Rural Water Resource Management
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Week 03 Lecture 01
Key Hydrological Parameters for Rural India Part-2

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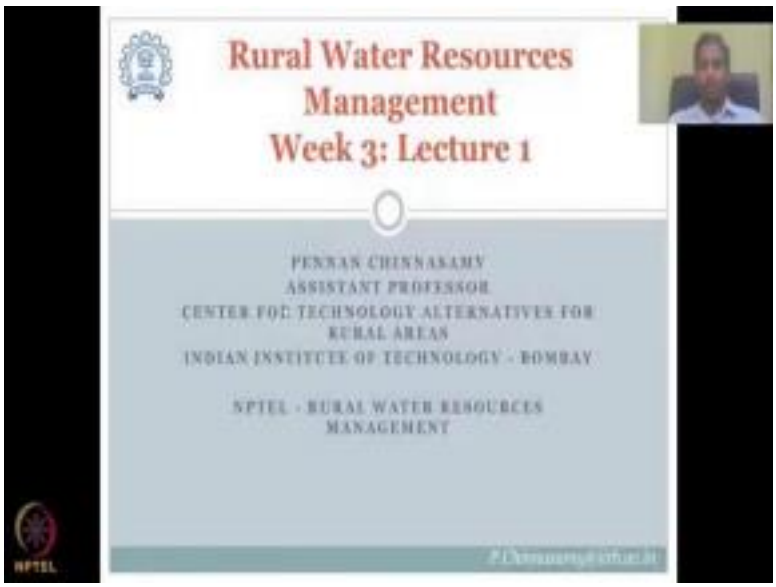

Hello Everyone, Welcome to NPTEL course on Rural Water Resource Management week 3, lecture 1. The first lecture of the first week, we looked at the introduction to the course and over the first week we looked at how the course is going to shape and the introduction to Hydrological cycle. The second week, we identified three parameters, which are very close to the rural water resource management. Namely, precipitation, evapotranspiration, and surface runoff and discharge.

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In this week, week 3, we will be covering another three parameters from the water cycle. As I mentioned, there are multiple parameters in the water cycle that could contribute to the Rural Water Management also the time and also the length of the course, we are focusing on the dominant three.

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In this water cycle, you would have seen the size of the arrow is bigger, which means bigger contribution of water boiling. So we have the precipitation, which we covered in the first chapters and then you had evapotranspiration, which is also a bigger arrow which is also a loss to the system and we also looked at which is a component.

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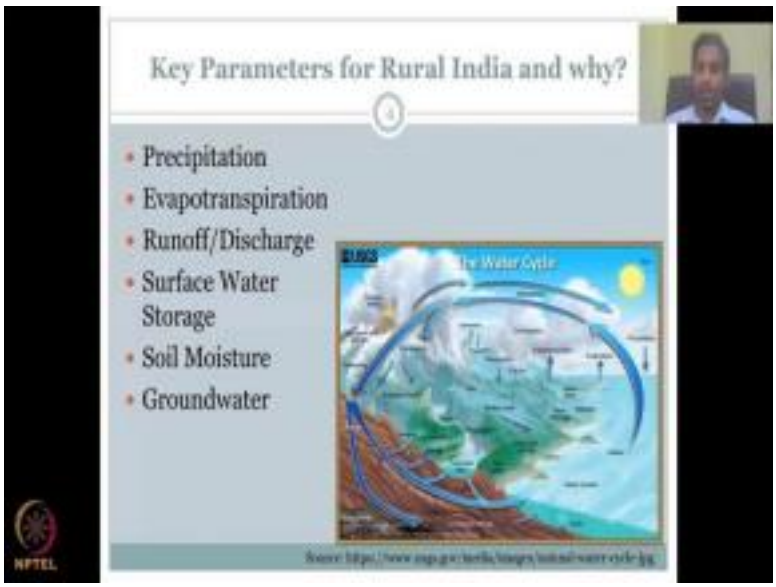

So, we also looked at, why these 3 parameters are really important for rural India, especially precipitation because it drives the agriculture in rural areas, the livelihoods are based on this

precipitation. And then we looked at evapotranspiration, which is the combination of evaporation and transpiration. Where evaporation is from open surfaces, so you have your freshwater bodies or oceans and land, this barren land can also evaporate.

