**Groundwater Hydrology and Management**
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**Lecture 05**
**Energy for groundwater pumps**

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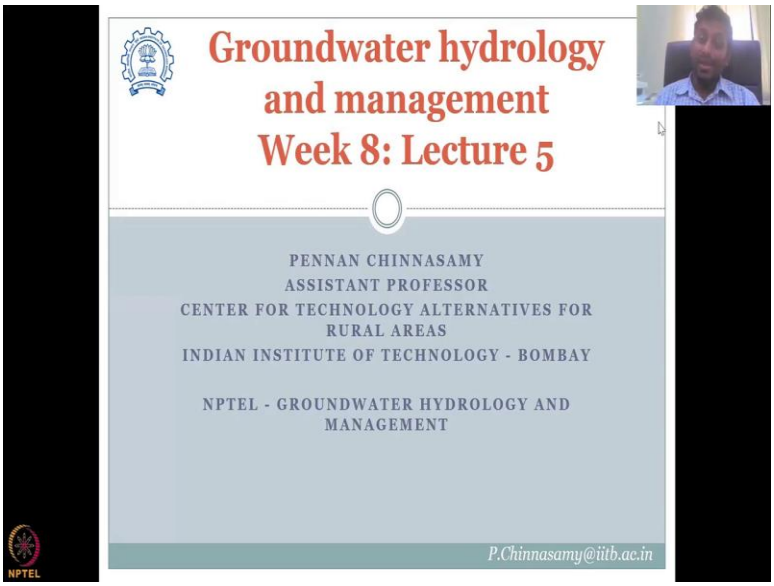


Hello everyone, welcome to NPTEL course on Groundwater Hydrology and Management. This is week eight, lecture five. We have come to the end of the week eight where we discussed about the types of wells. What are the issues between the wells, what type of construction is in the wells and finally, what is the pumps that are being used. In today's lecture, we will look at the source of these pumps.

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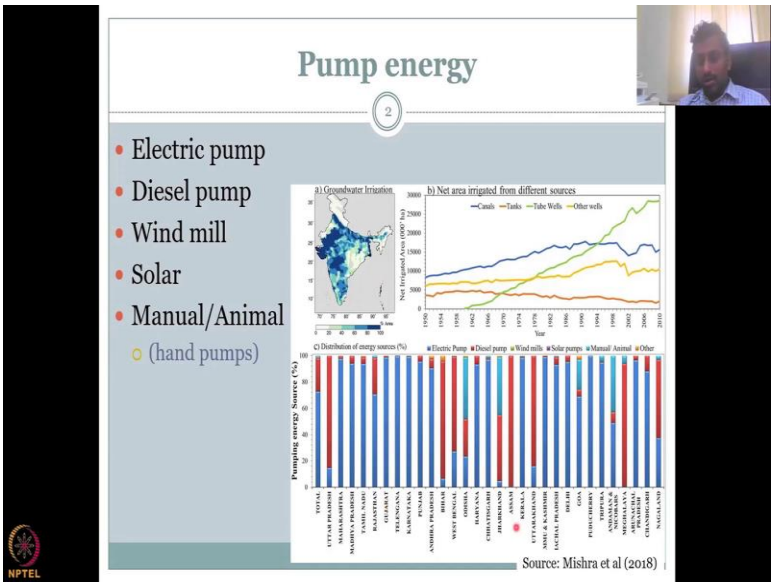


Pump energy, this study has done a very good review of all the states in India or most of the states in India where agriculture is predominantly a livelihood option. And they have made a map about groundwater irrigation what they mentioned is from 1950 to 2010 the change is happening in what water they use for irrigation. Again, irrigation is only during the Rabi and winter crops, which means, there is water being pumped or used by surface dams and other resources to supplement the water for irrigation. It is not by rainfall.

So, that is the understanding which is why you do not see rainfall here. When you say irrigated, you are applying water by using a different means, and by spending energy to be gravity also when you call about canals and dams. So, you have your canals, which has been increasing steadily but then it started to taper off because that was a big dams era, a lot of dams were built, but after a lot of dams are built, there is not much space options budget that you can use for dams.

Then you have tanks which is also a surface water body, not much increase and it has been almost coming down or stabilizing. Whereas your tube wells and other groundwater wells have been increasing steadily the tanks is in the orange line, whereas your other wells is in the yellow which starts to go up and come down most probably, but your green line shows a very steady increase which means a lot of tube wells, bore wells that we saw in the previous lecture have been used.

So, where does the energy come from? That is the last figure that you have here. It says about distribution of energy source as percentages of the total which is very interesting in India, of the total more than 75 percent of the groundwater irrigation is done by electric pumps. Where is the energy coming from? How sustainable is the energy is all these questions? Please do not mix electric and Solar Pumps, because those are totally two different entities here when I talk about electricity, it is mostly by the power which is generated by coal or nuclear power that is being supplied to the public by the government.

