Groundwater Hydrology and Management
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Lecture 04
Groundwater pumps

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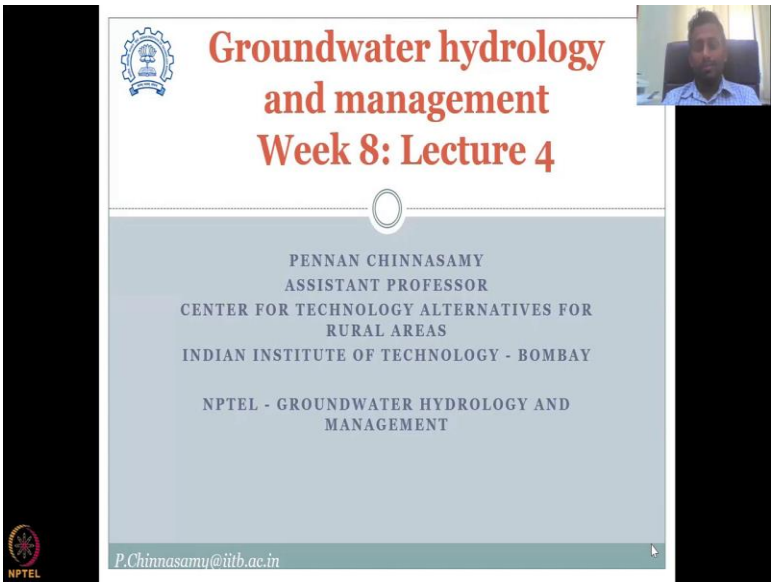

Hello everyone, welcome to NPTEL course on Groundwater Hydrology and Management. This is week 8, lecture 4. In this week, we are in particularly looking at the well types, the pump types and how to access water from the ground. The previous classes we also looked at how you construct wells and how do you extract the water. So, for the extraction of water, pumps are very necessary. In this class we will look at the pumps and also how or what type of energies are available for groundwater pumping.

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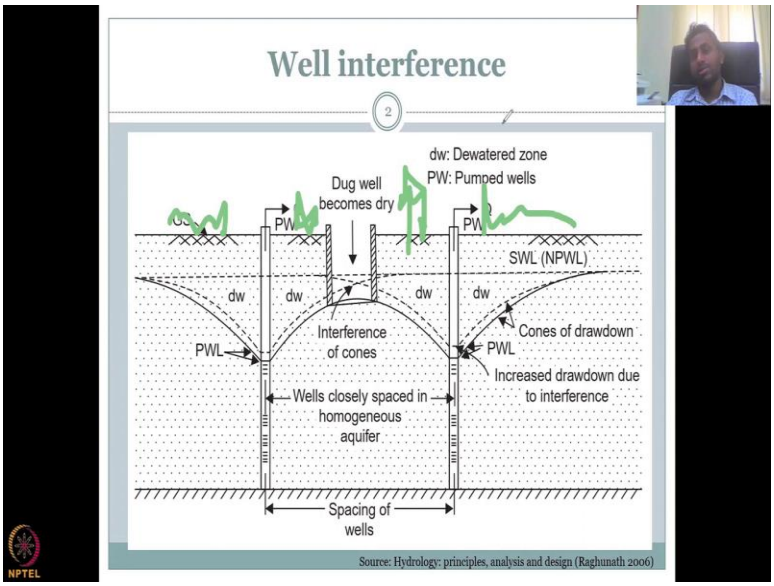
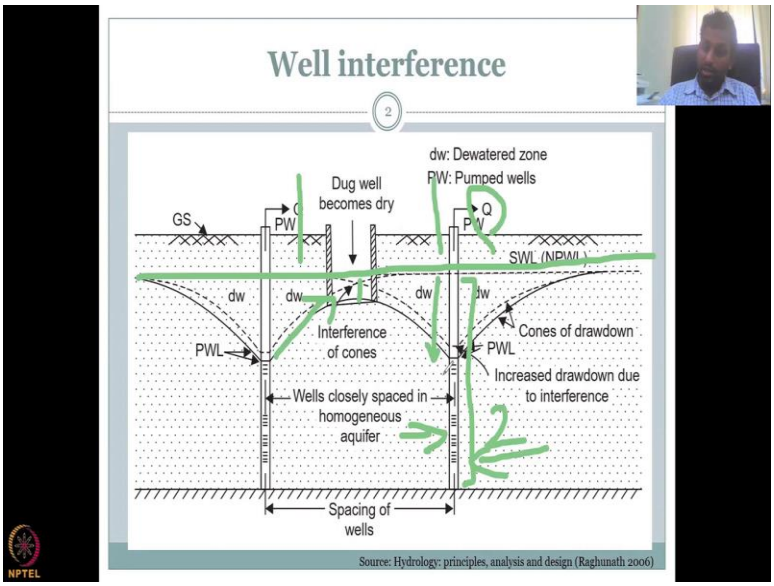
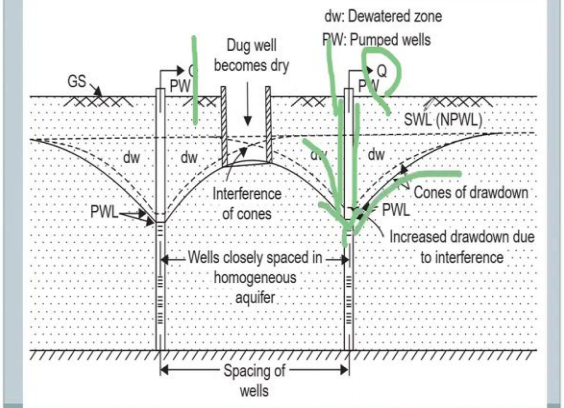




