Rural Water Resources Management
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Week 9 - Lecture 1
Rural Water Resources Management Infrastructure (Engineered)

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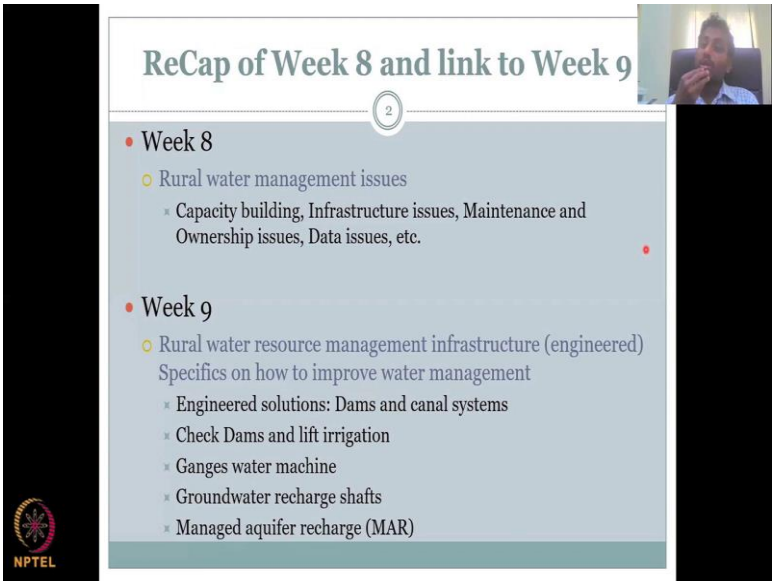

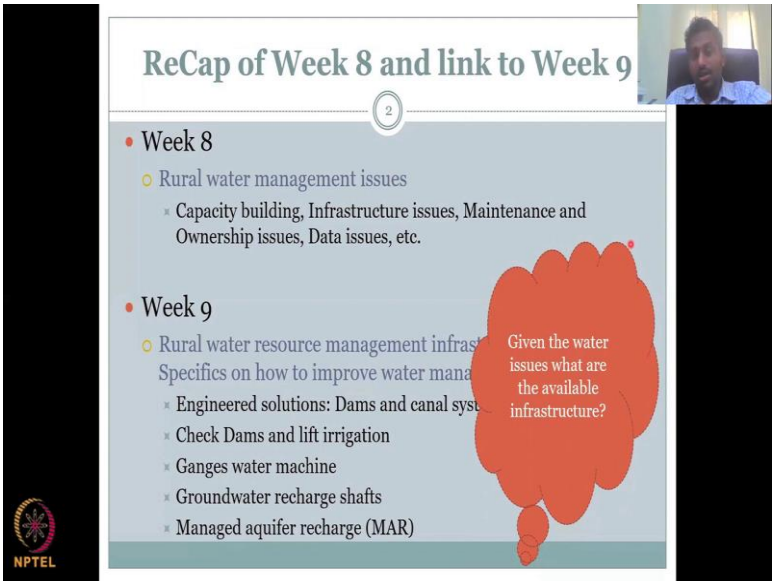

Hello, everyone, welcome to NPTEL course on Rural Water Resource Management. This is week 9, lecture 1. Let us do a recap of week 8 and what we looked at what we discussed in week 8. And then I will discuss what we are having to see in week 9, in week 8, we looked at rural water management issues.

So, what are the issues that are causing the water not to be used wisely and lack of water or impacting water security, what are the issues, we looked at capacity building, where you may have the water, but if you do not have the right people to work together to conserve, to sustainably use water, that is an issue that is called the need for capacity building and we looked at certain aspects, we looked at also infrastructure issues, especially maintenance and ownership.

We might have a check DAP you might have drop water recharge system, but if it is not being maintained and no one takes care of it, then it is not going to be efficient enough. We also looked at data issues as I say, you cannot monitor nor measure if you do not have observation networks.

Similarly, if you cannot measure you cannot monitor how groundwater or water discharge happens. And if you cannot monitor you cannot manage. So, you cannot measure if you do not have observation systems or other proxies like satellites, and if you cannot measure you cannot monitor you cannot max this is the line that a lot of researchers use to say that you cannot manage what you cannot monitor and measure. So, measuring monitoring is very very important for water management especially for rural water management.

Coming to week 9, we will look at rural water resources management using infrastructure which is engineered. So, there are multiple infrastructures available. But how do they differentiate between each other is mostly if it is engineered or a natural solution or a nature based solution therefore. So, engineer is where a lot of engineering happens, you have to clear the land, level the land, etc. Whereas in nature-based solutions, you evolve with nature you develop with nature, preserve nature, and then make it use for water resource management.

That is in this week we look at the engineered solutions, which is mostly dams and canal systems for surface water, we will also look at once you have dam the water once you have canal systems, how do you use the water for irrigation? Having the water storage is one thing, but how can you use engineering solutions to better use the water is important and that is where check dams and lift irrigation systems play a vital role.

Then we will look at the Ganges water machine as an engineered solution for groundwater management which uses groundwater recharge shaft. And another aspect is using technology to understand ground water depletion and then communally use ground water which is called Manage aquifer recharge with the program.

