Rural Water Resources Management
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Surface Water Storage in Rural Areas
Week 06 - Lecture 01

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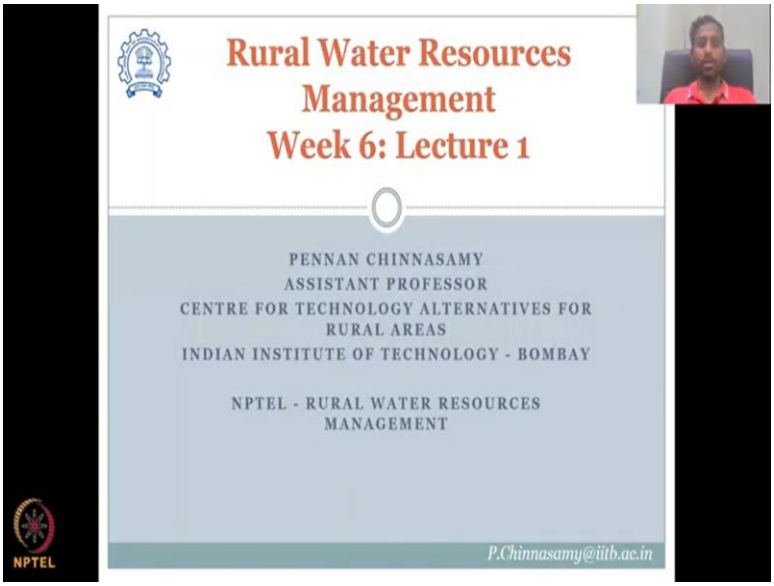

Hello everyone welcome to NPTEL course on rural water resource management, this is week 6 and we are at lecture 1.

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Let us see what we have seen in lecture 5. We looked at in detail the groundwater hydrology components. We made sure that we understood the key hydrology components in the groundwater component. And we then further progressed on finding the measurements and data where it can be available; we also looked at the role of groundwater in the overall hydrology. Now, moving on since we have looked at the groundwater as a important resource, we will look at the other resource, which is very important which is the surface water hydrology.

So, in this week, week 6, we will be looking at the types of surface water storages mostly in the rural regions, because we are dealing with rural water resource in this course. We will also look at rural water bodies and lakes. We will look at methods for irrigation from the lakes, for example how do you take water from rivers and lakes within the rural system. It is not only a running water, but also stored water, so ponds through lakes etcetera. And then there is a big concern on what is being happening in the current scenario, most of the villagers are experiencing loss and conversion of lakes, we will look into why this phenomena is happening.

Wherein, we have disappearing of lakes, encroachments and conversion from rural to urban. Disappearing is also kind of plural to urban, but most of the time disappearing just means that the entire lake or water body is drained and then construction is built on top of it or like in Kerala you have vegetation growing on it or agricultural crops. Encroachments is where you block the water, so that you drain it indirectly and rural to urban conversions is again like where the urban center is increasing in size and some villages on the boundary of the urban setting are losing the water bodies.

Please understand that water bodies are government property and it has under no one's name and so the boundaries are kind of very not stringent, there is no exact line, because one day the water body would be big and then one day because of summer it will be small. So, there is a demarcation however people do not know and they start to encroach it and abduct it saying that that is airline. This is the key reason why in Bangalore we have a lot of lakes that are lost. So let us dive into week 6. First why do we need surface water storage? We talked about groundwater storage yes but there are specifics to why we need surface water storage.

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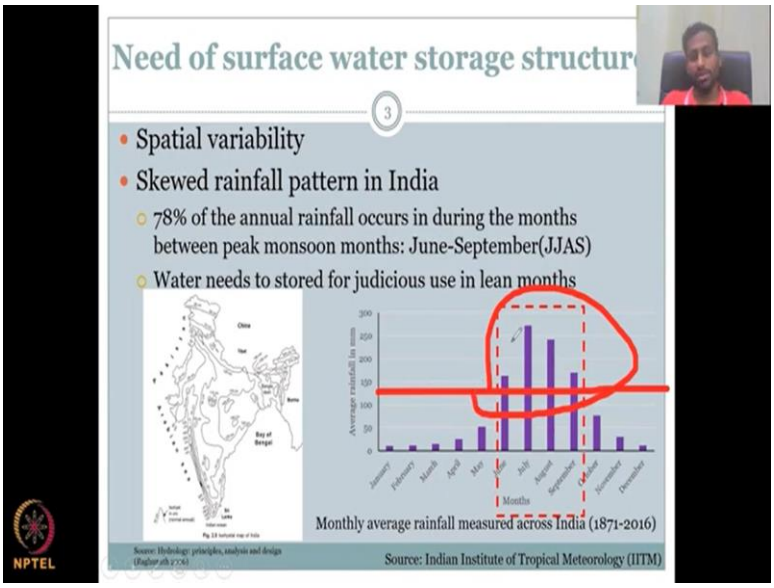