Well interference

2



Source: Hydrology: principles, analysis and design (Raghunath 2006)

Well interference

2

dw: Dewatered zone
PW: Pumped wells
Dug well becomes dry
GS
Q
PW
SWL (NPWL)
dw
Interference of cones
Cones of drawdown
PWL
Increased drawdown due to interference
Wells closely spaced in homogeneous aquifer
Spacing of wells

Source: Hydrology: principles, analysis and design (Raghunath 2006)

Well interference

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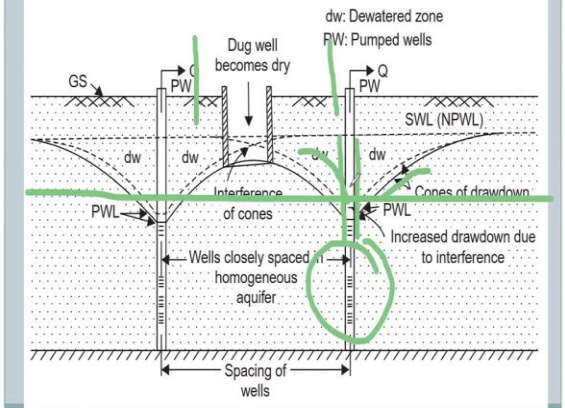

Source: Hydrology: principles, analysis and design (Raghunath 2006)

Well interference

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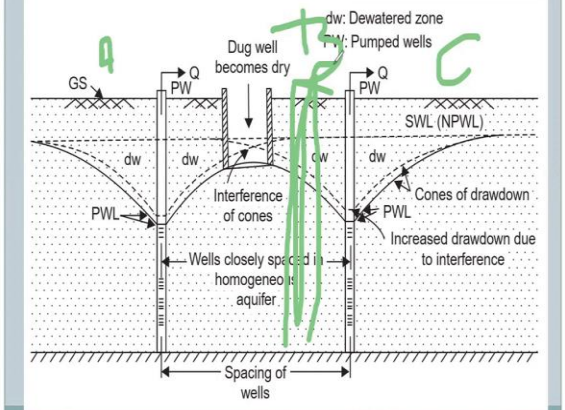
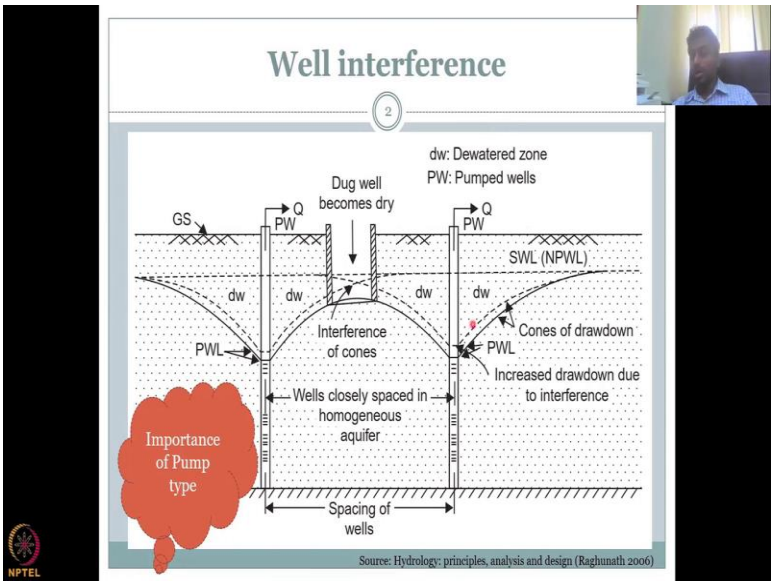