Whereas, transpiration is the water which is taken up by plants and transpired into the atmosphere. We could see the plant water uptake and then giving it back to the atmosphere, as evapotranspiration. So, that is where you have transpiration and evaporation together, and evaporation separately would be on places where there is no plant or animal life.

For example, on top of an ocean, there is no living plants and animals that are breathing on the top, which could transpire, same thing is under the water. So, most of the losses of water is evaporation. So, that is a good point. Please do not think that oceans also have life forms in terms of plants like planktons, and big whales, etc., do not they transpire, they might, but it is under the ocean waters. So, all of it is combined to the water and only the evaporation is taken into account.

Runoff and discharge, so, we looked at a bigger component of runoff and discharge into from precipitation converting into the storage units. In this week's lecture, we will be looking at surface water storage, a very important part for rural water management, because precipitation occurs and I have shown you if you do not capture it, it ends up as runoff and discharge. So, if you have surface water structures and storage units, you can capture these water for future use.
So it is naturally there in the system, whereas most of it is engineered or manmade we call it, so those type of water structures we will look at and how natural resource engineer can help rural India we will look at those concepts also.

Another important component is soil moisture. Your soil moisture is already kind of included in your evapotranspiration because water goes in and then gets relocated, from soil moisture the plant takes it up. However, there is some dynamics that happens at the soil moisture level. So, we will look into detail that aspects in this week's lecture.

Moving on, the most important part for rural India in terms of water during non-monsoon season is taken from groundwater. It is a very key source for irrigation in rural India and especially during climate change extremes, because studies have shown that floods and droughts are occur at a very high frequency compared to 20 years 30 years ago in India, however, the volume of rainfall does not change much.

So which means the rainfall is occurring in an annual event, but it is concentrated, when you

have a concentrated event that is a flood. And also when you have a dry spell, that becomes a drought. So, instead of three months non-monsoon, here, because the monsoon is shorten, you have a five month non-monsoon period, which contributes to the drought, the plant stresses, trees stress and they die. So, it is very important to understand soil moisture and groundwater, which are components that can alleviate or reduce the impact of climate change on plants. So, those are the three components that we will be looking at in detail in this week's lecture.

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Apart from this, there might be some inter fluxes and inter storages also, so please do not understand that surface water is totally disconnected from soil moisture and soil moisture is disconnected from groundwater, like in the previous lecture, precipitation is 1 unit and that converts into evapotranspiration and then it converts into runoff and discharge, there is no mixing back and forth.

But here, there is a possibility for example a surface water storage can lead to soil moisture, which can also lead to groundwater. And in the same way, groundwater can lead up into soil moisture, due to capillary rise, and your soil moisture can contribute to groundwater storage also. In other words, groundwater can also contribute to surface water storage. So, all these aspects we will look at in this week.

So, these arrow marks kind of telling the same what I have explained right now, wherein your groundwater can go into a lake and river. So, groundwater can go into a surface water storage, which is your freshwater lake. However, your lake can also give back to groundwater. So, there is internet connections also exist.

So, once you understand how these compartments are and also understand what are the

differences between them, then you could also understand that there could be some linkages between them. Please understand that all this water comes from precipitation, and precipitation, we have defined it as rainfall, for all throughout the lecture, snowmelt, hail, sleet, rainfall, everything is there but for rural focus, we would be only looking at rainfall.