Let us look into detail for the need of surface water structures. First this image we saw in the early part of the course wherein we have a variation in rainfall. If you look at it the rainfall is not the same across India and even within a village or within a district you can have a high rainfall zone and then shared with the no rainfall zone or a rainfall shadow zone. This leads to variations in rainfall and or skewness what we call is how rainfall is less in one area and high in another area.

So, spatial variability is a phenomena which occurs because of the map you see here it is not the same rainfall is not the same. And if you make further more iso heights or lines of equal rainfall you could see that there are some within a small village or within a small district also you will have variations in red for spatial variability.

Then we have a skewed rainfall pattern what is skewed rainfall. It is not the same across every month because we are not in for example in these regions the northeast you do have rainfall almost every single day in the wettest part of the planet but in most regions at least weekly you will have some rainfall a very little rainfall etcetera hill stations. But most of the agriculturally active regions have a skewness which means 78 percent of the annual rainfall only happens in the monsoon months and that too between the peak monsoon. Here the peak monsoon is given as JJAS we call it or June July August and September.

This is kind of the overall average for India even though it shifts where you are most of the monsoon is at the peak monsoon where the annual India's annual rainfall happens 78 percent almost 80 percent of the rainfall happens in JJAS. If you look at it this is the average rainfall in millimeters monthly and you have Jan, Feb, March, almost very low rainfall pattern and then may whereas you have the summer and in some regions the summer extends until may. But after may you have June, July, August, September. So here we say that every June 6th you will have rain in Mumbai or in Maharashtra that is the onset of the monsoon.

So, but before we get the monsoon the monsoon comes from Kerala so here the monsoon is coming and while it rises here maybe a week later after the monsoon onset we call onset is the coming in of monsoon from there it can come here. So just a week more or less that is why you see this variation but it is a beautiful probable t distribution a bell curve we call it normal distribution where you have more rainfall happening in a particular concentrated zone or concentrated months which range from June July august and September.

And then you have your winter post monsoon seasons rainfall. So, if you look at it there are some regions where there are zero rainfall, but because across India there are some regions which also get rainfall in January and December we have for example in Kerala region in the northeast region you do have rainfall across most of the time. You go to hill stations there is always rainfall right elevation gradients. So, the monthly average rainfalls this is from 1871, 2016 so more than 100 years rainfall from IITM shows that this is the average pattern and there is a skewness.

So, because it is happening only in a concentrated time you need to capture it so that you can use it for the remaining months. What do you mean by lean months? Lean is like how I am lean or you have lean chicken thin. So in another word what it means is these are the lean months where is less rainfall is happening. So if you say what is the average rain fall so maybe somewhere here you can draw a line below the average you will call lean or below average months and then this is the above average months which is for sure during the peak rainfall season you will have above average rainfall.

Moving on we have to capture this rainfall so that we can use it for the lean months both your summer or the monsoon and after the monsoon which is your winter season so water needs to be stored there.

