Rural Water Resource Management
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Lecture 46
Rural Water Resource Management Infrastructure (Nature-Based)

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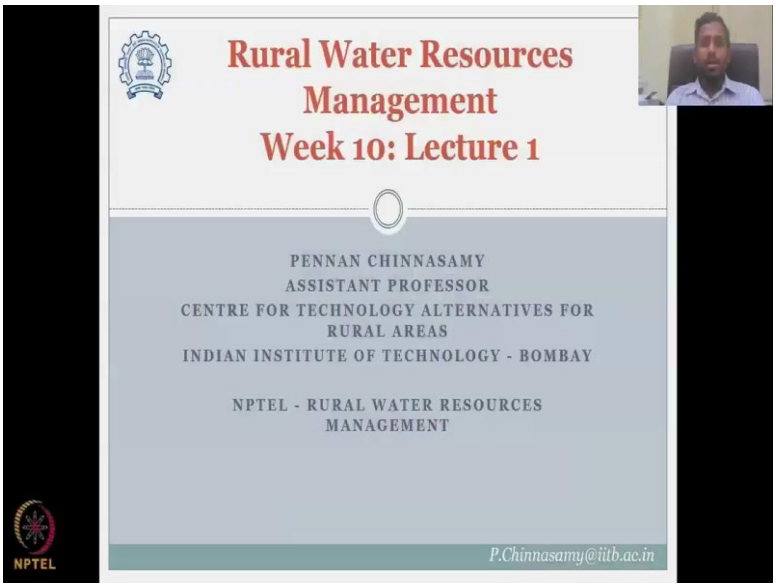

Hello everyone. Welcome to the Rural Water Resources Management, NPTEL course, Week 10 Lecture 1. We have been looking at water management issues in rural areas especially due to the increase in domestic agriculture and industrial demand. And we have been noticing that most of the regions are going to be highly stressed in the near future because of the business-as-usual scenario and climate change impacts.

So it is very important to understand and manage the rural water resources properly, especially for agriculture and domestic laboratories.

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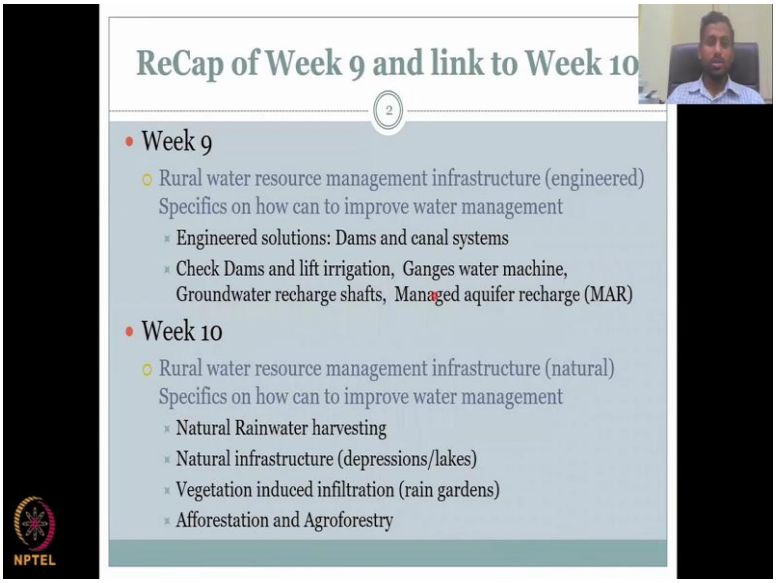

Let us look at what we saw in Week 9. Because of these issues, as I mentioned today, there is a need for infrastructures to enhance the water resources. Enhancing the water resources can be of two types: one is the engineered infrastructures and natural or nature based infrastructures. In Week 9, we looked at rural water resource management infrastructure (engineered), specifics on how to improve the management of water.