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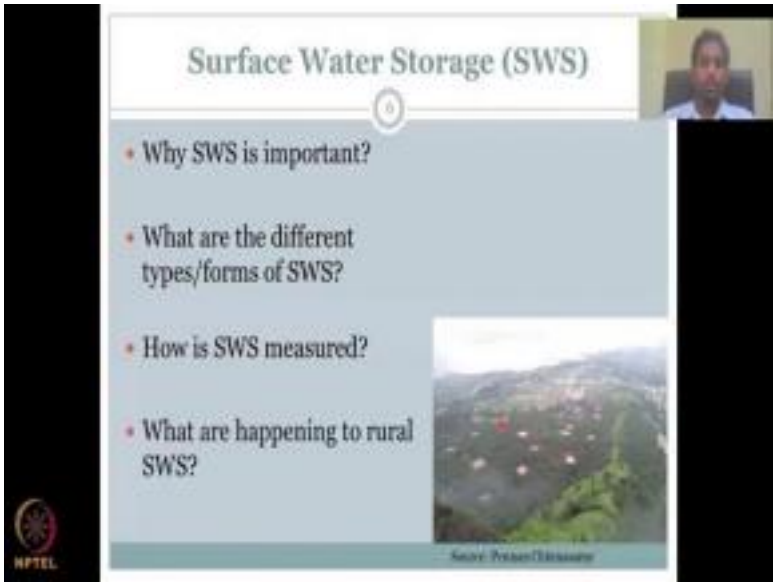

Let us look at surface water storage. In short, we can call it as SWS. Why is this SWS important? It is important because all rainfall cannot be caught and used at once. Because the rate in which the plant takes up the water is much slower, much slower than the rainfall. So, if you do not catch, if a plant cannot catch the rainfall within a period, then the excess rainfall converts it into runoff and it is lost from the system.

For example, let us take here in this image, if you have a rainfall, on one side, you have the rainfall, and no tanks here, no farm ponds or tanks here. Whereas on the other side of the ridge, it is like a small hill and there is a ridge. So, in this side you have tanks, if rainfall occurs on this area, what would happen?

You would be seeing a, in this area I am saying, so what you would see here is rainfall would heckle and it will convert into surface runoff and then exit out of the system, it will go into this lake, and then go out. However, if you have water flowing on this, it will be captured by these surface water storage units. So, that is why it is very important to have surface water storages depending on your setting, because you have to lose land, so land is a commodity that is very precious when it comes to farming.

If you have land access or some land that you can sacrifice to capture the water, it is good. So, here a farmer has given 10 percent or 5 percent of the land to capture the water, so that

the remaining 90 percent can be benefited. What are the different types and forms of surface water storage? There are many types and as I said, there is natural versus engineered or amendment.

So, we will be looking at the difference between them, we will be also debating on what is better and this course if you look at there is a lot of debates and discussions, because I would like to have things other than saying this is the best or another system is the best, I would like you to apply yourself, take the understanding the physics and the properties of these water bodies and then you apply it to your field then you would know which one is better for your division.

So, what are the different types and forms, there are multiple different types, we will go into some of them in detail and we would also look at how do you quantify the water in the surface water storage. Because when you want to do a rural water resource management, you would eventually need to understand how much storage you have and how much are you capturing for future use.

So, that is where we have to understand which method we use for measuring the water discharge, what is the method you have for calculating the release of water all those aspects we will cover in this lecture. What is happening to rural SWS? What are the conditions of this rural surface water storage units? We will be looking into this also in detail, because surface water structures have been there from a long, long time, before the things that I would say.

Because in those times during the things that are you did not have groundwater access, digging a well is not as common as now, because technology has actually eased out the situation you put a point and say I want a well there, you can bring your bore logger in a truck and then within an hour you will get your well. In those days it was not that easy.

So, you would have to hand dig it, there is no dynamites or bombs to blast and then build a well, everything was handmade. So, it took a long time. So, what people did is to rather going deep groundwater, they used to capture the rainfall into tanks, and other systems dams, canals, etc. So, we will be looking at what has happened to these water resource structures in rural regions or whatever it was used for irrigation.