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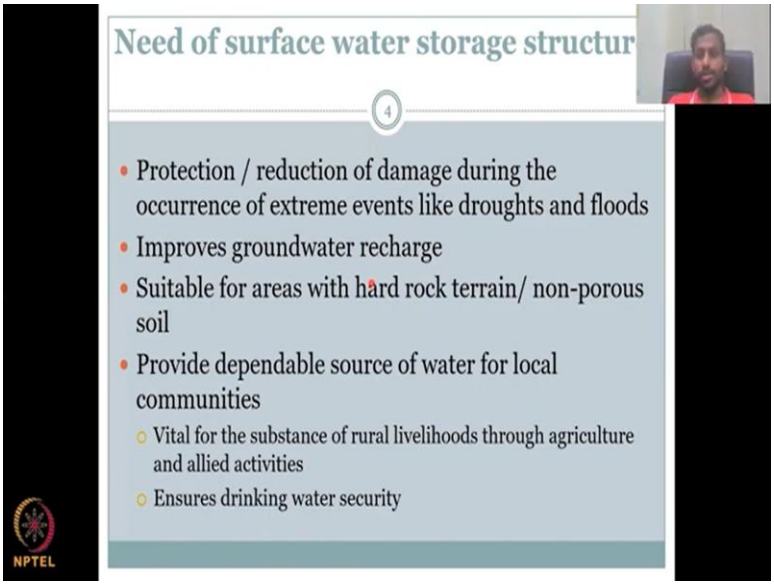

And groundwater we saw in the previous week lecture it can be stored but the rate is very low, so it is very slow compared to the rainfall. The rainfall can happen for example 50 millimeters in a week but it cannot go that fast into the ground remember it has to go infiltration percolation and then go to the groundwater aquifer. So, that does not happen that fast so that is why we are in need of surface water structures it can protect and also reduce the damage during the floods and extreme events of climate change which are droughts and floods.

Let us say drought let us take an example you have a drought which is a less rainfall year. So if you have a less rainfall here and you have already captured the previous year's rainfall in a storage system surface storage system we will look at what are the systems in the upcoming just this lecture. But let us think like a tank you are capturing the water from rainfall and river and storing it in a tank that can be used for the lean season which is the right next the post monsoon season and also in a drought year. For example 2020 was a good rainfall year and then 2021 was a drought year if you catch the rainfall in 2020 and conserve it you can use it in the 2021 drought year so that is what a climate extreme drought how you can use rainfall from storage structures.

How does it reduce damage in floods? Suppose you have a big flood coming through your river system and on the land and it just inundates the area. If you do not hold it at least in smaller quantities what happens is the water gets collected and comes downstream and floods more. So these structures actually hold this water for a particular period of time or until the volume is

reached for example dam. Let us take a dam it will just stop all the water and until the one damn water is full.

Suppose a dam was not there and there's a big flood all the water would come and flood the entire area. So this is how these surface storage structures help in a climate extreme and climate extreme also means drought and flood so in both seasons it does help. It improves groundwater recharge for example if it stores the water in the store storage the water is stored then there is also infiltration and evaporation is happening.

So, the infiltration you cannot stop unless it is ninth, ninth means you put cement on the bottom of the tank like for example a petrol tank. You do not put nothing under the tank you have to put a lining so that petrol does not seep in, swimming pool you put a cement lining on the sides otherwise water will just get leaked into the aquifer.

So, we are talking about a natural system for agriculture where it stores the water and it can recharge. Suitable for areas with hard rock terrain non-porous soil, because groundwater is needed and it takes long time to recharge so when you store this water and push it into the ground it can recharge slowly.

Because you are also creating a potential head when you have a dam or a storage water level will rise and it creates enough energy to accelerate pushing the groundwater into the recharge. Provides dependable source of water for local communities if you look at the water storage structures like a dam or a small water lake agriculture lake you could see that around the system around the storage structure there is a lively water hood developed by the locals.

For example fishing and it could be the drinking water supply for them and also agricultural means. So it is vital for the substance of rural livelihoods through agriculture and allied activities when I say allied activities it includes fish, livestock, cattle, poultry, anything that supports your agricultural livelihoods. And it also ensures drinking water security even though drinking water is less compared to the use of other units that I have described still it is very, very important. So, this structures could provide good drinking water source during the lean season which is drought or the high flood season.