Source: Hydrology: principles, analysis and design (Raghunath 2006)



Before that, I would like to show you something called, Well interference. This is very important when we have multiple wells or different type of wells nearby. In the previous class we looked at dug wells, driven wells and then bore wells. However, in the last part, we also look at how we have dug plus bore well, which means you have a dug well and underneath that you have a bore well.

What you see in this figure, is a dug well and a bore well separately spaced, not as a dug cum bore, but they are nearby. The ground surface is GS. The pump wells are, pumping wells are PW, and this well which has become dry that is why people would go to the bore wells. So, this is a classic scenario in India, where you have a dug well which is being used prolonged and maybe unsustainably and so, the water level fell down. Once the water level falls down the farmer would invest in a bore well not a dug well, because already the dug well is dried which means there is no water for further extraction in the shallow aquifer.

Let me just draw the shallow aquifer so that we know where we are. So, this part until where your dug well is maybe we could assume it is the shallow aquifer and the unconfined aquifer. Below that goes the deeper aquifers or the confined aquifers. And that is where the bore well runs, if you see it runs throughout until a long distance and maybe it is to a confining layer that you see on the bottom. So the question here is why do these wells go dry first? And is there an interface between the wells or is a farmer safe when another farmer puts a bore well nearby?

Let us first take the classic example of all this is one farmer, only one farmer and he or she is having only dug well. So, this is a classic scenario. So initially there is water and every year since it is being used and maybe the current year does not have enough rainfall or enough water to recharge. So, you might have good rainfall, but if you are exorbitantly using it, using it unsustainably, then you run out of water and that is what is happening.

So, if you look at this scenario, you are actually depleting the water or the recharge is not low, is not high. So, what happens is water just keeps on seeping into the well and then the well just recharges or discharges it outside the well in terms of it goes from one well to the other well or it goes into the land. So this is a water loss to the well and well goes dry.

This is the first and every three months well went dry. What will the farmer do? The farmer will just abandon the land and say next time I will make sure the water is available or the farmer goes to, with extreme measure do put a bore well, which happens normally to save a crop. So, you have crops here growing. So, you want to save the crop. So, you are actually investing in a bore well, which is not going to take a lot of land you can look at how much land it is taken.

So, now what has happened is this bore well will keep on decreasing the water table and because of that, your shallow aquifer recharge will not happen much. So, even though you are having it in your same field, now, your shallow aquifers are not this dug well is not going to be recharge optimally, because you are pumping at a very very high rate. And normally when you put up bore well and you see a lot of water people just keep on using it without sustainable measures like drip irrigation or something.

At one point it just goes dry and then this wall also goes dry, your dug well is not going to recharge that fast because all the water that could have come from your deep aquifer recharge may not come now. So for example like this, this is the first case. The second case is a very interesting case. It is because your land is very small in India, landholding size, per farmer is approximately one hectare, if we go back to the notes.

So what happens here is in between your field, or between farmers, there will be multiple wells. So these wells cause an interference in your dug well and that is what we are going to see how one well influences the other well. We have also seen this in the induced recharge, but there is a

zone of interference which depends on the aquifer first is what type of aquifer you have. And then it depends on the power of the pump, how fast you can take the water out.

And third is the amount of water in the aquifer which is also a property of the aquifer and the pumping speed. So, the remaining water pretty much influencing the other wells. So, initially this was your water level. Then what happened the dug well is there and it was having a slight water thickness of H1 on this let us keep it one here. And then these guys were having a big water table of 2.

