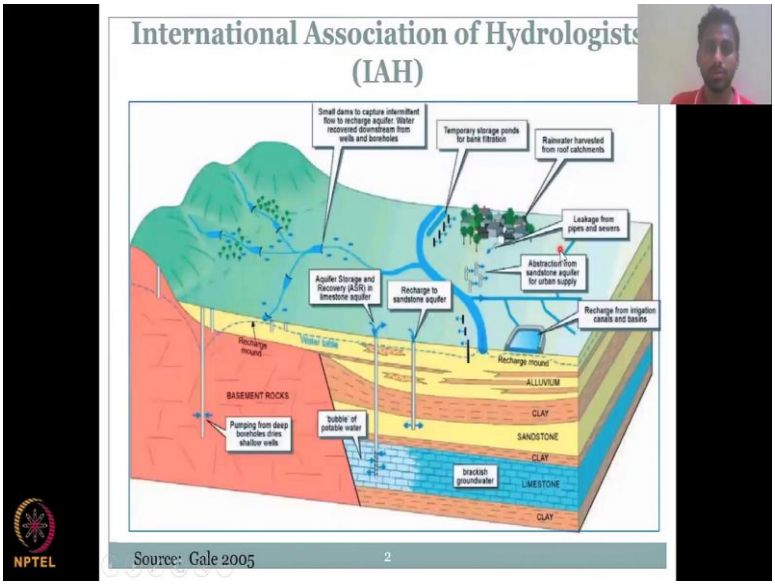

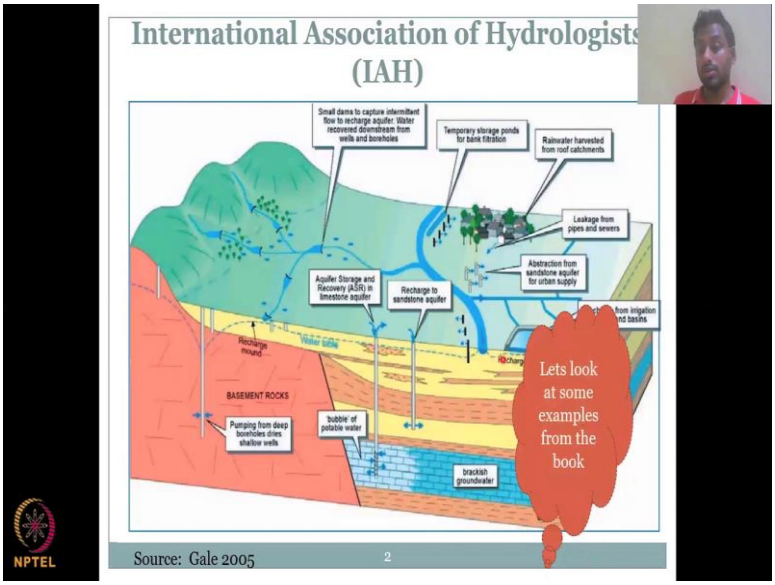

As per the International Association of hydrologist, which is also where the book is being published, we could see that not one specific structure is needed in a larger scale, but you can have multiple different methods to attain rural water management. If you look here, you have check dams on one location and if you look at the entire stream, you have multiple check dams along the stream which is something I said about cascading check dams.

So, you have cascading check dam one large check dam which is bigger than the smaller check dams. And what it does? It stops the water, stores it, now you could see that the volume is increasing. So, from the watershed, the water is flowing towards the stream outlet or river outlet. And you could see that wherever the check dam is placed, you have a volume of water which is being created and from there will be left irrigation and other schemes, but the surface water has definitely been improved.

Then part of the water goes down as groundwater recharge which is also part of your management activity. Then we also have storage ponds along the river network. So, there is 2, one is away from the watershed or the farthest part of the watershed boundary what can you do and along the river what can you do so, along the river you can have storage ponds for bank infiltration, where a pond is placed water is sent and then what recharge happens also the pond can serve as a surface water storage pond.

We looked at this in the UTFI and then we also have aquifer storage and recovery in the deep aquifers and then recharge into the confined and unconfined aquifers, but we will just look at mostly where you have other networks to capture rainfall, capture stream flow to store in the rural resources.