We looked at specifically the big concrete and infrastructures that are needed. For example, dams and canals networks. We looked at how we could establish a dam command area and the catchment area. Catchment is where the water is caught to be supplied to the dam. And then the release of the dam could be your command area.

Then we looked at the canal systems as a part of your dam network, as an engineered solution to bring the water to the farmer. We also noted that the farmers may not be in a low-lying elevation thereby pushing water down so you may have to lift it up. And so that is where we looked at check dams and lift irrigations which are more decentralized in manner.

We looked at Ganges water machine for groundwater, decentralized recharge and more in depth of how do you get water into the deep, deep aquifers of the groundwater. For that we looked at ground water recharge shafts and managed aquifer recharge schemes. In this week, we will be doing mostly the similar focus areas and theme areas but we will be looking at nature-based solutions. So it is again rural water resource management infrastructures.

But it is nature-based solutions. Specifics on how to water manage in these scenarios is going to be given by rainwater harvesting through natural methods, natural infrastructures that can be used to store the water like depressions and lakes, vegetation induced infiltration: "How do you enhance the ground water recharge through vegetation induced infiltrations?" and more importantly afforestation and agroforestry.

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So let us jump into this week's lecture. Given the water issues, what are the available infrastructure we have? So I have given a quick example of the water issues in India, especially for rural India. So what are the available infrastructures? Let us look at it.

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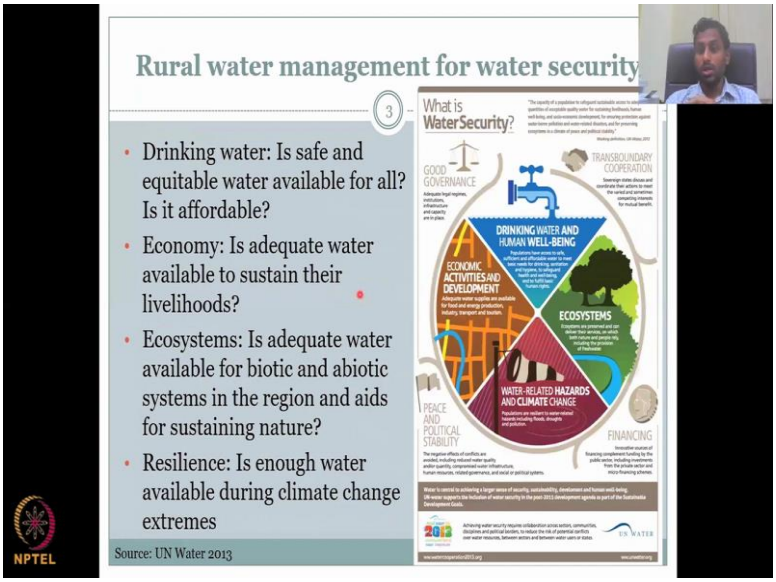

We did look at this definition of water security. And in the definition of water security, we had the 4 pillars which is drinking water, economy, water economic upliftment, ecosystem services and resilience. Where do you think nature-based solutions fit more? Yes, all these infrastructures would have to enhance drinking water supply, provide water for economic stability and provide resilience to climate change.

For example, droughts and floods. But more specifically, it has to be providing the ecosystem services because you are a nature-based solution. Drinking water tanks, underground tanks, sumps etcetera are clearing the land; clearing the soil, putting concrete etcetera, thereby reducing the ecosystem services.

I hope you understood last time when I discussed this water security theme. We have to be careful that if we do engineering, your ecosystem services are going to be disturbed. Big dam is there. Water flows and what happens is water is stored, but then downstream the ecosystem services are compromised. So that is where we need to be careful on releasing the water in a timely fashion for nature-based ecosystem service.