Now, what has happened is you have different hydraulic heads in terms of accessible hydraulic head, because here the well runs deep so, you can take all this water. However here the dug well it is very shallow. So, the thickness of water in the well is very small. So, what has happened is, if this guy is pumping Q and this farmer on both sides or maybe the same farmer is pumping at a very high rate of Q, then what happens is your water table falls down as a cone of depression because your this your pumping rate is much much faster than your natural recharge rate.

Your natural recharge is what goes into your dug well. For example, you have a dug well and then you have a pump, when the pump is taking the water out the dug well goes dry. However, in a bore well not only the well goes dry, but the suction the pull of this pump would cause water to move faster into the well. So, that is why you see because of this pumping, initially the water table was this high it went to a del h. And then from there, what happens is it does not only take the water which is in the surrounding, but also pulls the dug well water before it was dry.

You could now, I will erase all these things to just show you the initial dashed lines, the initial dashed lines were the initial water level and then when you start pumping, and here the water may be pumped or may not be pumped is not relevant here. Because what has happened is this water table goes down not because of the pumping of the dug well but because this pump has been pushing pulling water and same as the other pump bore well from a very deep aquifer.

It is in the deep aquifer and the connection is there the shallow aquifer water will still be pulled. Remember I said most of the bore wells do not have a casing, it is too expensive to have casing, which means all this area is available for this water to push into the well and then get sucked out due to pumping.

So, this constant pumping this high pressure pumping would mean that water would be pulled out of this aquifer at a greater speed. Because of that not only the aquifer depth decreases, the water depth decreases, but also it pulls the water table associated with another well. So from here the water comes down. And that is why your water table comes down how and the most critical part is it comes down below the base of the dug well, once it goes below the waist of the dug, well there is no recharge, the dug well becomes dry.

So when you go to field, when you see all these big dug wells, very dry, you should look around and see if there is any bore well which is pumping at a very high rate. So this connection between the shallow intermediate and the deep aquifers is called interference.

And if there is a impermeable layer, let us say for example, if there is an impermeable layer here, then this pumping will not affect this pumping, or this water level, which is called non interference of wells. And it is the separated. However, there is no zero flow. And as I said, this is not cased, so when you are not casing the well then and you are pumping the water here in that deep bore well, then all this water can also drain. And because of the draining, the water level moves down throughout the entire area, it is not only in your well, the water goes down, but throughout the entire area, it goes down thereby going below your dug well. And once it goes below your dug well, you are done for good groundwater or shallow groundwater.

So this is the classic case in India where dug wells are going dry not only because of your recharge, the slower process, which is because of rainfall climate change, not only because your farmer as my dug well, I am not exorbitantly using I am not using too much of groundwater but because of pumping of others my well water has gone down.

And if this farmer, so this is A and C, if farmer B has a bore well then it is not much affected because when the dug well goes dry, he she will turn on the bore well and then this water is taken up, he or she I am saying male farmer or female farmer. I kindly request you all that, please also use when you say farmer, it is not males alone, there is a lot of female farmers in India especially during the phases where some farmers migrate to cities for better jobs or foreign countries for labor work. So the females are left behind to take care of the farms and that is why female farmers are also important.

So now if farmer B has also bore well then interference still happens, but at least he she will have water in the area because they will get their own share of the water beneath their ground table, whereas these guys if this well is not present, the farmer A and C are actually pulling the water from in between farmer and also lowering the water table thereby not giving access to groundwater.

So here the access to groundwater is cut, because you are blocking kind of like blocking a pipe supply through some blockage or cutting the tube and saying no water for you. So, that is what is happening you lower below the water table. And at one point, the water does not enter the dug well and thereby do not recharge.

So be careful when you do some field works. It will be very interesting to see how the dewatered zone behaves. So from initial level to a level because of not pumping in your well, but also the surrounding well. And what determines the radius as I said, what determines the radius of influence, it is dealt by the pumping speed, it is dealt by the depth of the bore well and is it cased or not, and also, most importantly, the hydraulic conductivity of the medium. If the medium is very permeable, it is easy for water to move, then you will be pulling a lot of water otherwise, if it is like cracks and hydrologic fractures, then you will not have much of a connection. So, your pumping may not be influenced.

So, this is how you should also keep a monitoring well, wherein you would keep a monitoring well, which is capturing all these dynamics rather than keeping a monitoring well here and not even in the full aquifer with saying that no no my water level okay because it is not influenced by this interference.