So, you can also see rainwater harvesting in the rural villages can be done. leakage from pipes and sewers are taken where water leaks from pipes than the sewage system. Those can be recharged into the groundwater indirectly. And also, most importantly, you have a recharge basin or large dams inside your boundary of the river.

Here since it is a rural setting, you will only see small, small structures. And we will get to the specifics of each structure in the coming slides. Let us look at some of the examples from the book. So, this diagram is also taken from Gale which is MAR book. And you could see that all these systems have been used for increasing the groundwater recharge in the rural village and also the surface water storage.

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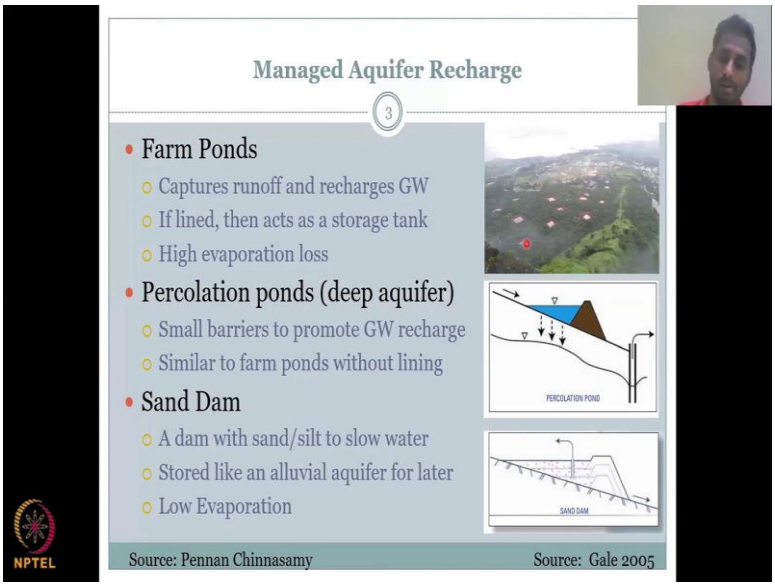

Now, let us look at each one by itself. Manage aquifer recharge, even though it is for groundwater, there are some surface water storages also happening in these structures, so let us see how they happen. The first one is the farm ponds what you see here is taken in the Maharashtra area where you could see that from the hill slopes, the picture is taken from top of the hill and on one side of the hill, where there is good rainfall occurring, you could see that the farmers have made big, big ponds farm ponds.

So, all the water which comes as runoff would go into these farm ponds and then recharge occurs. Also, the farm pond can store the water for long time. So, maybe a month or 2 after the monsoon which can be used for irrigation. So, it captures runoff by storing the water in these ponds and you see that it is not only one it is like a decentralized small, small pond.

But across the area, so that all the farmers who have these small, small acres of land can be satisfied with this surface water. The surface water also goes into the groundwater if the pond is not like in some areas you have plastic sheets under the pond. This prevents the water from infiltrating but it is mostly used as a surface storage like a swimming pool. In a swimming pool, you do not see water going down, it is a stored like a surface water body.

So, that is what it means us if you line it up, then it acts as a storage tank. High evaporation loss, there is a lot of evaporation happening you can arrest the recharge by putting a plastic sheet under the bed, but how do you arrest recharge evapotranspiration, evapotranspiration is losing of water to the atmosphere. And it goes through mostly evaporation because it is the open surface evaporation, there could be some plants like water high sun and then other things inside the water which can transpire but mostly it is evaporation.

So, even though there are good positives, there are a couple of negatives which you should take into account when discussing about farm ponds. Some people what they do, they put trees around the top, trees around the farm pond so that top area would give a lot of shade the canopy we call it the branches would give shade to the ponds thereby reducing the evaporation however, the trees can also take water because trees also need water to grow.

So, there is a given take and depending on that these farm ponds are made. The next method the book describes is percolation ponds for deep aquifer recharge. So, it is like a check dam. So, a small barrier which is placed along the river or stream network for the camera and the bottom of the layer bottom of the check dam is layered with gravel and other materials which has higher infiltration rate.