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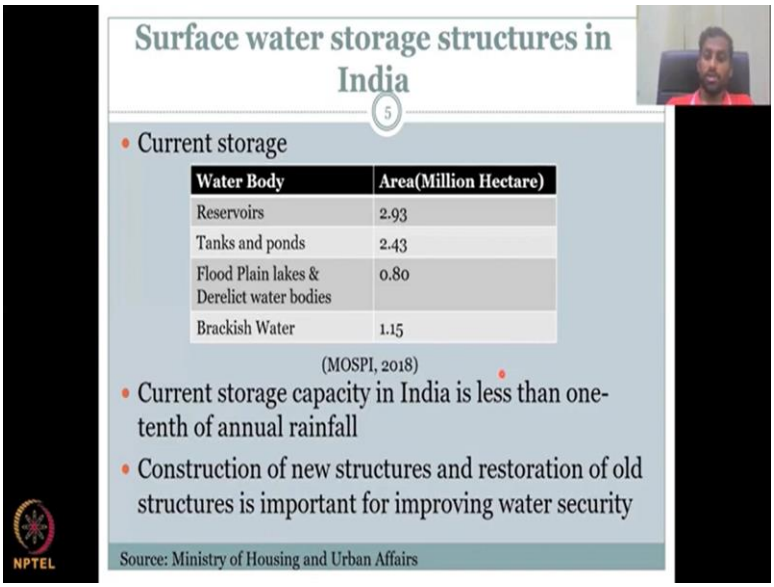

Let us take a look at the surface water storage structures in India. So the current storage as for MOSPI 2018 says that the reservoir is around 2.93 million hectares, tanks and ponds occupy 2.43 million hectares, floodplain lakes and water bodies around 0.8 million hectares and brackish water is 1.15 billion hectares. So, this gives a good understanding that your reservoirs, which is tanks and big storage structures occupy the most area in India followed by tanks and ponds. The floodplain or and brackish are smaller however your tanks and ponds small tanks in villages and your rural ponds still occupy a good chunk of space.

The current storage capacity India is less than one tenth of the annual rainfall. So, if you compare this volume so this million hectares multiply the thickness and the volume total volume stored and then you compare it with the volume of rainfall we have it is not even one tenth of the annual rainfall which means 90 percent of the rainfall is left to go into rivers water storage in groundwater and etcetera. Is it good or not that is a different question, because you still need your rivers and lakes and streams to flow. But is it all washed away into the oceans and seas is the question. So that number we do not have exactly we need to calculate.

So, construction of new structures and restoration of all structures is very important because we are losing a lot of water into the oceans and rivers which can be captured for a water hungry nation like India, where agriculture is predominantly using a lot of water and it is very, very needed to have this water supply. Not only in India but almost all south Asian countries are water

hungry which means the population is increasing there is a demand for water to sustain the livelihoods and demand for agricultural productivity. So, all these countries are actually wanting more water you cannot create water so you need to store and then capture as much as water is there.

And given the trans-boundary natures and international you know issues in getting the water between countries it is always smart to at least use the water that you collect in rainfall capture it use it and then make sure you are not wasting too much water into the oceans and seas considering your agricultural needs.

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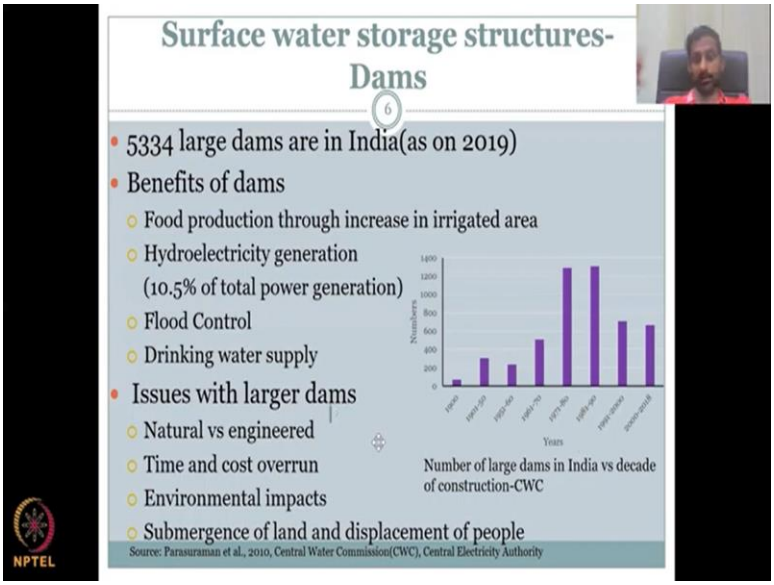