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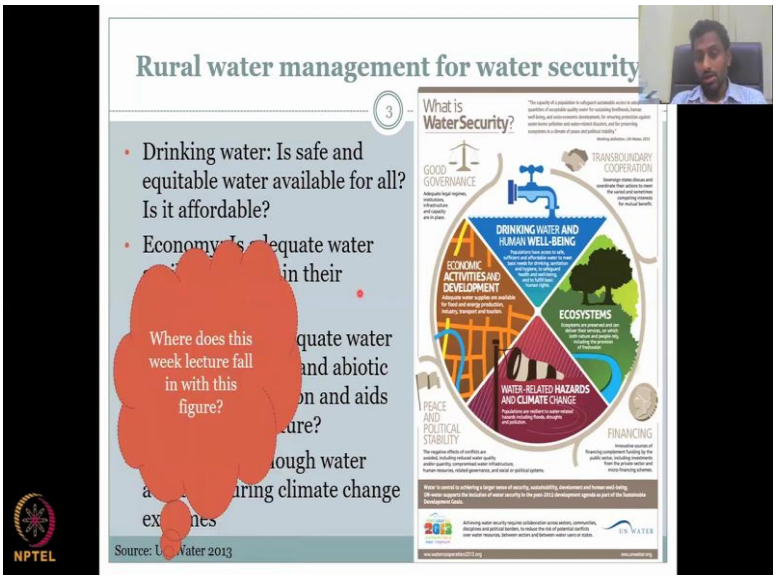

So today's lecture or this week's lecture will be mostly focusing on the ecosystem services. Yes, it will go through all of it; all the 4 themes but most importantly it will look at where does rural water management, which is nature-based solutions, help the ecosystem services and more stability to the ecosystem.

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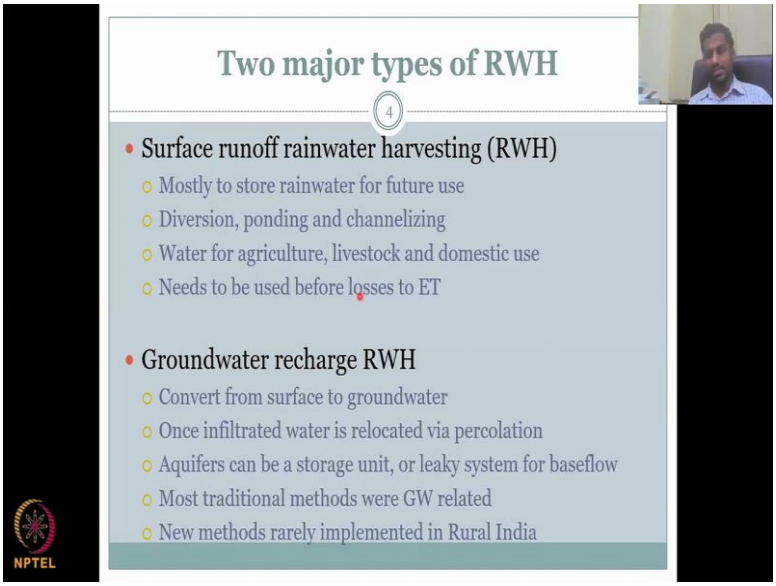

So now there are two types of rural water harvesting networks and rainwater harvesting networks. So let us look at the two types of rainwater harvesting using nature-based solutions. So the first theme we are going to look at is capturing the rainfall and then using it for different aspects. So how can we do rainwater harvesting?

Surface runoff, rainwater harvesting is the first theme where you capture the rainfall after the runoff has been generated mostly to store rainwater for future use. Diversion of the water, so rainfall hits on the roof, plants, trees of the road and then it turns into runoff, then you capture the runoff for future use using diversion, ponding, channelizing etcetera or water for agriculture, livestock, domestic use.

But if you pond it, you have to be using it before the evapotranspiration losses. So that is the first type of rainwater harvesting wherein you capture the rainwater and use it for surface applications. Be it storage or be it applications such as agriculture which is on the surface. But there is another type of rainwater harvesting also, which you can do groundwater recharge using rainwater harvesting.