Thereby, water would go faster down into the deep aquifers. So, small berries to promote groundwater recharge similar to farm ponds without lining and also it has materials to enhance the infiltration and percolation rate. Remember the farm pond can be acting as an infiltration pond, which means water stores and then water is released also if it is not lined waters recharge to the groundwater.

But if it is put a plastic tarp, it is not allowing water to recharge. The next one we are going to see is the sand dam. This look at how the sand dam has been constructed. You have a barrier which is this one along the slope of the hills are along the slope of the riverbed. Where you have water flowing, it could be a stream flow or it could be the runoff along where the runoff happens.

What does this dam do? The sand dam it is filled with sand already, it is not sediments it is sand which has high infiltration and percolation rates. So, what happens is when this water comes in, it actually flows into the sand because of the porous space and stays there. So, it is a wet sand, it does not really release water to evaporation much on the surface yes, but underneath the surface the water is in still good amount. And so, the idea is you cover sand and silt along the dam. So, water is slowed down.

So, when water hits the dam, it slows down because of the sand silt and then stores in the porous space the sand and silt and then you can pump it out later. So, you see here that they have put a pump and using it out very easily. So, compared to the farm ponds, it has less evaporation. However, the storage volume is also less because part of the volume is stored with sand particles.

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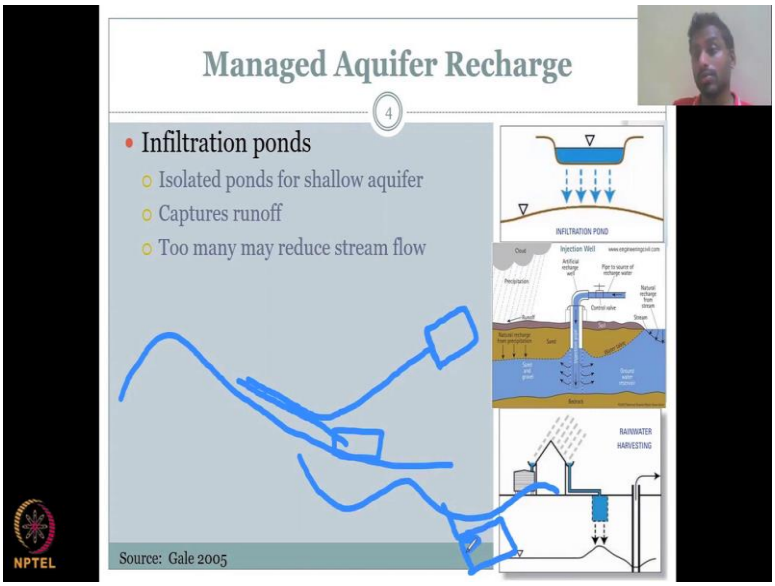

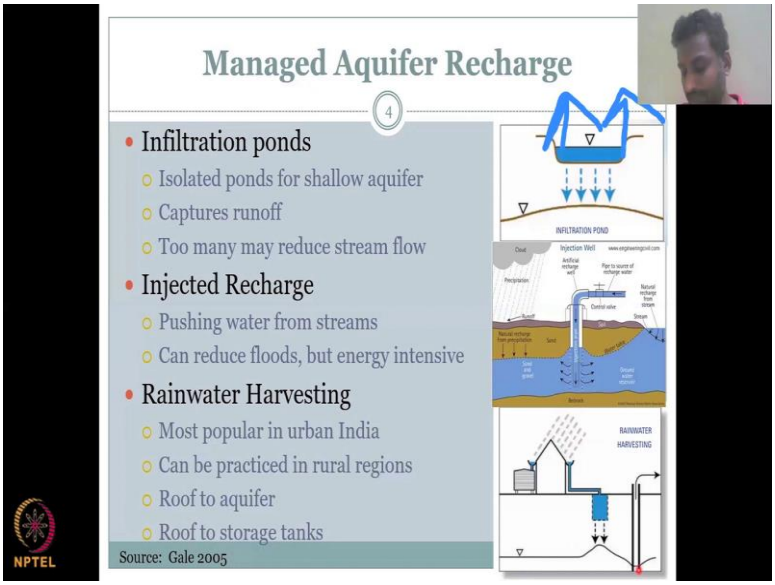

As I said, the infiltration pond which you see on the top, it is isolated ponds for shallow aquifers, it deals only with the shallow aquifer where on the bottom you do not do any change. You could just dig it up and then make sure that water is stored and it has space contact, contact with the ground and the ground slowly infiltrates the water to the aquifer.