So, you have these bifurcations and you could see that most of the groundwater irrigation is by electric pump followed by diesel pump which has been predominantly the pump in the olden days. And then you have little bit of manual or animal which we saw the treadle pumps in the previous lecture. So, those pumps are available. So, what are the different energy sources? You have electric pumps, diesel pumps, windmill, solar, manual, and animal hand pumps.

All these are very important for your groundwater irrigation. Windmills are the wind generated electric power which comes and takes your groundwater to a higher level for irrigation, solar pumps are there and manual animals. So, even though the wind and solar converts the solar energy or the wind energy into electric power, we are not mixing them as electric pumps.

So clearly electric pumps are the pumps which get electricity from the grids and the grids are supplied power by the centralized power stations, which could be called power station or your nuclear power stations. So, in India most of it is 75 percent of it is from your pumping source which is electricity and then the remaining percentage mostly is diesel. So, I would say diesel and electricity are the most important sources in India 75 and 25.2 percent is a very, very less percent for other sources.

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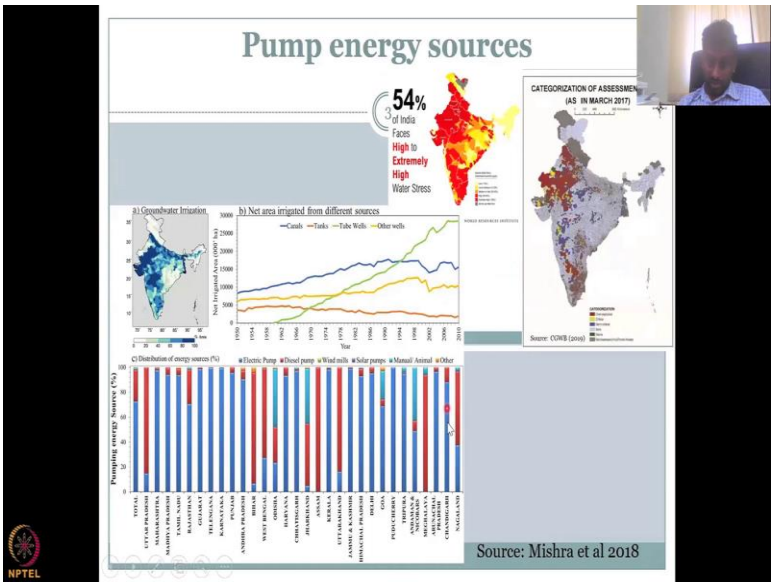