So interference should be a good term during monitoring. But during actual benefits of groundwater, you should try to reduce the interference or if the interference is there, communally use groundwater like talk to each other and then use groundwater communally so that everyone benefits if it is a loss, everyone takes a loss and the net loss on per person is less however, if it is profit, then everyone shares the profit equitably. So, this is what is needed in communal farming and for communal groundwater use.

Let us move on. So, this also brings us to the most important part of this week's, one of the most important part of this week's lecture, which is importance, understanding the importance of the hydraulic pumps or groundwater pumps. These ground water pumps determine how much water you access and are you accessing your area water or water from underneath another farm. And therefore, it is very important to look at these definitions and see how it fits what type of water pumps there and how they work.

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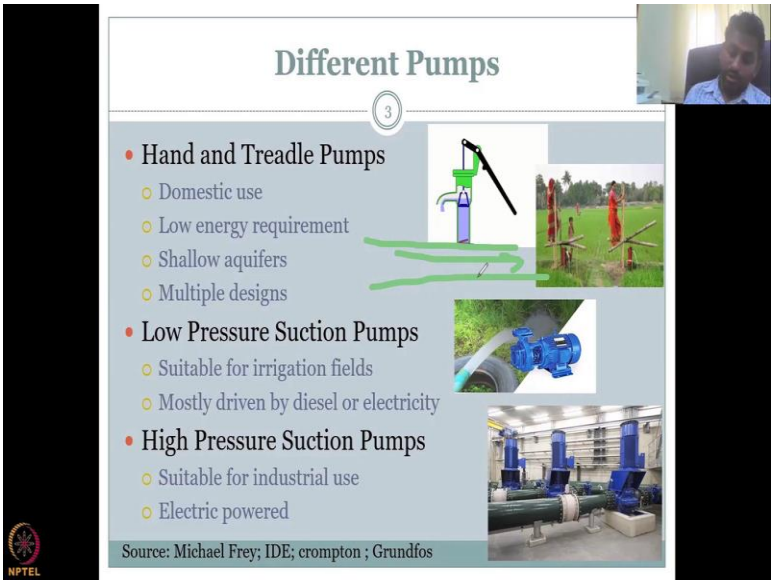

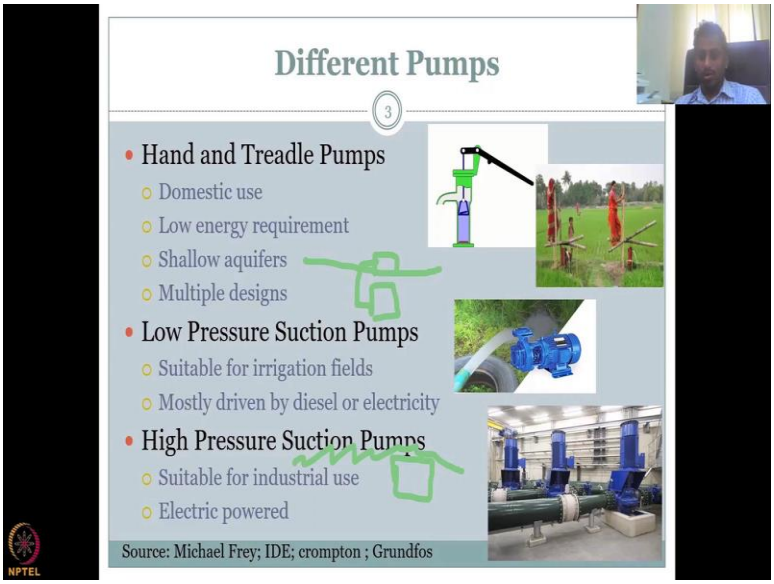

So in India, there are mostly three types of pumps there is different ways you can create types of these pumps. I will use something which is very similar to how we started the lecture this week about the wells. What did we say the different types of wells are there, we said domestic, agriculture and industry. Same way we will be looking at pumps for domestic use, pumps for agricultural use and pumps for industrial use high pressure pumps. So, what you see here is something where a hand pump is working and it was purely manual. And this is the first set of pumps where there is hand and treadle pumps.