So, we look at all these different technologies and engineered solutions where you would either make a dam large scale infrastructure or a small scale like manage aquifer recharge, check dam or a pond that recharge ground water and you can use it later. You know the water issues, what are the available infrastructure in India? So, even before we go into the optimizing these engineered solutions, in this lecture, we would look at what are the available structures and how are they useful?

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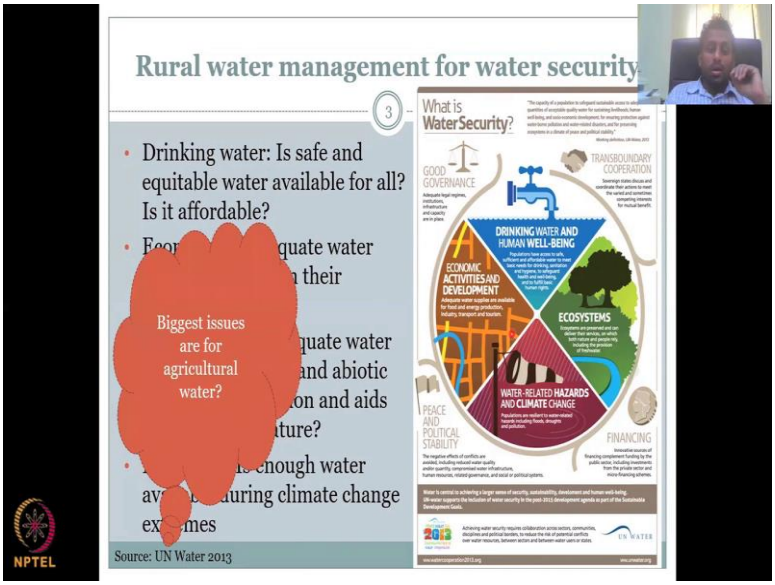

Again, I would like to re-stress the fact that rural water management needs water security for all. And water security is defined as, do we have enough drinking water? Is the water available for economic solutions based on all livelihoods? Is there enough water for ecosystem services, which includes biotic and abiotic processes and is it enough to buffer us

during climate change or the other terms resilience to climate change? We have already discussed this in detail in the last lecture, but I am just bringing you to think about this water security in terms of an engineered structure.

So, already you could see ecosystem may not be that appropriate, because most of the engineered structures have to take some parts of the ecosystem out. It could be birds, animals, could be your land, soil, forest, etc. However, it does satisfy the other things it does give you water for climate change, drinking water, economic development, hydropower, etc. You will have to balance the water use according to all these 4 things.

Sometimes you may have to say that it is highly weighted on for example, drinking water, but as I have to clear the land, sacrifice a little bit of the ecosystem. So, this is where a give and take does happen in engineer solutions. The biggest issues for rural water management and water security are for rural systems. That is see why does that happen? Why does rural system rural entities have big water management issues especially for using engineered solutions?

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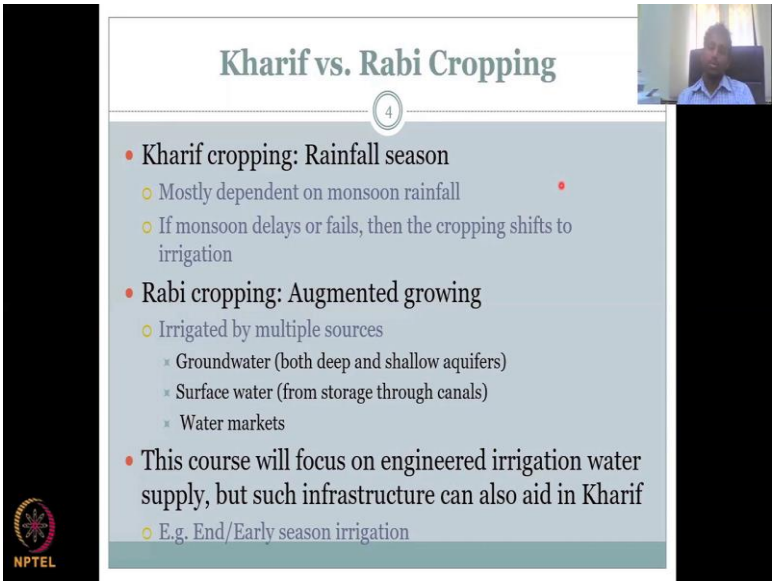

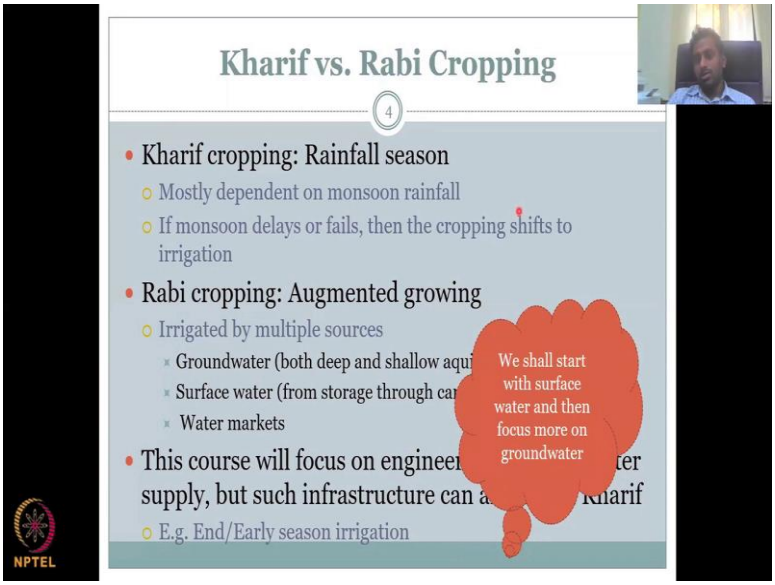

Let us differentiate Kharif and Rabi cropping. So, we know that Kharif and Rabi are the 2 major cropping scenarios in India other than the winter cropping, whereas Kharif is the rain fed irrigation or the monsoon water is kept for irrigating the field which means the farmer need not go everyday and open the channel water to go into the field and water the plants, it gets automatically watered by the rainfall.