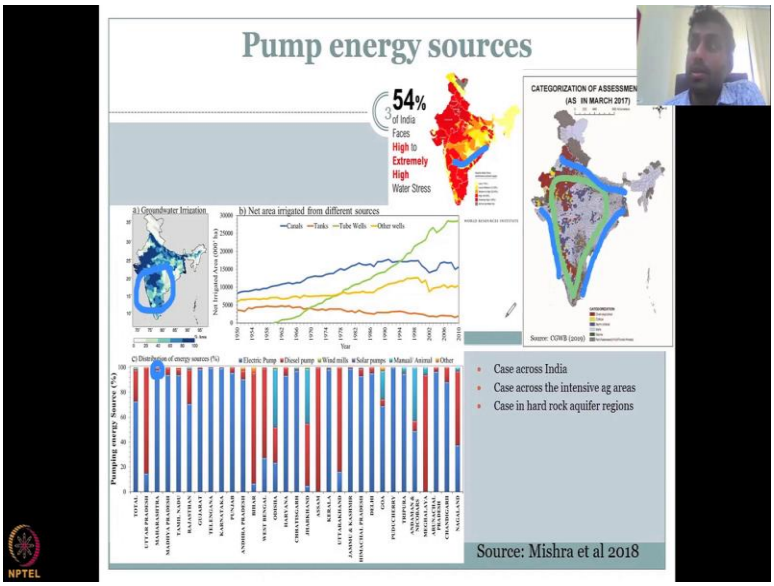

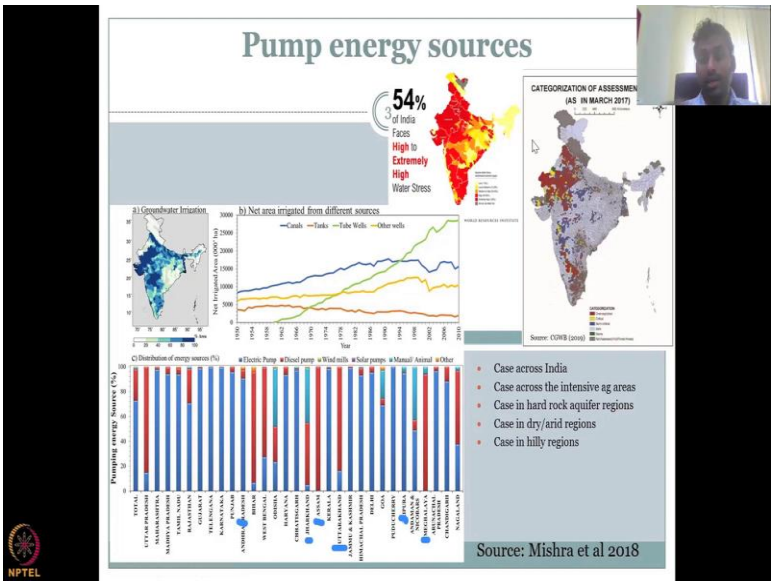


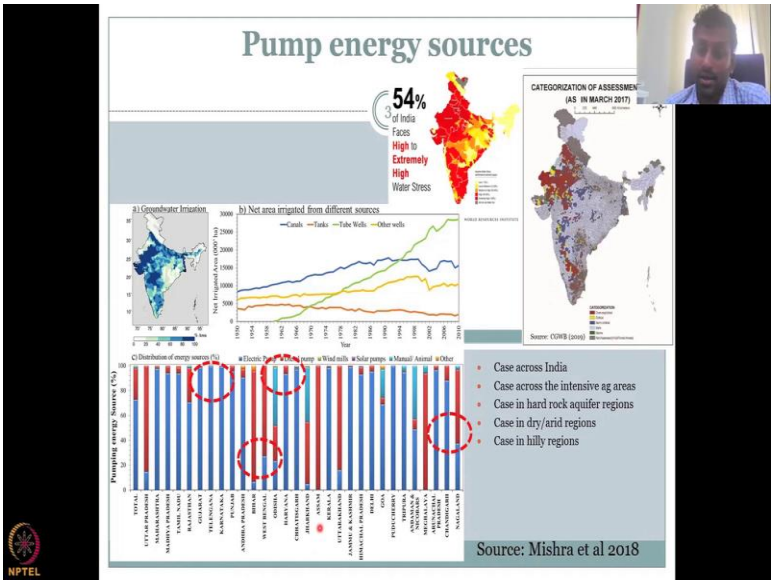


If you look at these states, individual states before we jump in to the where water is being scarce, if you could look at mostly the regions where you have good access to power they have electricity. So, you can say Delhi and then wherever you have good power stations, Madhya Pradesh, Tamil Nadu you have a nuclear reactor. So, all and add coal plants. So, you have a lot of power from electricity, very less diesel. So, electricity on one hand is good for because it reduces the pollution et cetera, but at one end where the electricity is being generated there is pollution.

So, for example, Neyveli is the coal, you know a thermal power plant in India powered by coal, but then it distributes to two, three states the energy. So, all these can be taken into account. Most

importantly what you other see is in regions where there is less electricity and accessibility to electricity like high elevations and stuff there your diesel pumps have worked well, Meghalaya, Bihar, Assam all these locations you have a good exercise, but before we look at the pump energy sources, it is important to compare this data along with the water stress by WRI and the CGWB groundwater maps.

See the paper diagram that we see here all these wherever ground water irrigation is high percentage of area almost 100 percent of these areas are using groundwater that is also the places which are highly groundwater depleted as per CGWB. So, there is correlation between the studies there are three studies here. One is a study based on groundwater data and irrigation data statistics from the Agriculture Department, where it talks about what is the water used for irrigation and what are the acreages that is done.

So, here almost hundred percent of your area is dealt with groundwater irrigation, whereas if you come here, it is very less amount of groundwater irrigation on these sides, you could see that but mostly your red matches with the blue in the Mishra et al paper and the CGWB data clearly shows that the groundwater extraction is more than the recharge. So, it is a critical phase for groundwater use.

And then we have the water stress indicator which sees that almost all these areas where the groundwater irrigation is happening, there is high to extremely high water stress happening and going to happen in the future scenarios. So, the pump energy sources tells a lot about the government plans the subsidies that are given for groundwater access, and also is it sustainable or not in the long run.

So, case across India, which is the total percentage as I mentioned is 75 plus percentage is used by electricity whereas your 25 percentage is used for your other resources especially your diesel pumps and case across intensive ag areas, which is these are the intensive ag areas but that is why you have 100 percent ground water irrigation. So, these states Punjab, Rajasthan, Gujarat, if you see that all of them are using tremendously electric pumps, tremendous power and also a lot of groundwater use you look at Punjab, Gujarat, Rajasthan. Punjab, Gujarat, Rajasthan all same story, Haryana also.