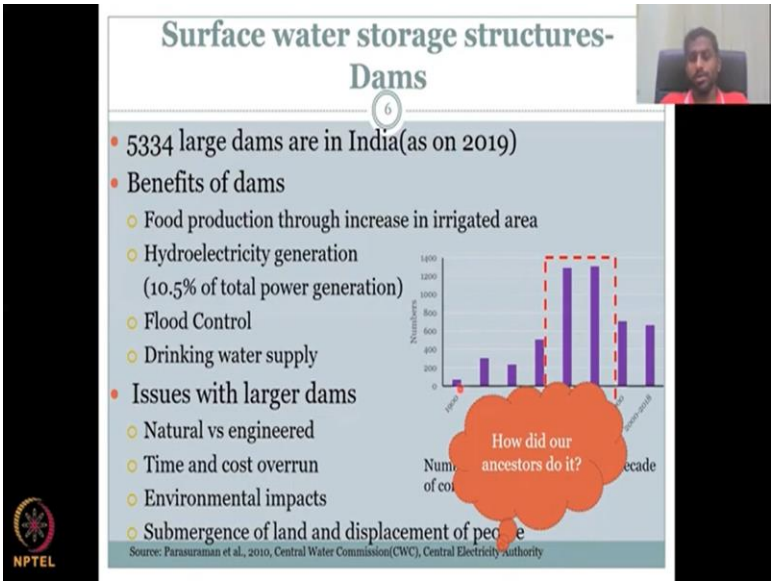

So, let us continue looking at the large dam so it is 5334 large dams are in India as on 2019. And these large dams is one type of a surface water storage and it is the biggest everyone knows how a dam looks like we will have some images. But dams have their own positives which are when others of dams include flood production because it is a massive storage it is a couple of feet high you know like it is not like you cannot just jump in and swim for days you know it is too big.

So dams are pretty that is why you cannot allow you are not allowed to swim in a damn zone it is massive so it can actually capture the flood water and buffer act as a buffer which means a storage space where extras water can be put.

And it also increases your food production because you have an irrigated area. So once you store the water that water is released into the command area we call where wherein water goes into the land for agriculture is supplied in the land for agriculture. If you look at the number of large dams so there is a difference between large dams check dams and small lamps medium dams.

So, large dams are the biggest which are not only for irrigation but also for hydroelectric generation which accounts to almost 11 percent and 10.5 percent of total power generation. So, also India is in need of power right electricity because we are also pushing industrial development and we need a lot of power we have solar and etcetera but hydroelectricity is also generated.

So, if you look at this you have the number of dams big dams large dams in India and it is not easy to make these dams because it before the British gave us independence when they were ruling us. So you could see that not they built a big dams and still operational but was slightly managed their motives were different they did not want much for India's development. But after India's independence that is when we started to push more on the large dam scenario and then because of the anti-benefits also or the issues with large dams there has been a slow down and not much you can build also the lands are already occupied by large dam.

So let us look at some of the positives as I said food production is increased hydroelectricity is increased flood control it can buffer the flood water and all this water can be piped into a water supply. For example, all the dams in Pune areas are catering to the drinking water supply of Mumbai because in a city of Mumbai you cannot afford to put a dam. It is too expensive the land where it is the industrial capital of the country so where would you sorry the economic capital of

the country where would you put all these you know dams you cannot. So the water supply is taken from outside.

Similar in Delhi you know water is taken from outside. So this dams do help in drinking water supply not only for that region but for miles and kilometers away. But there are a lot of issues if you look at dams there is a difference between naturally managed water and engineer dams are more engineered structures which means it is a kind of there to stop the natural movement and it is not accounting for the natural dependencies of water. For example you have downstream you have e flow which is the environment requirement of water so all this is not thoroughly taken up by large dams there are some issues.

Time and cost overall that is a huge cost involved in time to build it just recently you would have noticed the Uttarakhand dam they built it such large time and money but it just got washed away. There are a lot of environmental impacts you have to clear the land there is a lot of people's livelihood displacement happens we have to clear the land take the people away relocate them all this happens. Because it is a huge area when you stop the water a huge area has to be flooded and that becomes the flood becomes your dam water correct you just stop the water. One more thing is the size or not along the size alone but also the environment factors as I said it has to cater to the movement of water.