However, if there is a change in rainfall pattern or not enough rainfall happens then the farmer is at loss. The next is the Rabi cropping where it happens predominantly the non-monsoon season and the non-monsoon season happens either before the Kharif season or sometimes after the Kharif after the winter etc. So, Rabi is mostly dependent on the structures to supply surface.

Let us see what are the issues here? So, Kharif cropping is a rainfall season crop, mostly dependent on monsoon rainfall, because there are other rainfall also where it comes intermittently, but most of the rainfall is kept the 2 major monsoon seasons. The Southeast Northwest monsoons, if monsoon delays or fails, then the cropping shifts to irrigation. Again, if land is there and it gets rainfall, it is a Kharif or monsoon crop. However, the monsoon fails or delays then a farmer has to pump and then put water or open a canal and put water that works as a irrigation.

Now, the cropping is augmented growing where you have to supply water for growth irrigated by multiple sources depending on the location, depending on the crop and access to energy, it is different sources. The most important source in India is the groundwater both deep and shallow aquifers act like a bank to store water during the monsoon season. And

when the non-monsoon season happens water is taken out from the aquifer and applied to the fields.

Then you have surface water stored from big dams or smaller dams, medium dams, and then the water is routed to the fields through canals in Rabi period and then you have water markets where people sell water tankers to support whatever livelihood you have, it could be industry it could be agriculture or even domestic use. So, water markets are available and that can also augment Rabi crops. This course is going to focus on the engineered irrigation water supply. But such infrastructure can also aid in Kharif season.

As I said, mostly this lecture series in this particular week, we will look at engineered solutions for irrigation water supply, but remember that even these irrigation water are used in the Kharif season which is a monsoon. Especially now, during the climate change scenarios where too much flooding happens or too much water is given us rainfall within 2 - 3 months rather than 6 months so, there is more water of the streets, more water on the field as flooding whereas, in a Rabi season, you will have no monsoon. So, you will eventually have to use water from these irrigation structures. We shall start with surface water and then focus more on groundwater.

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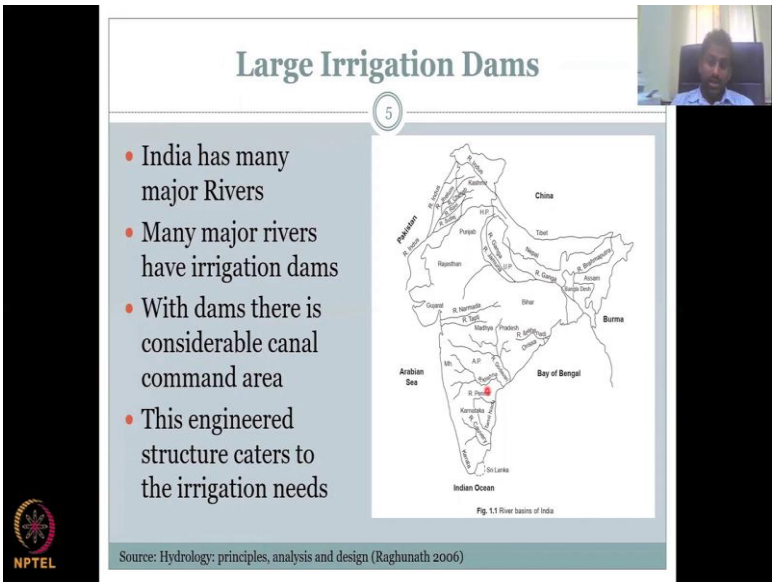

This lecture we will let us look at the surface water storage infrastructures. And the first key one is the large dams in India, India has made many major rivers you could see here as the Ganges, the Brahmaputra, Indus part of it comes here, but mostly Narmada, Tapti and you

have the Krishna Kaveri the narrow of these major rivers. Many major rivers have irrigation dams almost by default, all these big irrigation schemes are being supported by these major rivers Kaveri for example. With dams there is considerable command area.

So, each dam will have a command area when we discussed about watershed area and how these water boundaries are made. I clearly explained that each dam will have a command area we will discuss that also in today's class. This engineered structure caters to irrigation needs because it is made by cement, clay, sand, and lot of concrete, it is not a nature based solution. It is engineered to suit the water supply and water delivery to the field.