So, is this sustainable it is not, then you come down to the southern India where you have some pockets of groundwater irrigation, which are also matching here, Tamil Nadu, Karnataka and Andhra regions, you have good amount of electricity Tamil Nadu also, yeah. So, this does not look good for groundwater irrigation, because you are just exploiting the groundwater Tamil Nadu here. So, you are just exploiting the groundwater because you have good access to electricity and also you are not concerning about how to use water well. So, water is just extracted and then used surplusly.

Moving on, let us say what are the case in hard rock regions and which is very, very important for the groundwater lecture, we saw that all this central India let me draw it roughly for you, this central part of India has hard rock aquifers whereas your alluvium aquifers are here along the coast et cetera. So, in between is where your consolidated aquifers or hard rock aquifers are there and if you look at this region, where you have extremely hundred percent groundwater irrigation, you could see that Maharashtra is there.

Maharashtra yeah electricity is high, almost 90 percent electricity is given for pumps so, remember that electricity is much easier to take, especially with the rural electrification program, and other schemes by the government, it is easier to take it to the field rather than buying diesel, taking it to the station, refilling your diesel tanks and bringing it to the field.

Think about how much expenses it is, rather than you just pull a wire from your grid and then you start your irrigation. So, with, with appropriate permissions, I am saying so, electricity has given the ease of access to groundwater and the pumps are becoming very, very efficient. So, there is tremendous use of groundwater, but is it sustainable is again the question which from these figures, you see it is turning red it is not sustainable and the water stress data also says it is not sustainable.

So moving on, what is the other case you would like to see is the case in dry and arid regions such as the Rajasthan belt, you could see in Rajasthan, they use a lot of electricity but mostly also diesel because there is not much electricity availability, good quality may be there. So, for that, there is some diesel pumps. Important as I said, case, in the hilly regions of Meghalaya, here, let me just tick it for you. It is on the same page, Tripura, has a lot of electricity, maybe

hydropower, but you have your Meghalaya, Assam, all these places, where it is tremendously done by Uttarakhand, Jharkhand, Assam, Bihar, all these places have more use of diesel pumps.

And diesel, it is not because diesel is cheap there, it is much easier to take diesel rather than electricity because of the quality of electricity. These high hilly regions may not have good electric supply in terms of quality to run the pumps remember that you should have a stable connection and the power supply should be good to sustain the pumps otherwise the pumps would go into repair it will burn the coils will burn if too much power is there. And or if it does not have enough power, it will suffer it will not pull the water out.

So, that is what we will see here Gujarat, Telangana, Karnataka, which are the predominant agricultural states including Tamil Nadu you see a lot of water is being pumped by electricity whereas the hilly regions of Bihar, West Bengal or the east the eastern regions Odisha you have less electricity but more diesel pumps and manual and animal are mostly available in the regions where the water depth is shallow.

For example, the Andaman and Nicobar Islands, the Odisha and Jharkahand. Jharkhand would have a very shallow aquifer because of the hilly terrain; all these places have very less. Windmills, Solar Pumps are coming but not as much as we needed. So, that is a neat statement for the next future steps for the government to see can we have a renewable, less environmental polluting agents that can help irrigation with good power supply.

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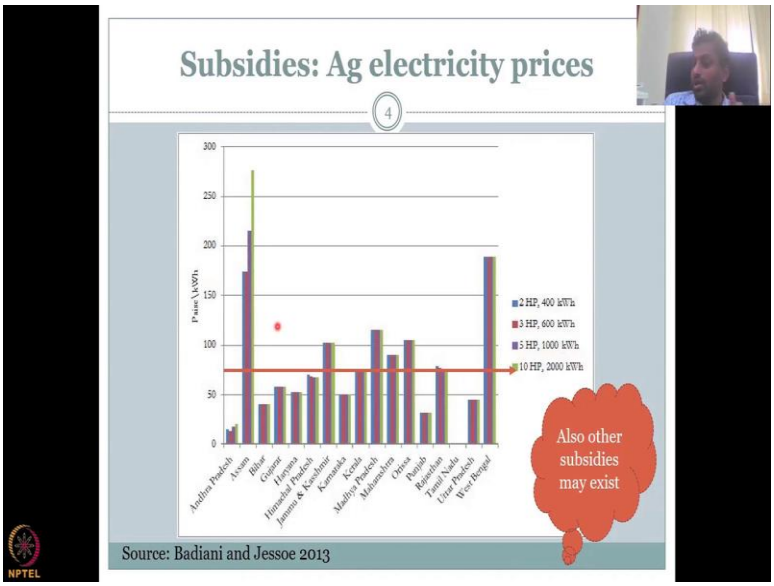


So, to occur this as I said, not only that the availability of power and availability of pumps have helped the groundwater irrigation in India, but most also the subsidies that are given by governments state and the central, not a lot of people talk about this, because it becomes very interesting topic when we debate on how the subsidies should be dealt with. So, if you look at this, there are some states which give good subsidy and no subsidy for example, Tamil Nadu has given a lot of subsidies for electricity and that is why you do not see a price.