Hand is where you are one would have seen at least in these days, rather than using it you would have seen you pump using a handle you push up and down and that drives a system to go up and down into the well kind of an architecture. So, here you have the pump base and the cylinder where the cylinder has water and the water is being pulled up, when you push the piston down the piston or the handle and that opens these valves you can see the valve opening and this valve in the pump handle opening and so, it brings up the water raises it through the mouth or output valve.

It is a very simple design not much energy used except your manual hand power and it has been very successful to prevent losses also, because you do not have leakages much, because only when you pump you take the water and then you use it you capture it in your buckets or vessels and then take it home. So this is for domestic use and very small low energy use. The other thing is it is low energy requirement. It is at a shallow aquifer, which means the aquifers or should be very shallow to bring water from the underground aquifer easily using a manual power it also has to mention that the water level is very high in the aquifer. So, you can easily tap it.

In some systems you could see that you have a pipe running underneath these wells. So a pipe would be running underneath and then water supply would be going and this water supply can be pulled up using these pistons that was given in before the pipe supply was introduced to tap supply or tap to each house or each street you would have a hand pump for each see each street and those people would line up and then when the release of water happens in the pipe, you are able to access it.

So the next one you would see today is the Treadle pumps, which is also a very common in shallow aquifers. And how it works is either you pedal it so instead of pushing by the hand, you

pedal up, down, up, down and the lever goes in and pulls the water up and then goes down, pulls it up goes down. So, similar fashion but instead of pushing it by hand, you would be pushing it by your legs, you have to walk up and down, it is a simplified version and those who could not do the, pushing the piston which sometimes may take time, you can just walk on these treadles and this is similar to your treadle instrument in your exercise in gyms.

You have these in the gym where you would stand up stepper or we call it, it goes up down, up down and then it pulls up the water in this case. There are multiple designs for hand pumps and treadle pumps, you could look at IDE and other sources to get more about these pumps.

Moving on the next set of pumps we will be looking at is low pressure suction pumps. And these are the ones which are used in shallow aquifer irrigation fields. So, these are suitable for irrigation fields, groundwater for agriculture, and it is only or mostly for your shallow to slightly bore well configurations. This requires some excess energy which cannot be done by hand. So, you go to your diesel or electric pumps.

Nowadays you also have a solar but I would show you some figures which actually says that electricity is the biggest consumer or a bigger supplier for these pumps, the irrigation pumps across India followed by your diesel pumps and then solar et cetera. So, you still are using diesel powered pumps or fuel powered pumps to extract the water and one such technique is a centrifugal system where it spins and creates a lower head compared to your head in the well. So, then what happens water flows from high head to low head and because your pump is creating that low head at a very faster rate the water would come from down to up and then starts to be used.

It is kind of tricking the system that the head is lower in the top whereas normally with elevation your head is at the highest but the centrifugal pump actually works on a physics principle to trick the system and say that now the head is lower and water comes up. There are other suction pumps also where it creates a suction and then you pull it like your straw mechanism that you have in drink you suck water out. So, same way your suction pumps. Most importantly to reduce your centrifugal pumps energy of these pumps energy requirement, sometimes a pump is not kept at the land but also inside the water or also in between the well.

So in terms of clarifying it, in terms of this is your land and instead normally the pumps are placed here, a pump house is there, you can turn on the pump, and then it waters the feed. But in some cases what happens is your pump can be placed in between the water level. For example, this is a water level, it can be placed in between the water level and land or inside the water when you place it inside the water, there is tremendous energy consumption losses reduced and the electricity bill is much much reduced.

However, there are some other issues the quality of the fuel and also how the water is pulled there are some issues in putting it in a submersible sediments et cetera. So, it depends where you are, what type of aquifer you are using, and how you would like to discuss the groundwater pumping. So, there is centrifugal pumps and then we would look into other pumps quite soon. The next pump if we move on is the high pressure suction pumps. So, these are high pressure, it has built a pressure and the pressure sucks the water out.

And suitable for industrial use electric power, mostly electric power, it is very suitable for industrial use, where they use mega mega water budgets compared to your agriculture. And compared to your domestic use. Remember agriculture we use is, if you waited by the crop area and how much water we use, it is smaller than the industry. However, because of the number of pumps and the number of acreage that is covered by groundwater, we call groundwater as a second highest consumer of water, whereas the private agencies and industries, factories, those wells are considered lower than the agricultural water use. So there is, there could be some issues on understanding the water budgets at industry level.