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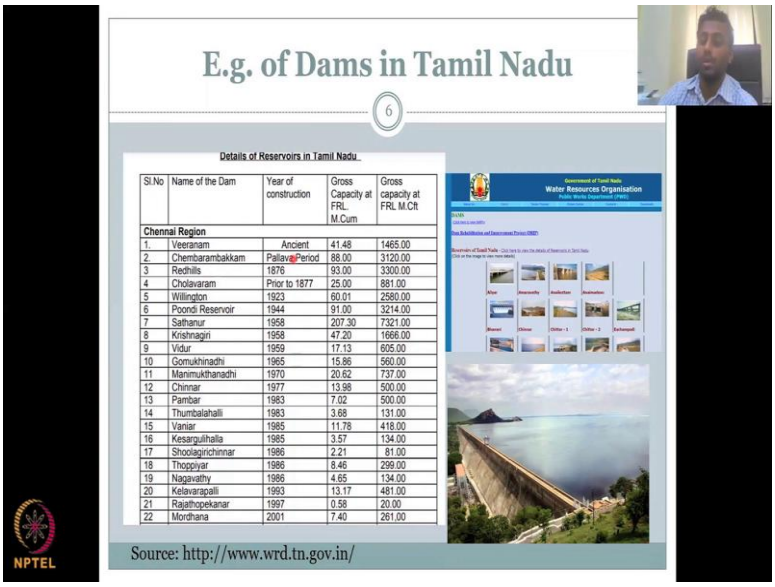

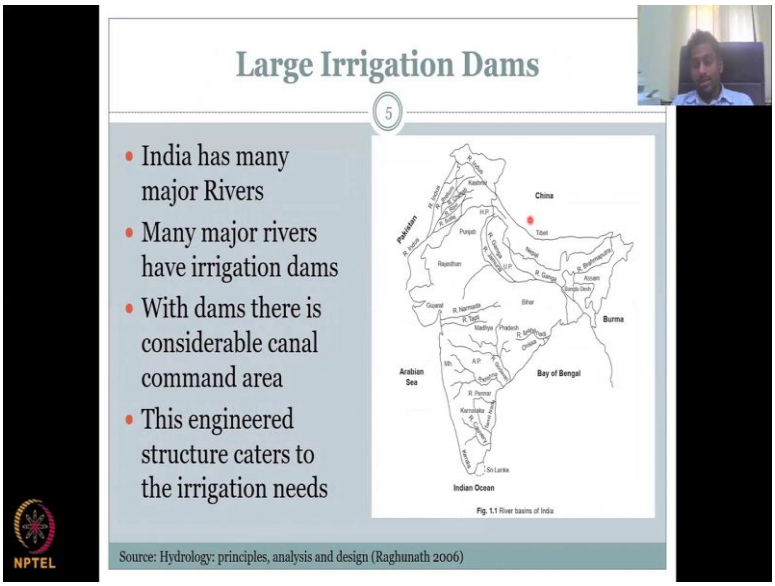

Let us take one example and it is not only the major rivers that I tell you, I will show you here that this image from the book Raghunath does not have all the other smaller major rivers in state wise, this is national major rivers, but there is also state wise major rivers and here you could see that a snapshot of the reservoir database in Tamil Nadu. So, reservoir is also another name for dams. And we have a good website where you can click on these dams, individual dams and get the daily water level.

So and if you can subtract the previous day and today's water level, you know how much water is released, if there is a loss, if there is a gain from yesterday to today, then the water has increased in the dam which means there has been a rainfall or a rainfall associated base flow or groundwater flow etc. So, this easy way of monitoring has been done in the government bowl where they keep all these data in online version where you can download quickly even whenever you need. It gives you the year of construction.

And also, capacities and full levels, how much capacity is available, gross etc. You could see that even ancient structures engineered structures are there, so engineer does not mean that you have to bring big bulldozer and build it. In those days Palava/Chola period for example, they used elephants to bring the rocks, clear the land and then make the dams. So, all these are available very beautiful structures still working, still catering to the irrigation water demand in Tamil Nadu same way for other states also you have these websites.

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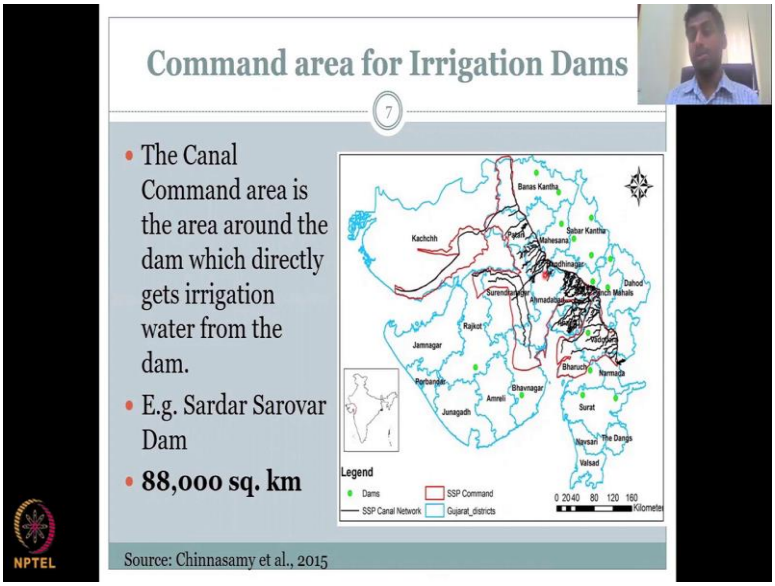

Let us discuss the command area as I said for irrigation dams. What is a command area? The canal command area is the area around the dam which directly gets irrigation water from the dam. So, for example, I will just double draw something for you to show first you have the dam each dam would have a area on the top and on the bottom. So, this is called the catchment area of the dam where all the rainfall, water pools together and comes to the dam and then you have a command area.