So, the farmers might have different pumps as I said, the pumps would differ based on the construction of the well, dug will driven or drilled and also based on the use of the well which is domestic irrigation et cetera. But in this irrigation aspect, all this is agriculture. So, the well also depends if it is dug, driven or drilled, which means deep aquifer or shallow aquifer and the acreage what crops they grow.

So, if you look at it here, the most of the state governments have a same price for all the different pumps if it is 2 horsepower or 10 horsepower, how much they use is we do not care about the pump, but you just pay 50 price for example in Haryana 50 price per kilowatt per hour which means at any pump you use is fine for us most of the states are like that, except Assam puts a big price on the 10 HPs because it consumes more power more demands high quality power 2000 kilowatt power.

So, with this, you can only see that it is not the same across India and that also drives the groundwater use and access across India. So, if I say this is the average the average price state has to pay a state farmer has to pay is around 75 price per kilowatt hour, I could see that most of the states are below that line and I picked this just looking at qualitatively looking at the graph this is high, this is loss of somewhere around 75 price.

But then if you look at most of the states, three-fourths of the states, maybe going up slightly, but most importantly Assam and West Bengal demand more price for the pumping. Whereas, there are other states which take very, very less. So, for example, Punjab, Tamil Nadu, Bihar, Gujarat, all take less and interestingly, these are also the same states that have high groundwater depletion. So, on one end, there is good supply of electricity for example, Tamil Nadu we have the power stations, both coal and nuclear reactors.

So, there is good power supply, which aids more groundwater use. However, there is also a lower price for the power that is used for agriculture. And that is where most energy would be used for ground water. You cannot get diesel cheaper just because people use it for agriculture. It is easy to use it differently. You say that, no, I have a diesel pump, I will buy the diesel and use it here in the diesel pump for agriculture, but you can always leak it use it for others, whereas a power line, a power line will go to your to your farm, and there the connection is taken.

So, thereby you are reducing the point of tap but still you would see some people building a house right next to the farm. And then they lose a boat the same connections together, but it is not going to be a big theft, it is small, small electricity thefts to occur. But the point here is there are subsidies and because of subsidies there is more groundwater irrigation as per the maps.

Other subsidies also may exist for example, crop subsidies, fertilizer subsidies, seed subsidies, horticulture subsidies, et cetera, et cetera. Labor subsidies, Montreal money is used for some states as labor subsidies, et cetera. And these improve or increase the acreage for groundwater irrigation is this sustainable or not, is the question. You have money to put more crops per area, you have the water, is it sustainable? Can you do it now? And can you do it every year is the question.

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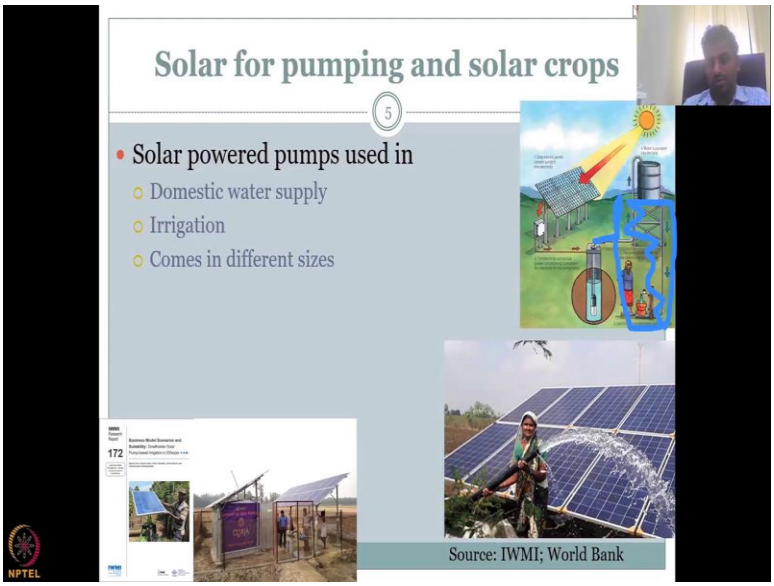