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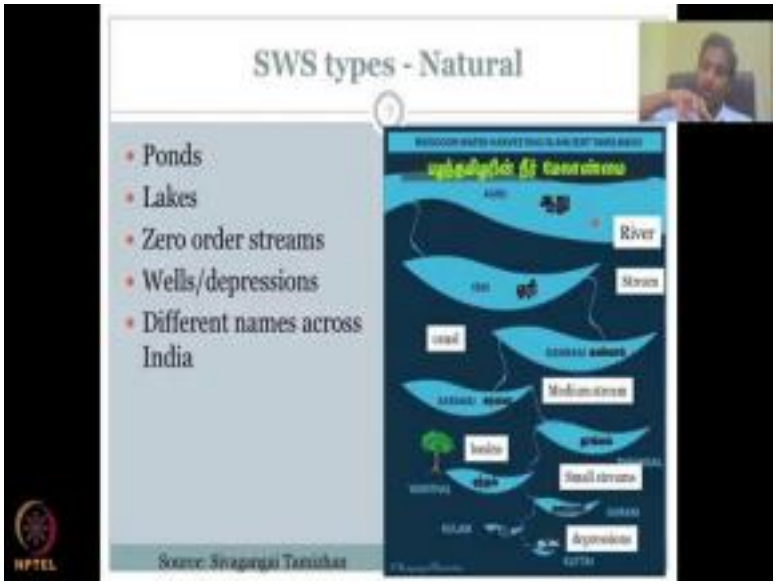

So, the first type as I discussed, let us look at some SWS types naturally there. First are ponds, you have these ponds in locations where there is depression, so land is not flat, you have uneven landscapes, some land is depression and somewhere you have a slope. So, you do not you do not see a natural land which is very flat, the natural because you dig it until it to make it flat.

So, you would have all these uneven disturbances or depressions in the land. So, those contribute to small, small water storages. So, what is a pond as everyone knows, ponds are small units in your land that can store water. And lakes could be visualized as a bigger lake. But knowing all these natural events, you can also have manmade ponds and manmade lakes.

So, the image that I showed previously is a manmade pond. So, understanding from nature a lot of farmers have included the same concept in engineering aspects. So, ponds and lakes or natural depressions, where water would be stored, runoff happens and from the runoff water gets stored in ponds and lakes.

Then you have zero order streams. So, stream order is something that connects or understands how a stream converts into river. So, when you have rainfall, some small streams are formed and small, small streams connect to bigger streams and then come back into the bigger river. So, you would have known from the watershed diagrams I showed in the last class, it have a stream which is coming and then another stream coming and then they combined into a bigger stream.

So, what is the zero order stream? Zero order stream is something that does not connect to another stream. So, it just flows and then stops. By the time the water flows, it is either

evaporated or transpired because it is taken up by plants or in other words, it can also go into the ground as groundwater recharge. So, by the time the water converts from rainfall into a stream and flows along a river or a stream, if it gets lost without connecting to another stream, it is called zero order stream.

So, you can visualize it as a long elongated water storage, because water comes in and gets stored, but by the time it goes to the end it is lost. So, zero order stream can be visualized as a water storage. Wells and depressions as I said some natural things can also be manmade, for example, a depression on the sides if you make some more space a little bit of disturbance you create it could be a well.

Some wells are naturally there if you go to depression and you see some water seeping on the sides, so that is becomes a well, you can find these kinds of wells in mountainous regions, if you go there, you see always a water which is being stored, it can be from rainfall, yes, but it can also be from groundwater giving in. So, whenever there is a groundwater influence it is called a well, if it is only a surface water influence, you call it as a pond, pond or a lake.
There are different names across India. India is a very beautiful country where every single state has its own language, different cuisine food, spice level and different way of clothing. So, in the same way, you would see that beautifully they have kept different names for their water structures. And also there are different methods, actually how they used to harvest the water. I want to give an example from Tamil Nadu where you could see that the village go from the bottom to up, the size wise. So in my explanation here, I did not go fully by size because ponds, lakes wells, depressions there is no size order, but in this diagram beautifully they have shown. So, let us go by size.