So, this is the dam water and then you have a command area where it is more like this and each village or street would get water from these dams. So, you are giving off some of the land here to save water and then slowly release it to the downstream of the dam which is called the command area or the irrigation area.

Example the Sardar Sarovar dam you have 88,000 square kilometers in Gujarat. So, you have the canal area and all the area where the canal serves the water from the SS dam that is where you have the water spread or the irrigation water being distributed. And that distribution takes them together the command area.

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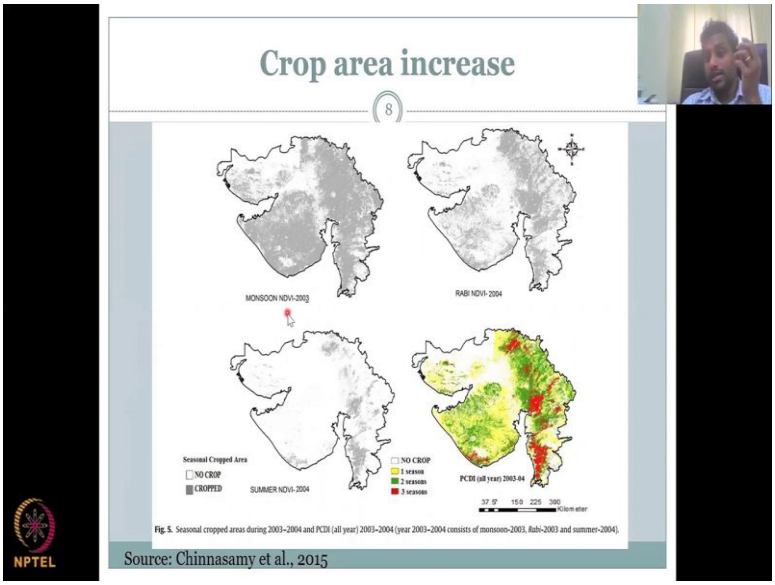

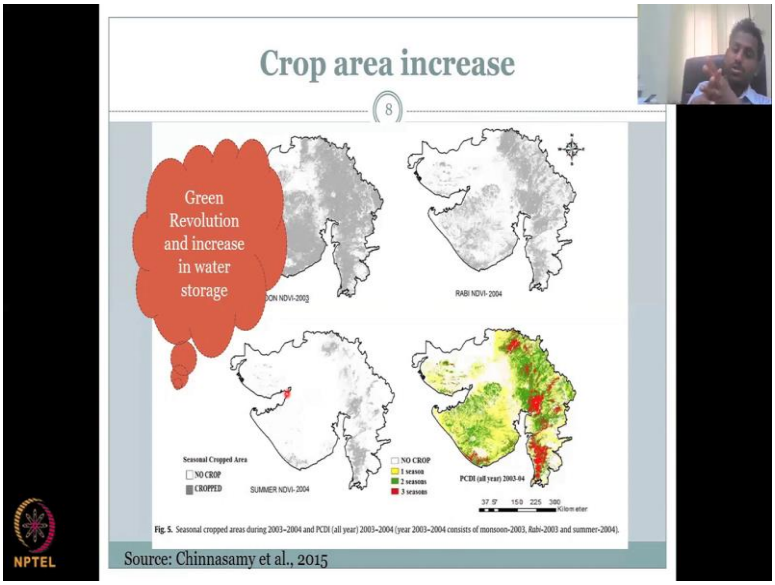

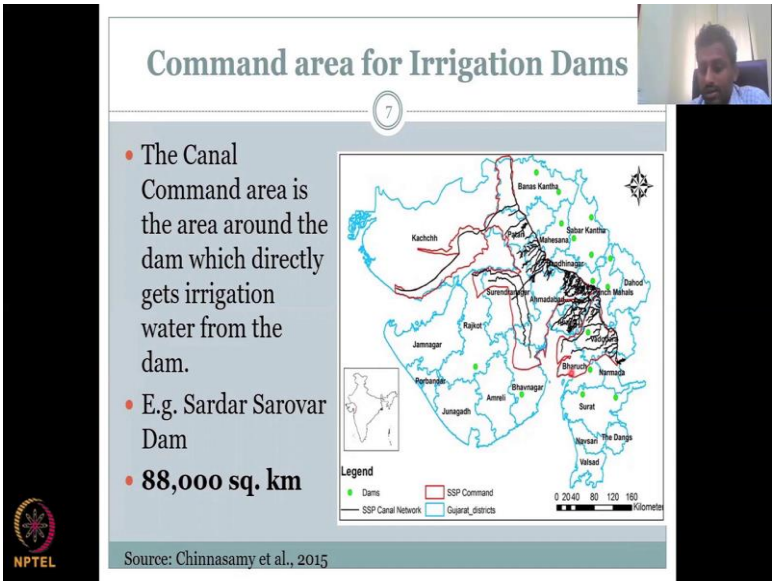

Because of this your crop area increases so I am just taking a case study of Gujarat from the previous slide that I have established a dam. So, the dam and the command area which is the red color while as the black is the canal network. So, you could see here that the water is stored and then release along the canals. Canal density might be high in some regions and low in other regions which is fine.