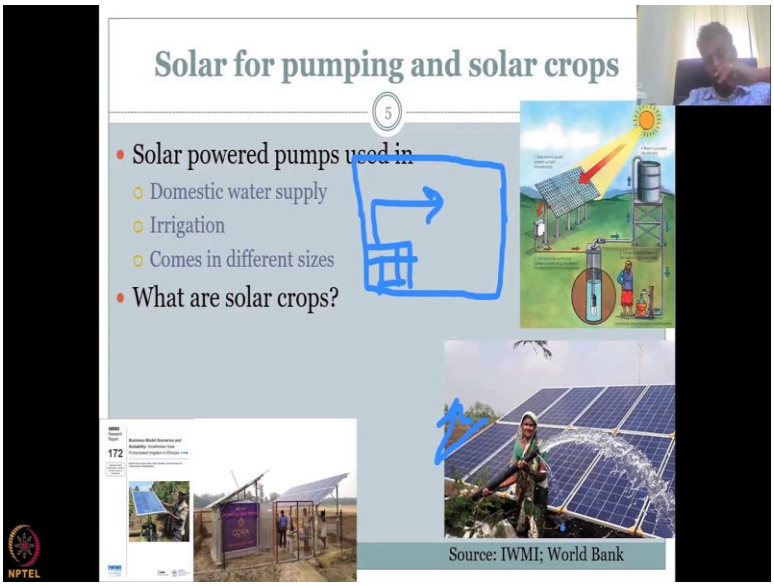

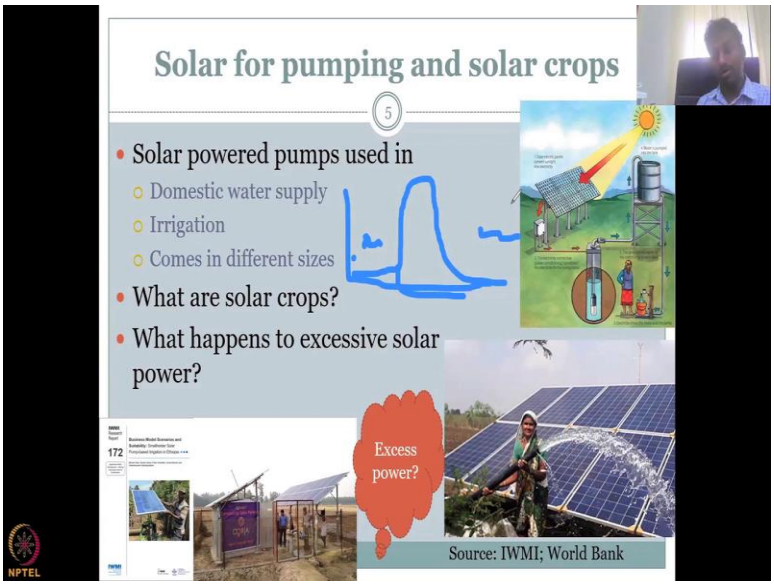


So, I will discuss one important aspect about renewable energy for solar for groundwater pumps, which is solar for pumping and solar crops, this concept is pretty much pushed a lot in Indian government, through the NGOs, like IWMI, Oorja, et cetera. Let us see what it is. Solar powered pumps used in domestic water supply irrigation, and it comes in different sizes. So, take an example, from the World Bank blog, you have solar, which is being used to generate power through solar panels, it goes into these boxes where it converts the power and then runs the motor. So, here is the pump which pumps the water into a tank and it is used for domestic.

So, if it is not used for domestic if you do not have a tank, just draw it, you do not have a tank this water can be applied to this field. And that is irrigation. So, both ways your solar power can be used for ground water domestic use and irrigation. Irrigation not much because you have very low power Solar Pumps, but science and technology is improving. So, sooner or later you will have high pumps right now, you do not see that for industrial water use, but you see for industrial power use for example, you know these big companies would have solar panels on top and that energy is used for lighting the factories running some machinery those kind of things.

So, does this stop here because you have some solar panels and this lady as you see is using that to pump water for agriculture. And you have books, good books, which says some model standards for using small scale solar pumps for drip irrigation and conserving water, Oorja is another NGO which works as you could see for communal farming. So, all the five farmers who would come and then put money for solar power plant like this, the power is kept within the

system, you use the power you pump the water, you supply it for five farmers, which put money for solar, and you share the profits.

But what are solar crops? There is solar pumps for crops, what do you mean by solar crops. This is the interesting part where a farmer may not grow the crop, but just use the solar panels for generating power, which could be sold. Let me draw this concept. You have a land, and you put solar panels here. So, you have solar panels here. And using that solar panel, you put water into the street.

Now, if you do not have enough labor to do the farming, and or like see, you can see the farmer is a woman. And same here, there is no crops, crops are growing on the side, because your solar panels would limit the sunlight, and also the height of the plant growth, you are not going to put a couple of feet high you are going to put very low. So, that energy hits and then drives your power systems. So, this is the concept where slowly farmers are understanding that the power is good in solar panels. And I do not need that much power.

I put the panels but I do not need it every day, because during the rainfall season, what happens, you do not need solar, you do not need ground water. So, if you do not need ground water, you do not need solar energy to pump. So, here is a concept where water is used only in the groundwater irrigation season. And the remaining part the solar panels will still collect because there is sunlight, it will still collect power and push it to the grid for power supply.