Wherein you convert from surface to groundwater because you are capturing the water and instead of letting the surface water runoff to generate, you are pushing the water into the groundwater. Once the water is infiltrated, it can move further due to gravity via percolation and increase the groundwater storage. So aquifers can be a storage unit because you have a big groundwater storage unit under the ground.

In porous spaces, the space between the solid, the sand particles you have spaces where water can store. So those spaces collectively can be a storage and it can be a leaky system also because once you build a water table, it will start flowing from high potential to low potential to the rivers, streams or even your oceans etcetera as baseflow.

If you look at the traditional methods for rainwater harvesting, most of them were having this ground water ideology in the background. For example, we would have a village tank, village pond, etcetera where all the street water would be channelized to go to this pond and lake. But the pond would not be lined underneath, whereas water would be just going down as infiltration.

There was much less use for agriculture, like capturing the water, putting it into the pond and agriculture because there was no pumps. They would use it for domestic use like drinking, bathing and your animal washing, etcetera but not much. New methods are rarely implemented in rural India.

If you look at it, if you go there, it is more traditional base knowledges and less newly applied methods. However, in the recent visits I am also seeing that the old traditional methods are not maintained well. If you go back to the previous lectures over the weeks, we have been debating that if they do not maintain, it is a big loss and they lose the system.

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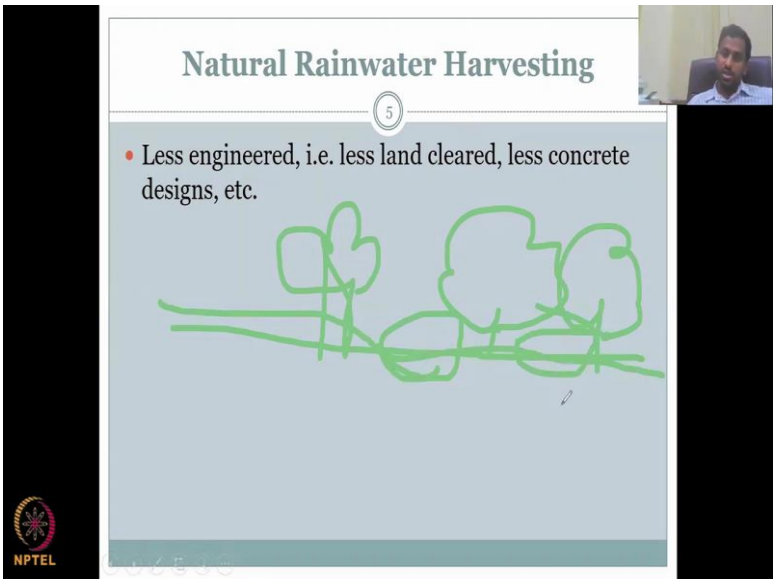

So let us look at the nature-based rainwater harvesting. Call it natural rainwater harvesting or nature-based, the question is are you using less concrete, less construction for rainwater

harvesting. I would say zero, zero construction, etcetera. But still you have to do some movement of stuff so there is more nature-based solutions and you would also use natural settings; not levelling the field, not creating buns etcetera. It is all a naturally built.

So let us see, what is the benefits of natural rainwater harvesting and we will look at some examples this week. It is less engineered. Example or that is less land is cleared, less concrete is poured on the ground, less need for concepts of designs, etcetera. So if you are having, for example, a land, you are having a land and you have you are wanting to store the rainwater.

You do not clear this land. You do not make it straight where which is done in the engineered method and no trees and plants are lost. You still keep them. You would try to build storages in between the existing nature's benefits and nature's parameters rather than removing it and making dams and check pits. So how do you evolve together is nature-based solutions.