However, the canal distributes water to the red line which is the command area which is the area there the irrigation happens just because a canal is passing does not mean that the water is going to be served because it may be lined and the water is going to a different location. So, understand that from here to here there is a command area and if they increase the network of these canals there will be more command area.

You could see the other side, the other side of the major canal there is no irrigation, no command area only dam because it is elevation also they do not want to pump it but not not even small pumps are used to take the water most of the water goes to the down-stream locations which are been chosen for this dam.

So, the crop area has increased that is what we found in a study that because of the command area there has been a crop increase. So, NDVI is an indicator using satellite images which tells you about the agricultural activity in a land or any plant trees activity. Since we are looking at agriculture area, we want to just look at the agricultural activity. So, in monsoon season during the monsoon the NDVI 2003 we could see where the grey colour is that is where agriculture was happening.

And in Rabi season, there is this area which has been catered and most of the area is being catered either by groundwater or canal network. So, you can see all the canal network which we discussed in the previous slide getting water. So, all the monsoon season water is stored in 2003 in the dams and then released in 2004 to the irrigation area or command area.

Let us look at the summer. So, it just goes to the next monsoon season also but just before the monsoon we have the summer and in the summer season also some water is remaining so there is some irrigation happening in these areas. So, what is the total from 2003 to 2004 you have no crop only in this area because all 3 seasons there is no water and mostly it is a high salinity in these areas. So, they do not want to grow crops in these areas mostly the cuts and other areas.

However, there is 3 season crops if you add 1, 2 and 3, you can see that the third season the red color is the winter season. And then the green color is your Rabi season. And then the first season is given in yellow so there is an overlap. So, one piece of land can also be used for multi cropping season. So, for example, I am putting 1 crop in 3 months. Then after the next season, which is the Rabi season, I will clear the land and put another crop. We are not talking about sustainability, fertility of the land, we are only talking about water availability and growing the plant.

So, in Gujarat, you could see that the 3 season crops are present in this area, which means in the red area 3 times the crop has been taken in a single year. Whereas, in the yellow season, it is only one which is mostly the monsoon, but then in the 2 season areas, you can see most of Saurashtra, most of the canal command area given in these areas. So, this is how a structure engineered concrete large structure can increase the water storage thereby increasing the agricultural productivity.

So, as per the Green Revolution, an increase in water storage can lead to better crop growing periods and also better crop productivity. So, both green revolution other measures like engineering, technology, your pumps, all the electricity, fertilizers, all these aspects that went into green revolution also had excess water due to the surface storage structures and now the crops are growing.

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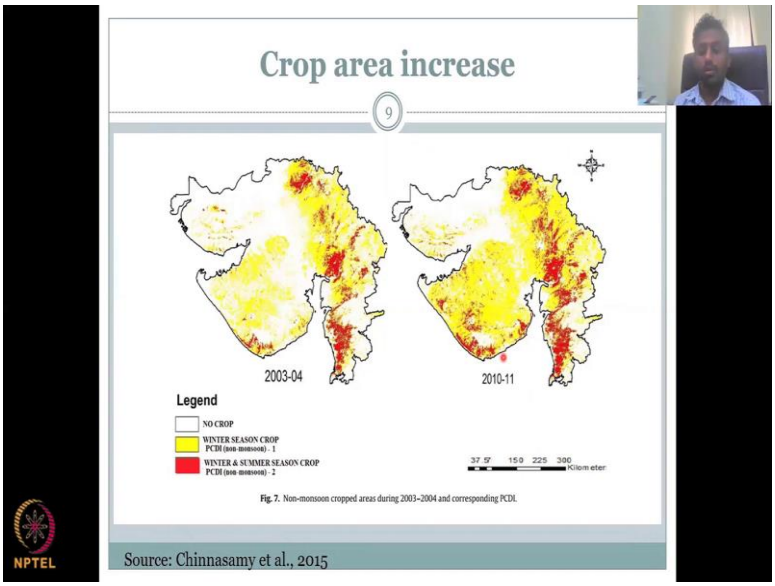

So, this has influenced the crop area increase as you see between 2 years to large difference of years 2003 to 2004 and 2010 - 2011 you could see that almost 10 years difference, but the cropping area has increased and the number of times the crop has been grown as increased. So, the no crop region says the same. Whereas the winter season crop PCDI non-monsoon is given a number 1 which is the yellow color in both regions.

Whereas the 2 cropping winter and summer season Rabi cropping has increased greatly along the north and southern parts of Gujarat and also in the Saurashtra region, you can see that a lot of red color is coming. So, what is driven this? This has been driven by your structure your water structure, the major structure for dam SSP, SSP dam and then the canal network just not having the dam would be the SS dam is there but you have to take the water and supply to the villages which is the channel wide network and how canals are running. So, wherever the canals are running, the cropping area increased, thereby giving more profit to farmers.