And this is also accepted in modern day terms. Especially in places where the farmers cannot do farming, wage, migration or other issues. And there is a need for excessive solar power. So, what happens to the excessive solar power is a question. As I said, your demand for let us say that this is your cropping calendar, and your groundwater need is only during your groundwater season which is your Rabi season, and some in the winter.

Now, most probably from May, April to June. After that you have for example, Maharashtra I am saying April to June and after that you have good rainfall, it will be really not efficient if you have rainfall and groundwater, because you have enough rain coming. So, why do you use ground water so, at that point, your solar panels the solar panel used here and here is not much you do not use it if you are only driving a pump, but think about taking the power and putting it

into a grid and that is what NGOs have been working now, for example, IWMI. And I will show you a case study what happens with excess power.

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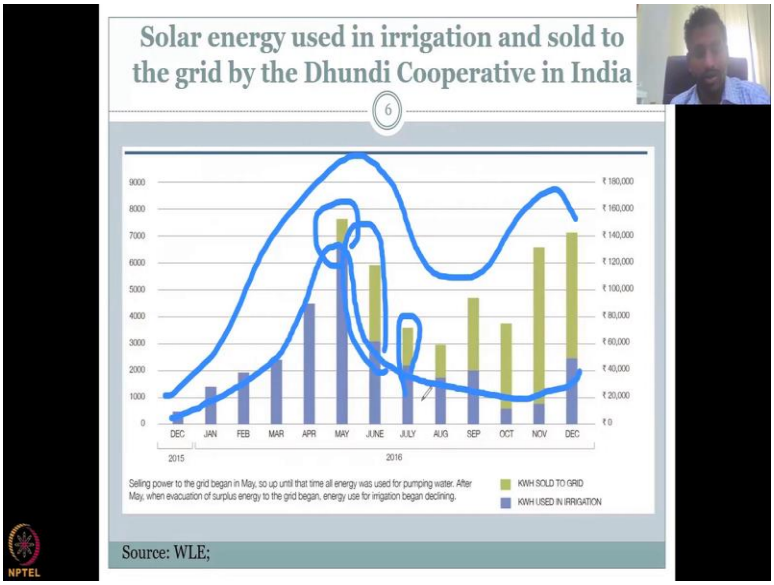


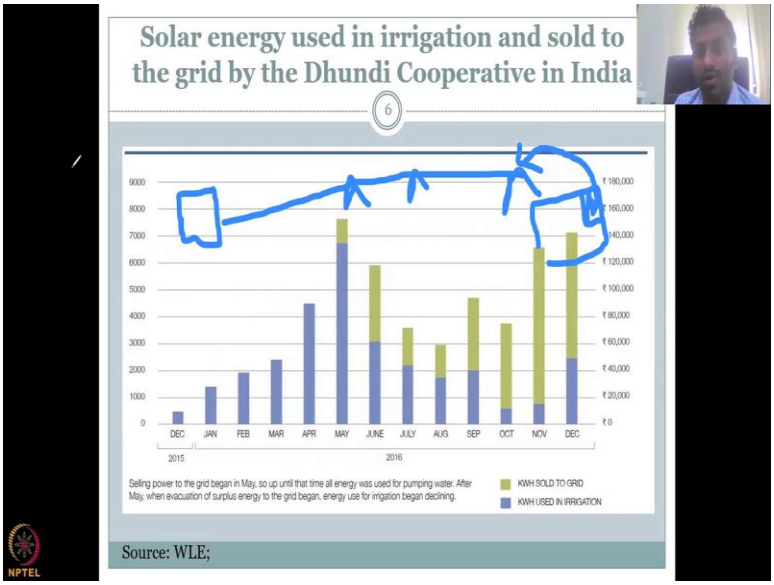

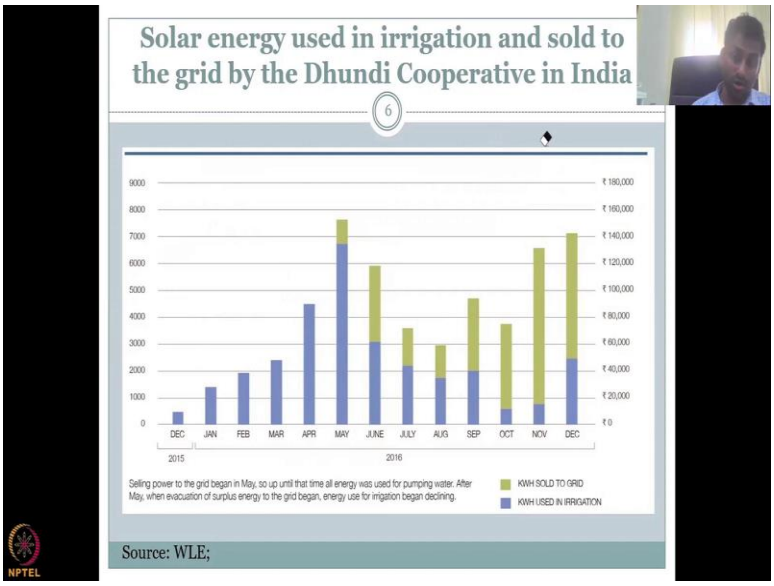


So, this is the case study as WLE IWMI which I said it is in December most of the groundwater irrigation happens and so, your use, the power use is full. So, here is your how about, how you could sell it after you take the power and what do you do with the surplus power. So, you see here that in the lean season, this is where there is no rainfall. So, in the lean season, you have all the solar power converted into groundwater irrigation, this means, the kilowatt generated is equal to the kilowatt use in irrigation, and most of the water is used for groundwater irrigation.