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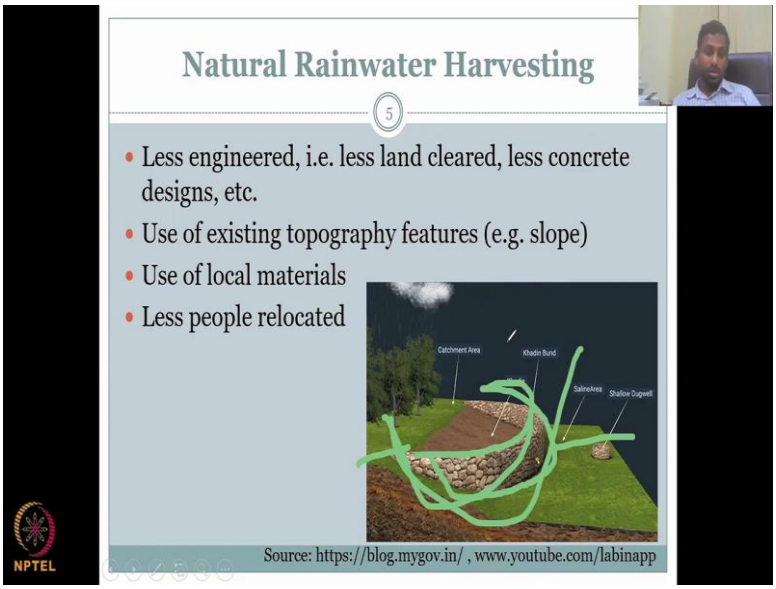

Moving on, use of existing topographic features - The first thing is, you are not levelling the field. As I said, the undulations, the up and low of the topography is preserved, example, slope. You have a slope. You do not make it straight or dig it more deep and then pour all the water in. So now you are going to get an idea that these are not big systems.

Nature-based solutions are more smaller, more decentralized, and localized. This is what the ancestors did, the traditional method: easier to maintain. And you are not stopping a lot of water which could be of use for others. You are recharging small volumes. You are also

bringing more water from outside the rainfall and channelizing, etcetera and bringing it into the small ponds. You are not clearing the land. You are not making the land straight, etcetera.

So basically, all the land, all the vegetation, etcetera is preserved. You are just making some small changes and also maybe bringing some nature, native species and you are putting it into these structures. Less people relocated. This is very important. You are not asking people to leave the land and go because you are going to have a dam. You are going to be in between the houses, in between the villages, how can you do it.

So one quick example would be this. See, if you look at it, the slope is not compromised. The slope is not taken away. The slope is slope. So I would, I would say that I would for example, you could say, “Oh, why do not we make it deeper?” “Why do not we straighten it so that the water stays in here?” No. So that will be more engineered. “Why cannot we make a wall which is more cement and concrete?”

No, that will be more engineered. So what do you want is something which is very nature-based and here you could have seen that the land has been identified as a sloppy land. A small pebble rock base dam is created, okay, wherein water can go in and store. There is also a small dug well which is dug just removing some soil out. That is it. All these dug wells z1could be kind of between the nature-based and engineered because you are not putting too much of engineering and you are not clearing big land.

So there is a bun and here you could have because of the water even if water stays there, all the plants would die. So you remove some of the grass, not the trees. Look at it. The trees are get as is and people are not relocated. So once water gets stored, it gets to infiltrate more and by infiltration, it can recharge these wells and other locations.