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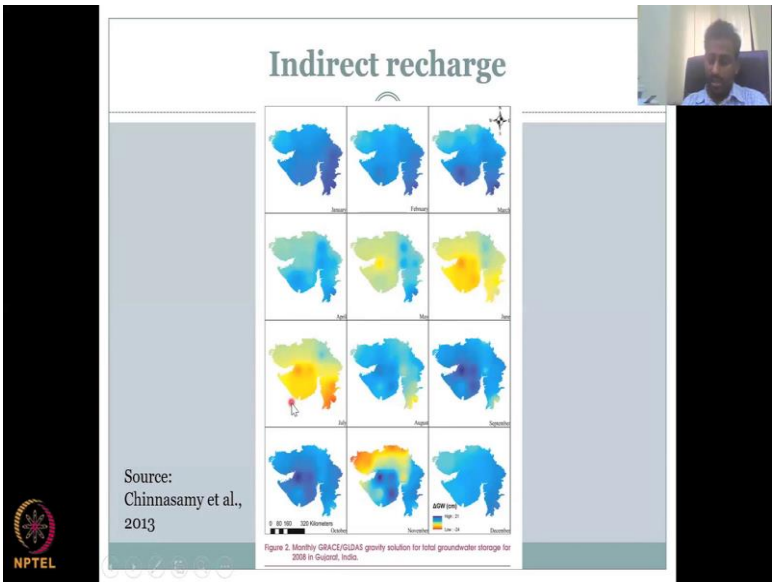

But not only that, we also saw that groundwater recharge increase in these regions, because when you send water in canal, the canal is not lined the bottom and water can recharge. So that aspect was taken by the film director and captured very well in the movies for groundwater related documentaries. So, you can see that a lot of these movies, which are documentaries, which are made on green revolution, you could see how groundwater is being captured and used well for recharge and other estimates.

In this new study, what the authors found is that not only does the channel bring water, but also the channel gives water to the groundwater network. Because these canals are not lined when they are not lined, the water can release into the groundwater recharge, but we are here only focusing on the dams and infrastructure. What I am saying is there is also indirect recharge that can happen because of water flowing in canals and recharging the network that is why even though the other regions are turning red in the peak summer season, wherever the canal is flowing the water is still available example here.

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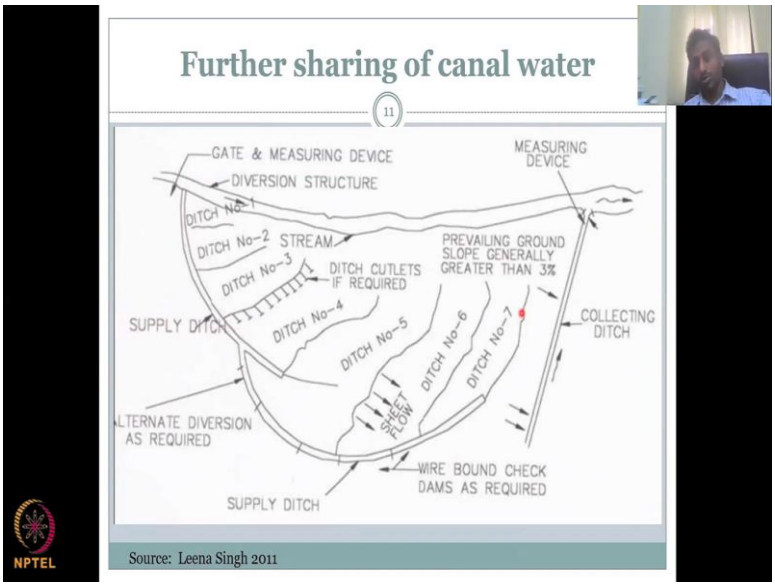

And it is done by like this. So, when the water is released, multiple ditches and smaller canals can be dug and taken out from the major canal which comes from the engineer structure of dam and that water can be intermittently supplied so that the groundwater recharge happens.

And this has been very carefully explained in this study by Lena Singh in 2011 which is very famous method called the ditch and furrow method, you take the water from your main channel, make smaller channels and then supply water in between the channels thereby increasing the time the water spends with the ground for recharge. Again, the walls water is from the damn water. So, your dam what is not only giving water for agriculture, but indirectly it can recharge also.

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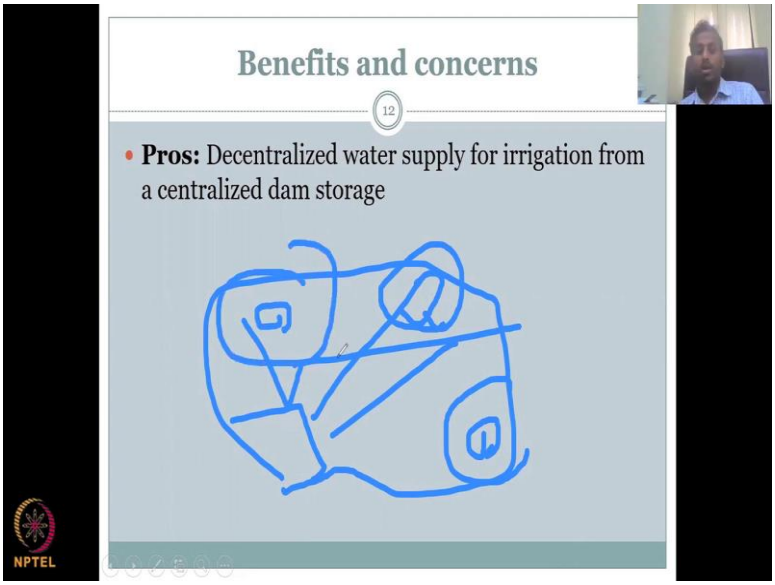