So some environmental benefits are lost if you stop running water. So these are mostly noted as the negatives of or issues of large dams by these authors given below. So you could see that as I said most of the dams were did only after the independence but there is a question how did our ancestors do this. If we know that dams were less during the British era and before that it was really less 1900s. So how did our ancestors kings and others who ruled before the British how did they control this water.

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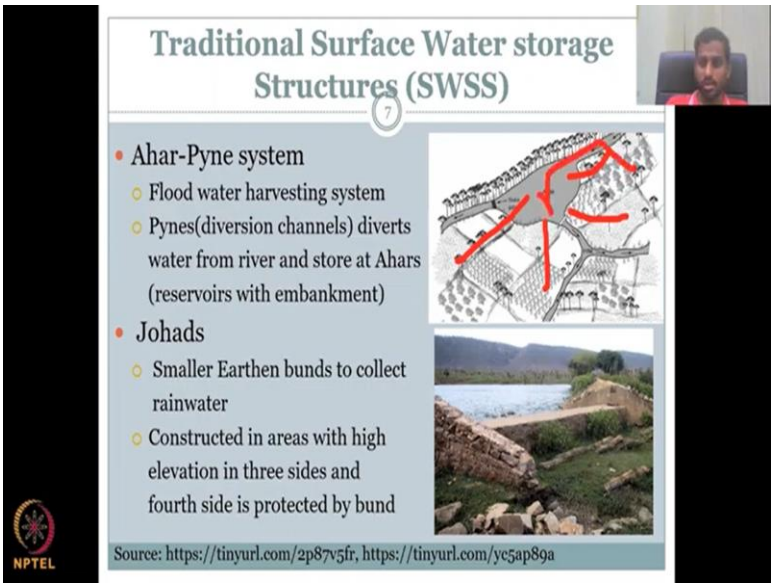

So there is a lot of traditional water resources storages we call it surface water storage structures as SWSS in just in short to put it in the slides. So there is multiple methods there is traditional there is nature based methods and there is engineered methods. Let us look at the traditional methods to understand how the ancestors did it. So the first one we would look at is the Ahar-Pyne system where floodwater harvested through a small area demarcated in the villages and pines are the diversion channels which take the water into these small stores or storage regions as Ahars which is reservoirs with embankment.

So it is a small reservoir it is kind of a small dam but it is made with embankments not much cement use not much land is cleared. So normally what the traditional ancestors did is to find a low lying area in the village and in that lower lying area already water would have been stored. So all they had to do is clear the land put embankments on the sides and then channelize the water. So instead of water moving in every direction like for example like this moving in every direction into the Ahar. They would just make sure that it is all pulled into one channel.

So this is how they managed this important capture the rainwater channelized it through these Pynes which are diversion channels and into Ahars. And into they might have some blocks to stop the water for example like this and from that blocks after a particular height is reached

people can use it for fish, drinking, livestock and also put smaller channels like this loose gate and then take the water into the villages into rural lands for example for agriculture.

Johads is another similar type where smaller Earthen bunds to collect rainwater are done it is not as big as the Ahar pyne. And it is constructed in areas with high elevation in three sides and fourth side is protected by bund. So for example you do not have a low lying area in the village what would you do. So all you do like for example here all this elevation land you would pick an area where all these four elevations are high and the smallest elevation which is the smallest height land is used as a storage. So you just build a small earthen bund, earthen bund is a structure like this and earth is just mud, stand and stones is not concrete.

So which means earthen bunds still can do some recharge still can have some leakages which are good. And so this bund actually stops the water from these high elevations and starts a pool so that pool of water can be used as a surface water storage.