So in a watershed when rainfall occurs, the first things to form are small, small pools of water, we call them pool like just you can five people can stand in that water, it is called a KUTTAI or in other words a depression, a smaller depression can lead to a bigger depression. So, you could see how this water is leading to the, so, from the bottom up, the size is increasing. So, a small depression can become a larger, larger depression and eventually it can become a pond. So, a KULAM is a pond. So, we have a pond here.

Then what happens is these ponds and lakes can actually give water to a small stream. So, when for example, you have a pond, the stream can come into and deposit water in the pond, also when the pond overflows, it can give water to a stream. So, that is where we see that once you have these small depressions filling up with water and they can no longer fill up more water, it can go into a bigger prospect, so bigger prospects will be a basin, where water

is caught, catchment, where water is caught and kept. What is the basin like you have in your sink basin or kitchen sink basin we call? It is a big storage for water well, where water is stored, so you can also have a big pond or lake.

So, these would then eventually give up water to a slightly bigger stream called a medium stream, these streams are of different levels, you have a small stream coming from small depressions and then the depressions can give way to a basin and then you can have canals, where natural canals are there, similar to a stream network you have natural flow paths where water is taken from the medium stream into a larger stream.

So, YERI is a bigger stream and now the small stream has become a medium stream and then a larger stream. So, once it becomes a larger stream it gets into a big river,. So, this is how you have different water storage types. And once the water storage types have filled up, they get connected to a different water network.

So, here what are the water storages, we do have depressions, we have small basins, ponds and we also have lakes. So, all of them in connection or when it is connected through a channel or a stream, it goes into the bigger streams. So, at the end of the day you get into the rivers, which is your discharge. So, it is beautiful at precipitation converts to these storages and once a storage fills up, then it passes on to the bigger river.

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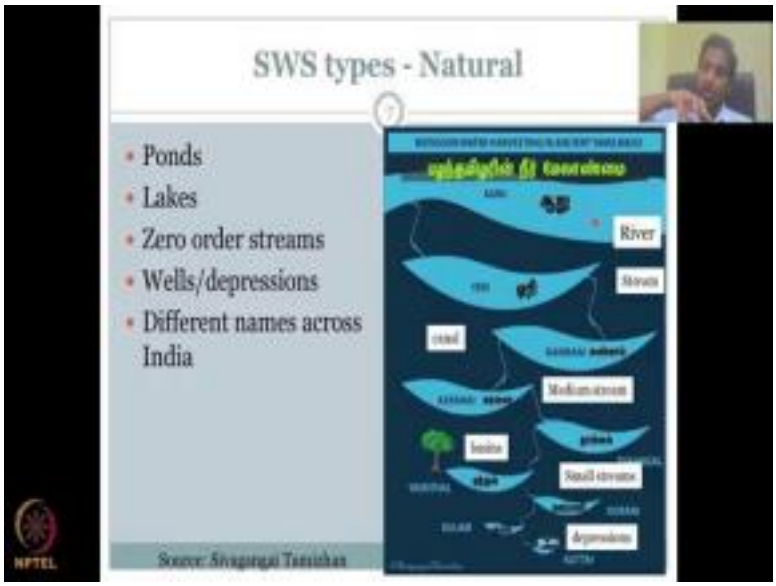

As I said, India is very beautiful in terms of the diversity we have, and there is a very unique country in the world that different origins of language, food, culture is there. So, that is being reflected in the water also. So, what is very connected to people, you would see that without water, it is actually connected through their food, their lifestyles, how they spend their time, etc. etc.

So, here, let is look at some of the water storage structures across India. Let us start from north and go down to the south. In the north you have in Jammu and Kashmir Kuls, where these are fed by snow melt, we can see the snow melt background and you have snow laden Himalayas and when there is big snow melt because of the radiation and Sun's heat, they come down and form big ponds or lakes. So, these are called Kuls.

Then on to your West, you have Zabos in Nagaland, where Zabos are along the trenches, so, they have trench farming and along the trenches, they do have some water storage, so, they are doing terrace farming, so, they cut on different levels and on the terraces some places they do have water instead of having irrigation or putting crops they can dig it deep so that water when it comes can be stored. This one is a beautiful structure because on the all the water that are becoming runoff from the river or also from your roads can be stored here.