Since only infiltration we are talking about this is for shallow aquifers and also to increase soil moisture in the rural setting. Remember that soil also plays a big role in water resource management in rural areas. Because water gets stored in the soil, the soil moisture goes up and that is what supports the plant life you need the holistic picture not just dams, not just groundwater, also soil trees, plants etc.

So, the infiltration ponds capture runoff it could be as simple as if this is your land, slope and then there is a land you could put upon along the slope where water can just accumulate like the picture I showed in the previous slide, or it can be channelized into a small area and then you put the water in channel means you collect the water into small canals or channels and then you put the water inside the pond basically collecting the water and putting it in.

And the third is as usual you have a river flowing and along the river you can put a pond and the water can be shuttled into the pond. So, there are many, many ways you could bring the water into the pond. What happens in the pond is that it captures the water and slowly the water goes down as groundwater recharge. There is also water loss as evaporation on the top.

Too many may reduce stream flow. So, if you do put too much overdo it, it may reduce the net flow because you are capturing water everywhere and one can go into the stream. So, you

have to leave some water to go into the stream if you capture everything then there is no water for the stream all the water is in storage.

Injector recharge this is similar to the UTFI we looked at in the previous day lecture 3 but here what happens is the water is pushed inside using a pump. How a pump can pull water similar way you can make the pump to push water inside an aquifer. By the brutal force and that force can push water from streams or flood plains or even a pond it can take the water from pond and push it into the aquifer. So, it is called an injection well which connects the pump into the aquifer. And directly the water goes into the aquifer.

There is no slowing down no delay for percolation or infiltration, because you are already making sure the water is clean, you take the water with the pump and push it inside it can reduce floods but energy intensive. In some countries you would see where it is very, very flood prone. However, if the country is rich and has enough money, they would keep on pulling the water from the ground and shunting it or putting it somewhere else through pipe networks.

So, the idea is if you have energy, you could still take the flood water, reduce it by sending the flood water somewhere else or putting it into the ground, you do not have groundwater floods you can have groundwater creating a flood for example, if the groundwater is too much all the side is full of water that infiltration does not happen the all the precipitation converts into runoff, which can lead to a flood.

But aquifer would resist after one point if you keep pushing it cannot take water it will just resist you cannot push water through a rock. So, it will resist at that point is also to be taken into note when you do injected recharge. And the last but not the least in this slide is the rainwater harvesting. Remember that rainwater harvesting has been made mandatory in many urban cities in India. Example in Chennai if you want to build a new house or an apartment complex, etc.

The rainwater harvesting plan has to be identified along with the plan of the house. All of it has to be approved together. You do not say that? No, no, I will build the house and then I will put the rainwater harvesting that is not accepted. Why? Because the rainwater harvesting is to be included in the design. Otherwise, you will just make some storage unit which is not rainwater harvesting, but just channelizing the water into one location.

So, what does rainwater harvesting, what is the name harvesting mean? Harvest means collect, like you harvest crops you collected, put it into sack bags and then you send it to the market. Similarly, here you collect the water from the rooftops and other land locations in the rural village and put it into storage tanks or groundwater. The storage tanks which I have seen in some other villages are like the plastic ones called like the Sintex ones, like drinking water can pick big ones, and the water stores there for a long time and then they take it out clean it and use it, at least for bathing, washing, you can use normally rainwater is good.

But while you are collecting in the rainwater harvesting method, some impurities can come, there are some places where rainwater is caught and put inside a subsurface tank where it recharges. So, this figure from the book beautifully captures both the scenarios. On the left you see that rainwater was coming what was being harvested collected here into a storage time.

Now, the house has the storage tank, which can be used for simple works like flushing, you know flushing also needs water. So, maybe that is used for flushing. On the other hand, on the other side of the roof, you see water hitting and going into the collection chamber. Here the collection chamber is inside the ground. And that is where water is being put an after some time what recharge happens you can see the groundwater table decreasing thereby collecting the water and putting it into the groundwater aquifer.