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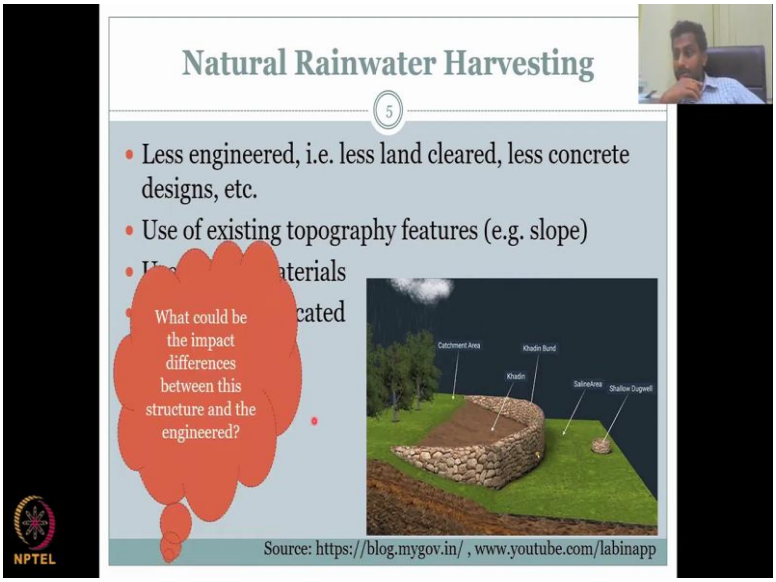

What could be the compact difference between, impact difference, sorry, between the structure and the engineered? What I am asking is how much of water would be recharged by these kinds of systems compared to a dam or a pond or recharge pit, is the question. So do you think there will be much differences? Yes, these are more slow and the volume is more or less because you are preserving the environment.

You are not clearing the land. If I had cleared this land and made a big pond or an embankment with all this material, I would have more water to store but I did not do it. What I did is rather I preserved the slope. I preserved the condition by using the local materials and I infiltrated the water. This is what has to be taken by nature-based solutions. It is easy to dismantle also. Just think about it.

You just remove the boulder, let the water to flow and this system can reproduce into a forest or grassland like this, like quickly. However, if you do it with engineered systems, they will not re-bounce back to the original state. It will take a long time. So the impact is high. But understand that it takes time for clearing. You are losing some features in engineered whereas less features are lost in the nature-based solutions.

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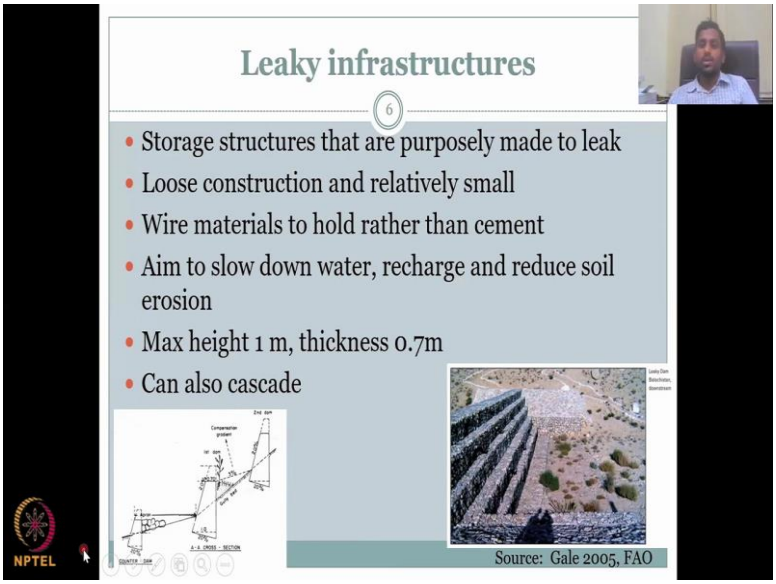

Let us take a dam which can be a nature-based solution and less impactful on the surrounding. So the other aspect is the nature-based solutions are less negatively impacting the area even though the water is also less-ly, low recharge is happening, low storage is there. However, the impact on the ecosystem, on the nature is less. This could be the same by using an infrastructure with some features to consider nature.

Let us take a leaky dam for example. What is a dam? A dam has to store water. It should not have leaks. It has a gate where you can open, send the water. It has a channel where water can be released. But what is a leaky dam? It is purposely made to leak from the walls rather water is stored, water comes and gets collected and it is leak like constructed very leaky so that water can still pass through.