So Bihar you have a Ahar Pynes, which are also similar in nature, we could see between the field and the road, we do have some structures where water is being stored. In Johads in Rajasthan it is more like a check dam, where larger manmade lake is being created by creating embankments on the side and then they actually block the water from flowing and storing the water there. You do have similar kind of networks in Virdas, Gujarat. So Virdas is also kind of check dam on these locations.

Then when you come to Meghalaya, you have bamboo drip irrigation, where the stored water

is being sent to or distributed across the field using bamboo irrigation. Then you have Surangams in Kerala and Karnataka. So, name is being shared similar because of the origins of the language and what is Surangams means it is like a tunnel. So, they have created tunnels where water can go in and be taken from one place to other or even stored there, because tunnels are in mountainous regions, you would not lose that much water.

And coming back to Tamil Nadu, we saw here also how it is but in this image to the size, we have Yeri, Yeri is like upon big pond or lake which is having embankments on the side manmade which is basically dug up mud or some stones that are kept on the side and then the water is just kept within the boundary.

So, there are major surface water storage structures in rural settings. What are the major types they are all traditional in nature, the natural ones I am saying. They are dependent on the rainfall, soil type, slow and availability of materials. Please understand that depending on the rainfall, these structures would work, you cannot put a Kul system in Gujarat because the water is too much in the Jammu and Kashmir regions, whereas it is very small in Rajasthan and Gujarat, these are semi-arid or arid regions.

So, the type of the structure changes because of rainfall type and soil type because some soils can hold the water whereas some soils cannot. So, you cannot expect the same structure to be used across India. Also the slope plays a vital role, you could see the slope in Nagaland being straightened out, and then storing the water where that practice cannot work in Gujarat. And availability at local materials like the bamboo irrigation, or wood, which is kept on the sides of Ahar Pynes to stop the water from flowing on that sides, etc., etc. Local materials also into the rocks here, for example, it is made by tunnel, so you need a big rock, any area on the sides, they will keep the rock materials. So, all of this depends on the local materials.

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So what we have come across this, all these natural types are mostly traditional knowledge, lot of trial and errors the people have tried, and they have settled in a particular type. And these have been there for generations, hundreds of years. So, it has still working in many regions, for example, the Anicut in Tamil Nadu, Tiruchirappalli district is the oldest in the world, oldest in the world of a water structure that is still operating. And some people call it as a dam, which actually channelizes the water for irrigation.

So, those who would like to check it out, you could check out the history of Kallanai Dam, it is called a dam and Anicut both because it does store water, but an Anicut actually changes the course of the water direction. So, that is both is being achieved in this meet project. It is, it was done by the Cholas and it is still working very well.

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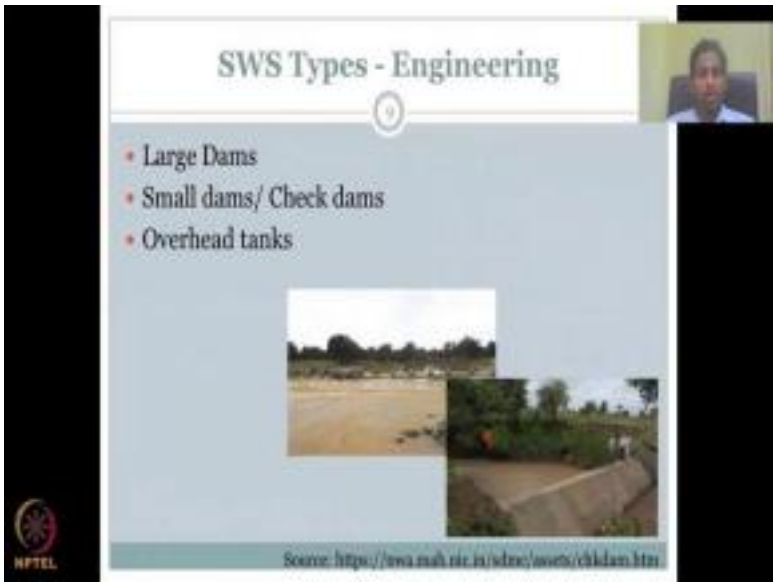