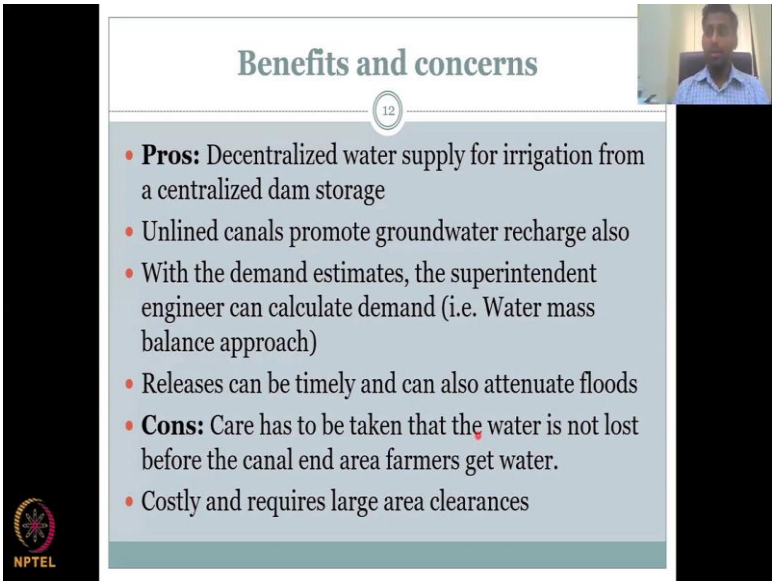

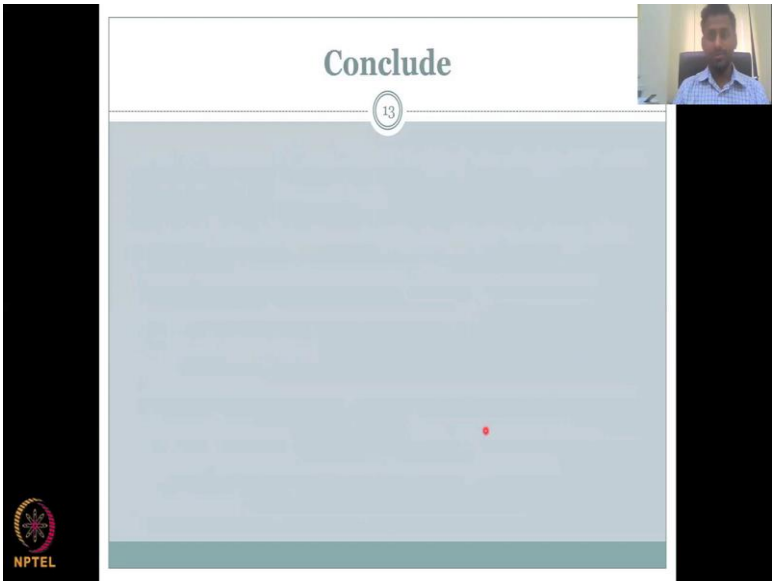

So, Let us look at the pros and cons of these centralized large infrastructures for rural water management. The pros are decentralized water supply for irrigation from a centralized dam storage. What does it mean centralized. So, you have a village and then the village has a dam here for example, this is a centralized location which supplies water to the entire village through canals, whereas the decentralized would be a small check dam which gives water to this village, a small check dam which gives water to this village, small check dam giving water to this village.

So, there are differences between decentralized and a centralized system. However, the pros the benefits are… you can use the centralized dam to make smaller decentralized units because the canal is taking water to the village and from the village you can have ditch and furrow method which can spread the water into multiple multiple locations, thereby making it a decentralized. Unlined canals promote groundwater recharge also which we saw in the previous slide in Gujarat, where groundwater recharge was happening even though the other regions where there is no canal network, the water was not recharging.

With the demand estimates the superintendent engineer can calculate the demand water mass, water balance approach for the dam and then she can say he or she can say this is how much water is coming into the dam. This is how much is lost to evaporation and transpiration along the banks, but I will still have water for supplying for other purposes. And that actually gives information for the release of water into the agricultural network.

Also, these centralized big dams can act as a buffer for storing the flood water. For example, the lakes and ponds that are monitored in Tamil Nadu and Chennai, they have to be on alert when there is a big flood. Because when there is a flood, the water in the water structure increases and they cannot release it if the downstream is already flooded. So, they have to be carefully slowly releasing it so that it does not affect the other floods. In other words, also when there is a flood supposed to happen, the water can be stored in these large structures so that there will not be a flood happening in the downstream location.

The cons, the opposite for benefits, let us see what are the cons, care has to be taken that the water is not lost before the canal end area farmers get water because most of the time what you see is there is recharge, there is evaporation loss, so multiple losses that can drive the groundwater out through irrigation and other sources or put more surface water into groundwater and thereby reducing the cannon water to go into the farm.

Our aim when you build the dam is to store the water and supply to the farmer, the supply network which is a canal should not be losing so much water that at the end of the day farmer does not get water. So, you have to maintain this delivery supply system. However, that is costly and requires large clearances and the dam requires larger area of infrastructure and clearing of the land because you cannot store water on a tree right you have to clear the land make it into a depth so that you can capture the volume and store the volume.

So, in this lecture today, we have looked at one type of rural water resource management using engineered structures which is your large dams. In the following lectures we will look at multiple multiple sources. Thank you, I will conclude with this slide.