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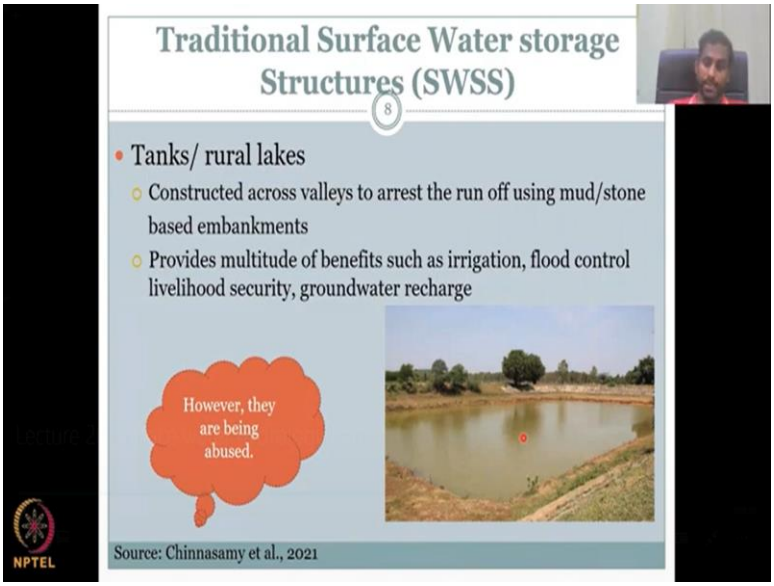

Moving on we also have another very important structure which is tanks in rural lakes. So these are a demarcated simple land which is channelizing water into and storing the water. So it is constructed across valleys to arrest the runoff so small valleys you will have and all the runoff is arrested and put into it. And around the area you will have mud or stone based embankments.

So basically the ancestors just dug this area through hand and plows and stuff made a deeper thickness of like a bigger well and then all this water would come in and on the surrounding

edges they made these embankments. Provides multitude of benefits such as, irrigation, flood control, livelihood, security, groundwater recharge.

So because this is not lined which means no cement is at the bottom groundwater does recharge, excuse me. So therefore it provides multiple benefits not only for irrigation, not only for agricultural water use flood control as we saw livelihood for fish and then for food security etcetera. And sanitation people used to bath there and most importantly groundwater recharge. However, they are being abused they are not protected well.

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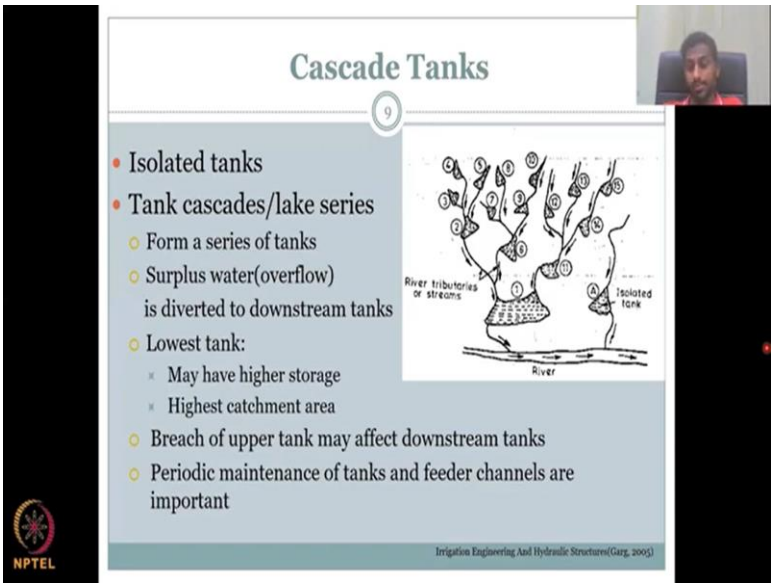

If you look at it we will cover some issues of these tanks in the next class, but you would notice that in the villages these tanks are not protected properly. As long as the tanks, we also have another tank system called the Cascade tank system. So just visualize we had one tank so this is just one tank in the village, think about placing small tanks and connecting those tanks. So the ancestors are very smart they thought, first let us make one tank and this tank could cater to the hamlets or the houses and villages around this tank. But then it can water can still go to another tank so as one tank fills up it goes through the channel and then fills another tank.

So only after number four fills up number three fills up and then number two fills up and then the bigger tank number one fills up. And they built it along the tributaries also which is this line you see. So the river is like kind of stopped and a big tank is made it is not a check dam it is a big tank so water flows into the river and when water flows a big tank is first filled up and after the

tank is filled up the next tank and the next tank until the bigger tank is done. And once the bigger tank is full it goes into the massive river out into the system.