Rainwater harvesting is most popular in urban India, but things have to move to rural also these technologies because a lot of benefits have happened for the urban centers because of rainwater harvesting. And slowly the rural villages also are getting toilets and other facilities, which requires more water can be practice in rural regions roof to aquifer so you can connect the roof water to the aquifer.

Only one concern is the housing may not be the same as an urban setting whereas lot of concrete is used. And also, pipes are there to easily connect. Whereas in a rural system, it might be different, the rules might be attached, the rules might not be good to collect rainwater or pipes to input.

Roof to storage tanks is also available as I show here, which can be used for different aspects. I have known in villages, some villages, they would collect rainwater in big drums and use it for cooking, they will just keep it in the open. And the water is very clean in villages because

the atmospheric pollution is less, so the water would be clean, so then take it directly, and then boil it and use it for cooking.

Whereas in urban centers, we do not do that. But mostly it can be used to recharge, the groundwater and the groundwater can later be used for cooking, drinking on all the other aspects. Most importantly, you should look at both surface and rural groundwater resources. Because both are important in these examples other than the injected well, the examples that I have shown today, you could see that you collect the water first in a surface storage.

So, you are increasing the surface rural water resources, then you are also pushing the water into the groundwater through infiltration, percolation or induced recharge, which is also helping the groundwater network. so, one water, which comes from precipitation, you collected into different chambers. One is your surface storage and then the next one is groundwater storage. But both have to be improved.

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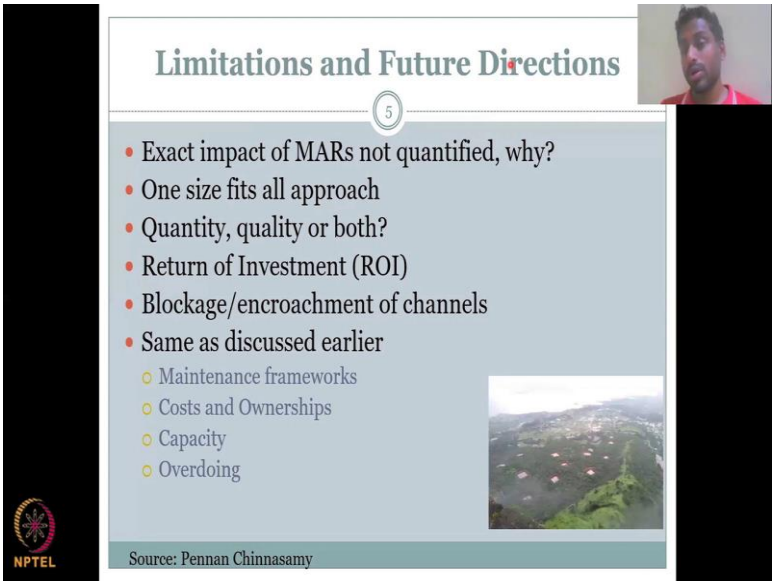

While these have been very successful in urban settings, there are limitations and need for future directions. Let us see what are the limitations? First exact impact of MARs not quantified. Quantify not qualified, qualified, or qualitative all these are terms that you would use without numbers, you can say that oh, the ground water recharged well. The groundwater is good quality, but there is no number.

So, that is where qualitative stands. But you would need to justify it with numbers, you should say the groundwater quantity increased by 10 percentage, from 5 liters to 10 liters. Or you could say that the groundwater quality is good because the nitrates are low, below the

WHO standards, those kinds of things. pH is more basic around 6.5 to 7, something you should tell why these are better? One size fits all approach.

The first point I think we should still debate that. Why is it hard to quantify? Because there is no data? In lecture 6 or 7, where you look at the issues in rural water management and data issue is a big issue. Because it is expensive and other reasons are that now you are talking about a decentralized approach, where there is no agency to monitor the data, use the data or to give the data to the public, there is no budget. In that case, it is very hard to quantify.

So, that is the first reason and not much interest to quantify the impact. They just want to do it. There is a one size fits all approach which happens. I did mention that there is a project done by Mr. Rajendra Singh, who built a lot of check dams and revived rivers. Now, does that work in every location on India? No.