So you have some water, yes, but then water can still pass through. So look at this book from FAO and images. You could see that storage structures that are purposely made to leak. You are bringing the rocks and making these step dams and making sure that water can pass through and if water passes through, it gets to recharge and you know get more water to the ground. Loose construction and relatively small.

If you look at the construction itself, it is not big as a big dam. So nature-based solutions are small and loosely constructed so easily people can construct it. Just bring all the rocks and then make it. If you think about it this is how the natural setting, the animals and small insects

will also do. It make something just bring some materials like a bird building a nest. That is not a construction.

Even though it does make a nest by bringing twigs and making a weaved nest, it is not called a constructed nest. It does not impact the nature much. Same way here. You are bringing all these. You are using wires, for example steel wires to hold on to the rocks and the water goes slowly. Why materials to hold rather than cement? Think about it. If you use cement water cannot pass but you use steel wires that can actually hold the rock so that the water can pass.

The major aim is to slow down the water, recharge the groundwater and reduce soil erosion. Because when water flows fast, there is a lot of soil erosion whereas the recharge would take time. So to slow down. So if you slow down the water, you can get more recharge. The maximum height, thickness given by FAO which is just 1 meter. Not too high, just 1 meter and thickness is around 0.7 meters.

So you can easily collect the local materials. I said the nature-based solutions have local materials. You do not have to bring cement. The wire, yes. The wire you may not get it inside but you can see the point. It is not fully constructed and you could see that all the area can still get water because of this and it is going to enhance the nature of biodiversity. You can make it also cascade as I am showing in the engineered system like a check dam.

Whatever approaches that we use for check dams can still work here. But most importantly, it is leaking. So, more water will pass through the check dam like this. So you build one leaky dam and then this water will go to this one, this one will go to this one. So slowly slowly it ponds and then water moves.

So if you look at a check dam cascading impact in a constructive manner, the water would actually stay in one dam fully. It has to be fully coming to the brim level, then it goes to the next, then it goes to the next. But here if since you have rocky, leaky material, water will go stand and then still continue flowing down even though the full dam is not reached and then goes down, goes down again.

So this is one type of materials that you could use to construct leaky infrastructures so that water is always flowing. You are not totally taking the water out but there is a lot of nature-based solutions.

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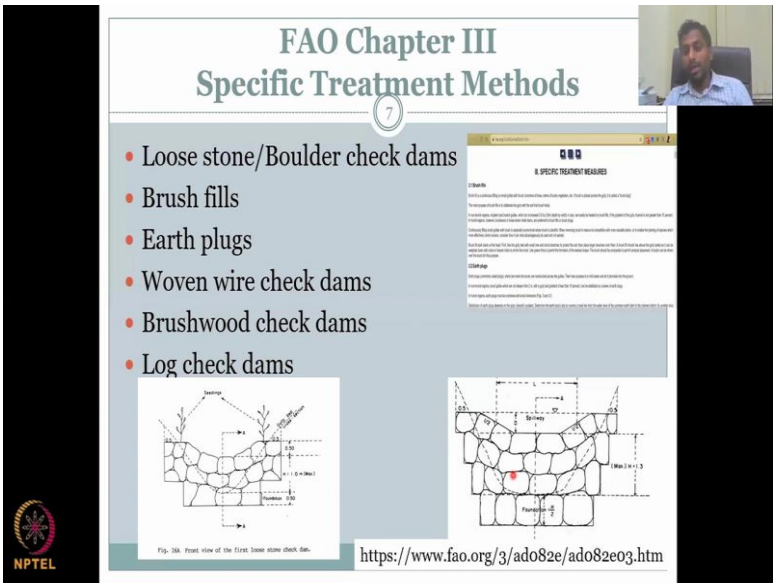

So there are a lot of specific treatments as given by FAO. So this manual I am sharing, this is the Chapter III, the link is given below. You can go and check a lot of materials that are relevant for these treatment measures. So treatment as in what type of check dams you build using the nature solutions. So you can build loose stone that we saw in the previous one. Boulder check dams: big, big rocks piled behind one another.