For agriculture, it is easy, you can have water on the field, you can calculate the area of the crops and also understand the crop type to get how much water has been pumped. That is not the same for industries. Industries, you do not know the efficiency of how they use water, there is no return flow, for example, you are applying water on the ground in the field, it can go back to the aquifer, that does not happen in the industry. So, it is very important to understand these facts and how the government supports these multiple schemes.

We will get into the energy consumption of these pumps and how the government supports these kinds of pumps in the next lecture. I would see you in the next lecture. But please have time to look at the different pumps because in the next lecture, I will be showing the distribution of

energy across India, and what type of subsidies are given for supporting these pumping activities. I will just give a quick a teaser of the next slide which I will be starting to discuss from other week. Sorry from the next class.

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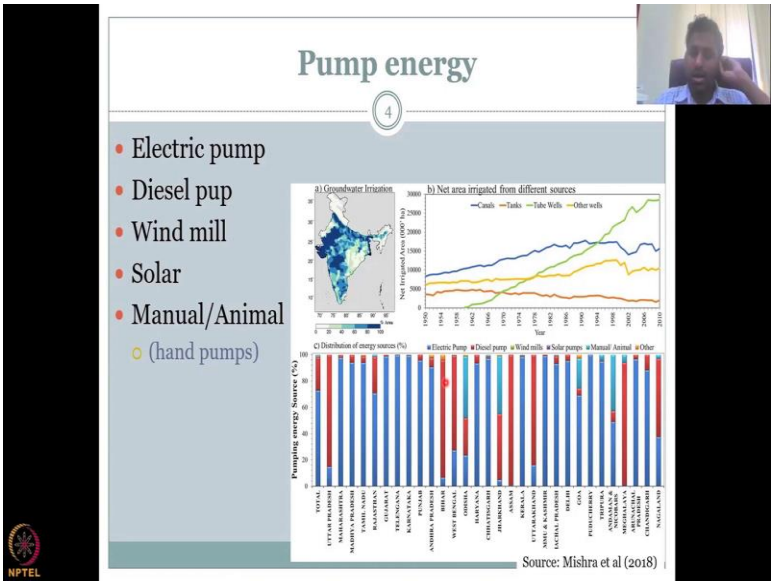

Yeah, this is what I will be discussing. What are the key energy types available? And why is there a different pattern between the states, think about these. I would like you to think before the next class rather than me jumping into these descriptions. So that it makes you think.

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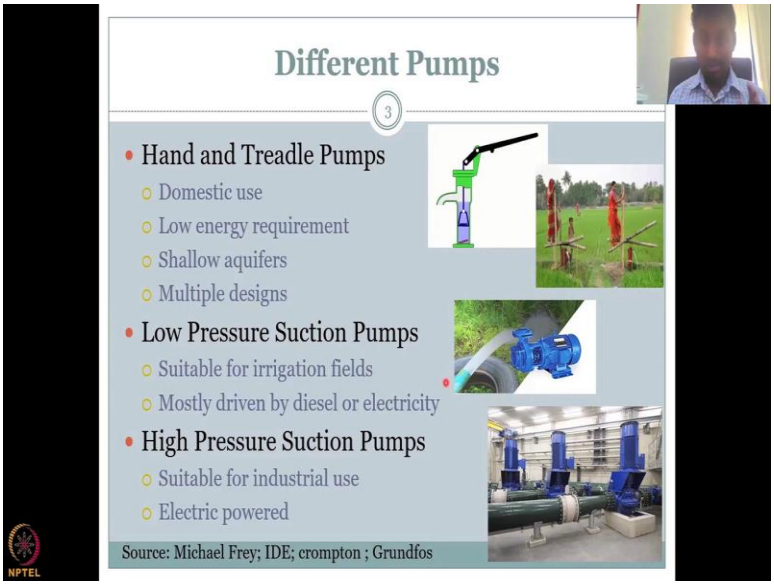

Now you have seen how the water interference can happen, how the pump regime can influence their neighboring land. But most importantly, now you know what type of pumps are there for the different key wells we discussed, domestic irrigation and industry and what type of mechanism or energy that is needed, you know the energy need, then think about government plans which we certainly discuss in this week's lecture. With this I will stop today's lecture. I will see you in the next lecture. Bye.