So, let us move on to the engineering types. These are more, newer technologies with concrete and other materials that are being used widely. The first engineering type is large dams, where a large piece of land is taken and evacuated, which means dug using JCBs and other heavy machinery and then on the banks, they put cement structures or embankments using mud and the most important the outlet is blocked, the outlet is blocked using a big wall kind of a structure.

So, those are large dams and everyone knows our dam looks like. And then you have different sizes of maps, you have a large dam which is used for hydropower and also irrigation water supply. And then you have small dams or check dams which are much, much smaller in size and budgets. And then you have overhead tanks where water can be stored in a tank on top of the houses or also you have tanks underground like petrol tanks, so all these tanks can also work and they can store water. So here what I have shown to you is how water can be stored in different volumes and as the volume increases the name of the structure also changes from dams to tanks.

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So, to conserve this water, it is very important to monitor, how much water we have and how much we use. We need to have a record of the level, water levels in the device. Imagine it is a pan and inside the pan you have water, rainfall, stream discharge, runoff, etc., etc. So, now to conserve the water or know how much we use, we need to periodically measure the level of the water.

So, monitoring is done by actually putting a stage so, you still see this measurement device or a painting on the wall is called a stage where it has markings for different units and basically you collect the data every day or how the level changes. So if you know the level is changing and if you know the size of your water structure, you can calculate how much volume is lost.

Same way if you know water is coming in and the level is rising, then you know how much water volume is coming into the system. So both the water coming in and the water release can be monitored by this simple measurement of the level. So, the water monitoring does need to know how much incoming water is coming off from the discharge and stream networks.

In the same way you also have to need to understand how much is released for irrigation or pumps are put and taken for lift irrigation so how much water is consumed is also very important to document. And it is also important to estimate losses, for example, it is a stored water. So, there is always evaporation please remember the evaporation we discussed, what did we discuss it is from open surface. So, this water storage unit can release water into the atmosphere through evaporation.

So, all this can be monitored if we periodically monitor the level of your water storage structure. That is very, very difficult in nowadays because it is very expensive to have a meter there and there are other issues on putting a meter, we will cover that in the separate lecture

but right now, we do not have good data for smaller structures, large dams, yes, we do have good data.

So, every day we know how much water is coming in, as some litre in the entry point to the dam and also they know how much water is released, because they could be similar to the entry point they put an exit point measuring device on the dam and they have an evaporation rate for that particular location. So, both incoming is monitored, evaporation loss is monitored and your release is monitored.

But also there is groundwater discharge and recharge. So, there are some things which have to be assumed because it is very difficult to measure groundwater coming in and going out because then we do not know how much evaporation is happening, how much groundwater, so somewhere it is being clubbed with evapotranspiration the losses. So we just look at as a loss, we look at as entry, as a positive to the system, the negative part is a loss due to evaporation and the water released is the negative to the system.
So, at the end of the day we have a structure like this, this is the work we did for Rajasthan and Gujarat under the MARVI project, where we basically said to the farmers please monitor this, and they did not know how to monitor, they did not have a scale. So, we just painted it.

We just made a wall along the river, and along the dams. And then we just put these structure things and said, okay, just now monitor, have a book and then take the readings every day, you know that at least, at least how much water was there compared to previous and today.

So, if we know how much water is that previous day and today, then we can know how much water is actually getting stored or losing from the system. And if we know how much water is stored, we can plan for irrigation. We can plan on a crop to irrigate the water. So, all of this is being covered by just a simple monitoring device or a monitoring exercise.

So, it is very important to monitor. And this is how one of the simplest methods to monitor surface water and storage. With this, I am concluding the water storage lecture, let us meet in the next lecture on the other topics that we will discuss with the Hydrological Cycle. Thank you.