So all these are very, very important and these are called cascading tanks so one tank is filled and then another tank is filled another time, what we saw in the previous slide was an isolated tank we just had a channel and then the water was filled. So what is the benefits of tank cascades it is a series of times it is not one tank so when you manage you have to manage all the tanks together to get good water in number one.

And then there is always surplus water is being taken from one tank to the other tank through downstream links. So these are the downstream lengths where water would come, the lowest tank may have higher storage which is the lowest rank or the lower elevation tanks has more storage because it can take the water from multiple resources and has the highest catchment area.

So this catchment area is the highest compared to this tank which is this is the catchment area. The breach of upper tank may affect downstream tanks so that is why it is very important to manage. And as I said in the previous slide most of these tanks are not well managed because we will look at the reasons in the future class in this week there is no community participation there is no funds for it people do not take ownership so all these issues are there. So there is a breach of upper tank and if that happens mostly all these tanks would not work well because all this water would come down and then we lose this land and then slowly this tank will also get broken because of this water coming in and slowly all these tanks will erode.

So after one tank breaks all these tanks other tanks slowly with break. Periodic maintenance of tanks and feeder channels are very important and even the transboundary tanks and transboundary connecting channels like the one in Koshi have to be properly managed and periodically maintained otherwise a lot of issues can happen.

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So there is a loss a lot of loss of these tank systems operational tank systems let us see some of the reasons and we will also touch upon this the upcoming lectures. There is a decline of traditional systems surface water storage systems especially because of population and dependence increase. When population increases people start to abuse and they take more than they want because of fear of others would take it.

For example here if you could see water was around here but then not proper maintenance you can see trees growing the rocks broken the stairs broken all of it. So if you do not manage it and people are using it and so they should also manage either the government or the local people.

Land use land cover changes because you tend to abuse it you tend to encroach it these tank systems are gone the traditional systems are gone, community disconnect and misuse as I said if those who are using are not going to take care of it we will lose the tanks we will lose the water bodies the ponds. Lack of maintenance and up keeping there is no ownership there is no money set for these revival of these systems and people do not understand the connection with groundwater. And also people have the access to individual groundwater so they have just started to abuse these systems they do not care about look how it is broken and once it is broken slowly it gets demolished and no one takes care of it.

So there is a need for revival of traditional SWSS especially because India has already 54 percent stress and it is going to increase pretty bad as per this report. Acute water stress is going to

happen groundwater is already depleting and the increasing water trends as I said because of population and overuse lifestyle has changed everyone wants to wash their car using fresh water you know and which is not correct. So when that happens you need more water to actually get into this lifestyle.

And there is increased frequency of extreme events namely floods and droughts so there is a very, very important aspect to conserve these structures capture more of this water before we lose it into the main ocean and big rivers.

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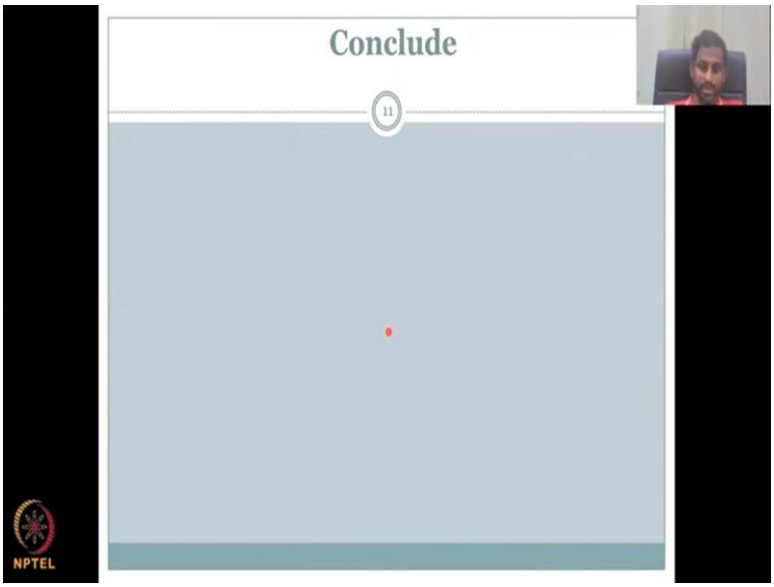

With this I would like to conclude today's lecture I will see you in the next lecture thank you.