There is some technicalities and suitability of the model which cannot be replicated easily that other ways cannot be easily used for other regions. So, that we need to be very careful about so there is no one size fits all each size is for a particular person or particular member of the family.

Same way, one size does not have one type of check dam cannot be suited for all applications that is what is happening in most of these states where they say oh, it worked in Tamil Nadu it should work in Odisha bring the model and put it down and the model will fail, the model as I said the method as MAR or anything.

So, that is where we need more scientific validation data and then show if the one size can fit all or not, all the failures have been noted, we can definitely say that one size fits all does not work, it is more quantity, quality or both. So, all these MAR are they talking about quality or quantity or both? Please have this understanding of any water project that you look at is it only talking about quantity, is talking about quality for both quantity and quality.

What is the return of investment? As I mentioned, the check dam is not as big as a large dam. However, a check dam is still expensive, somewhere 4 to 5 lakhs you start and it can go to 15-20 lakhs spending on the land depending on the height and where you are putting it, is it the accessible to materials or not? The return of investment is how much you put the budget and how long you are going to need to take the profit to earn the budget.

For example, I say 5 lakhs for check dam I give it in 2020, If I get 5 lakhs worth of profit in 2022, then I am getting the return of the investment in 2 years plus or minus your interest, but most importantly the return of investment should come back. So, how do I show the return of investment as profit because the 5 lakhs have been spent in building the check dam. Now, I have to show that because of the check dam there has been an increase in groundwater and because of groundwater increase, I have more sugarcane and that sugar can profit is more than 5 lakhs. So, this is how the term of investment is calculated numbers.

Blockage encroachment of channels everywhere unfortunately, there is a lot of blockages of waterways and so that these programs would fail. For example, you can have a village farm pond, you can have a groundwater recharge pit, but if water is not flowing through it, then how do you get it. Now, initially there was water and water were flowing into it.

But now the channels are being encroached. encroached means they would take the land and put a house or a car shed for example, they will fill the canal and put something building on top because canal land is the government plan, they will just take it up some public people saying or they block it throw rubbish garbage and then those do not help recharge estimates.

So, what can be done same as earlier I discussed in capacity building and other things, maintenance frameworks have to be worked upon, we have to discuss frameworks of maintenance, the cost of ownership has to be brought into account on day one when the project is on. As for ownership, later let the stakeholder's debate and if they want it they have to take part in it. And capacity is more important also you need to train everyone regarding the use of new science and technologies for water resource management and never overdo it, as I said if it is okay in one location, it may not be okay in all locations.

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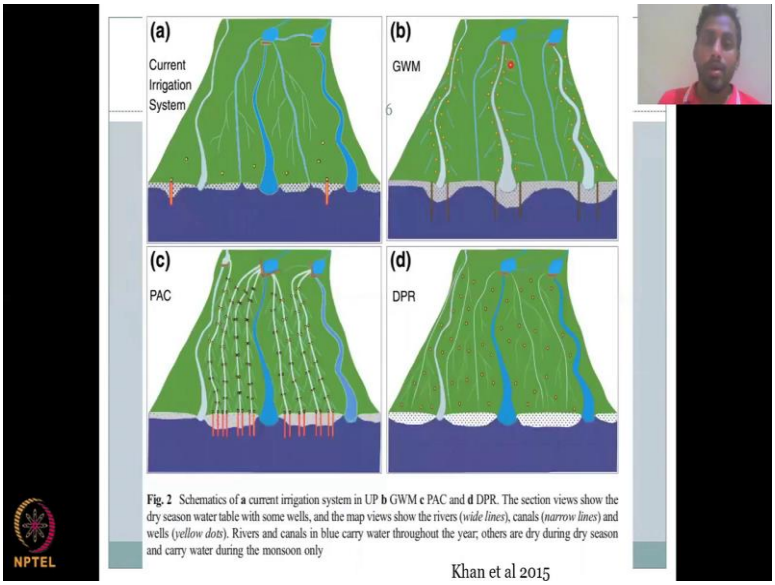

With this I would conclude today's lecture I just will show you this paper to be discussed in the next section where we have multiple different methods and to study the return of investment and how these things work. I will start with this from the next class. Have a good day. Thank you.