So, the solar panel collects the power the power is put into the groundwater pump and groundwater pump puts water in the land the cycle is closed. In May, June, July, August during your slowly your season of monsoon because June the monsoon starts you could see that the solar power is there and these are the regions where some solar power is still needed. So, the solar power partly is only giving power to the pumps whereas the remaining is given by rainfall, there is good rainfall.

So, water is being given what happens to the excess power that is generated? Why do we have the cyclic pattern, we have the cyclic pattern, because the solar radiation is not the same every month, it is hotter when you go in summer, whereas, it is not that hot when you go in December. So, depending on the solar radiation your power generation happens. So, that is why you see a cyclic pattern like this.

Now, you groundwater irrigation follows this cyclic pattern, but which is in blue, but now, there is some excess of power generator which is green, what happens to that you put it or you sell it to the grid, you give it to the grid and the grid is now connected to all the villages and cities. So, your solar power are being fed into the grid for supply.

So, initially you have somewhere there is a big factory, which is producing power and then it sends to grids, which are placed in villages. So, the power comes to grids, and then your farmers getting irrigated, but now, so, this farm is getting irrigated now, because of solar, the solar panel is there, you are putting power back to the grid, and then it goes into the cities, if but mostly in the villages, at least it will be used because all farmers may not have solar power.

So, this is how the government has included the farmers in producing power for themselves and excess power they could sell. It is like your milk cooperative, you have cows, you take the milk from the cow for your consumption, whatever is excess, you give it to the cooperative. And there is no particular rule you have to give every day one later. For example, tomorrow I have guests coming, my cow milk is only enough for me and my guests.

So, I will not sell the milk to the cooperative, it will be 0. But in other scenarios when my relatives are not there, then I would give more milk if my cow is good, and she gives more milk I give more milk. So, all these are similar patterns like a cooperative thing. And this is picking up speed for solar which is being used for groundwater irrigation and also a mechanism to generate power for the grid.

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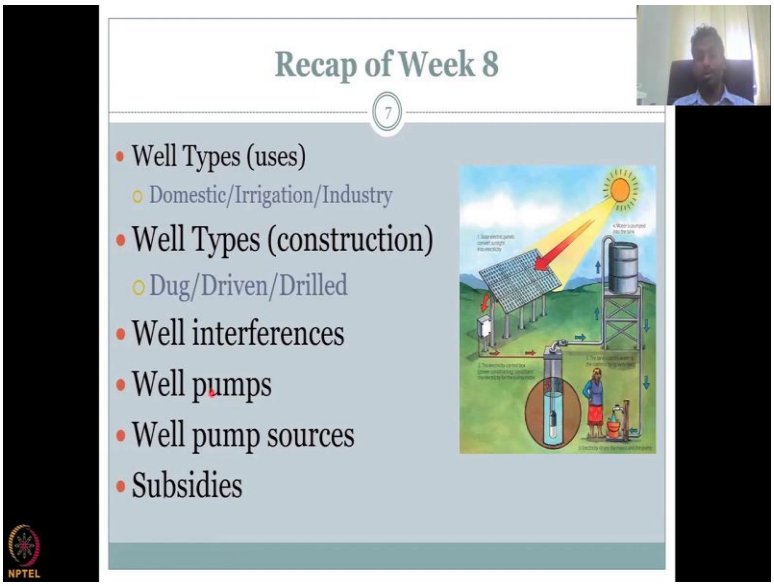


So with this, we would come to the end of the week 8, I will just recap quickly what we looked at. We looked at the well types may ranging from the users domestic irrigation and industry. We looked at the well types depending on the construction, which is dug well driven or drilled well, dug well is shallow driven as you hit lightly so, it is between the shallow and the deep aquifer and drill this you push it through a bore in a missionary and that is mostly in the deep aquifers.

We talked about well interferences, so, it is not only the well type and well use but how the pump pushes the water or extracts the water is very important for bringing down the water table in the entire village and for access of water from the wells we looked at, well pumps and what are the energies for the pumps and subsidies. Subsidies are good, but it may not be good for sustaining your groundwater sustainability. With this I would conclude today's lecture. Thank you.