Brush fills so you can have these dams and inside the dam you can put some soil and grow some brushes or like small, small plants. So they will fill the space. So the leakage will be there but even more reduced. So if you have 20 percent water leaking in the loose sand, you will have only 5 percent in the brush whereas it is 0 percent in a cemented check dam. Earth plugs can be done.

Here you put instead of cement and concrete, you can put in soil that can be there. So soil is not totally impervious. Water can still pass through. So those kind of earth plugs you can put and most importantly they do not harm the nature. So, for example, the check dams broken. What do people do? They just leave everything, go to an X location. What happens to the rock, the cement? It does not degrade.

Whereas here earth plugs, brush fills everything will degrade and then become soil again. So that is also what is called more as a nature-based concept. If you let it go away or not use it, it will still bounce back into one of the nature products. For example, I have a steel bridge. If the steel bridge falls down what would happen?

The steel is steel. It is just rusted. Maybe 1000 years, maybe 500 years it is just going to be a steel and slowly rust away. Whereas if you take a wooden bridge, if it falls, within 10 years or 5 years, it will be degrade, go back as soil carbon, get, taken up by the plants and then live as another living organism. So woven wire check dams, we have seen that in the last.

Brushwood check dam where you can make a check dam using wood rather than rocks and pebbles, log check dams, big big logs can be treated and then put. All these are nature-based solutions. So you see here how you are coming out of using bricks and stone and mortar rather than you are using earth plugs and rocks and stones.

So this is the example, first example I would like to consider where you have a rock check dam, okay, rock base check them and inside it there is some earth soil which has been inserted. And along the inserting you put seeds, seedlings, small plants. What happens is the plants would let the roots grow in. So once the roots grow, the soil is held tight.

So even if water comes, it would wash away the soil totally. It would wash away the plant but slowly the water will be released. So here is how you convert a concrete system; so plan cannot grow in concrete. Only one on the walls you would see but not exactly as a full plant. But here it can grow fully and still work as a dam. Here it is just using big, big boulders rather than concrete and in between you would not have anything.

So water will just flow through as a leaky stone dam. So what we have seen here is we have taken only one concept as check dam and then we have seen how we could build it on a location by not clearing the land, by not making it levelling, level through concrete networks or bringing a bulldozer and making it straight.

You are making small nature-based check dams. And when I say nature based, it has to be built using nature concepts: rocks, stones also are included. When you convert rock and stone to a cement that is not included because you are engineering. Here we are just using the concepts and also most importantly, wood and forest material to build these kinds of networks. Once you have done that, so that is the first part.

You have a nature and nature-based solution. The next part of nature-based solution is: “Is it completely storing the water or is there some aspects that can help in release of water?”. There is no engineering. There is no valve to open and close. So water can still slow down using gravity but at a much slower pace.

So as I said, all these studies have been testing all these and looking at different methods to evaluate these check dams and traditional methods which were lost during the previous centuries. Why was it lost? Because they did not want to let the water move and they did not want to manage it. If you engineer it, the management time is less because it will stay there for a long time. The rocks are not loose so why would they move.

But if you pile up the rocks and then water comes, it will slowly it moves out. It is like building a castle on a beach. If you build it with rocks and plastic, it will stay even if a wave comes. But then if you build it with the beach sand and then make a small puddle, then water comes and then it moves away. So each time there is good maintenance.

You can rebuild it again quickly but it is less expensive, time consuming, those kinds of aspects. So if you have the time, if you have the labour for the people, through the people, it is always best to have nature-based solutions. In fact, big, big countries and developed countries like Singapore, Malaysia, they are getting into these nature-based solutions.

So that yes, they store the water but also, they do not harm the environment because they want to store them. With this I will be happy to show more examples from the next class. I will see you in the next class. Thank you.