Rural Water Resources Management
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Lecture 50
Agroforestry for Water Conservation

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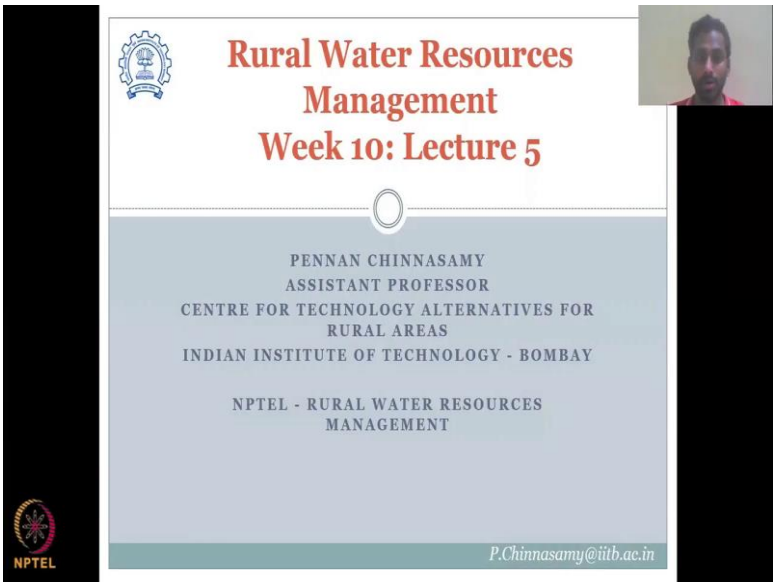

Hello everyone, welcome to NPTEL course on rural water resources management. This is week 10, lecture 5. We have come to the end of week 10. And we have been looking at natural methods or nature-based solutions for improving the land use land cover. Basically, adding more green, natural green to the system, which directly influences the water balance by slowing down the water, and causing more recharge.

It directly influences the water storage capacity in the soil, and thereby improving the water in the rural setting. In the last class, we looked at forest cover increase using reforestation and afforestation. Wherein, afforestation is planting trees on a land which has not been forested or converting a barren land into forest.

Whereas, reforestation is converting a forest land, which has been degraded into a forest, which means, you are taking a forest, initially forested land, but now it is no more of good forest. So, you convert it back, you bring it back to life as a forest. Now, when you bring that forest back, what happens to the water budget, we claim to say that, the forest, water resources would increase.

We claimed that the water is more stored in the soil. And we claim that the soil quality is good, quality in terms of the nutrients in the soil. Also, the soil thickness increases, because there is a lot of biomass regeneration going on. So, let us see from a particular study how this happens. That will be the first aspect in week 10, lecture 5.

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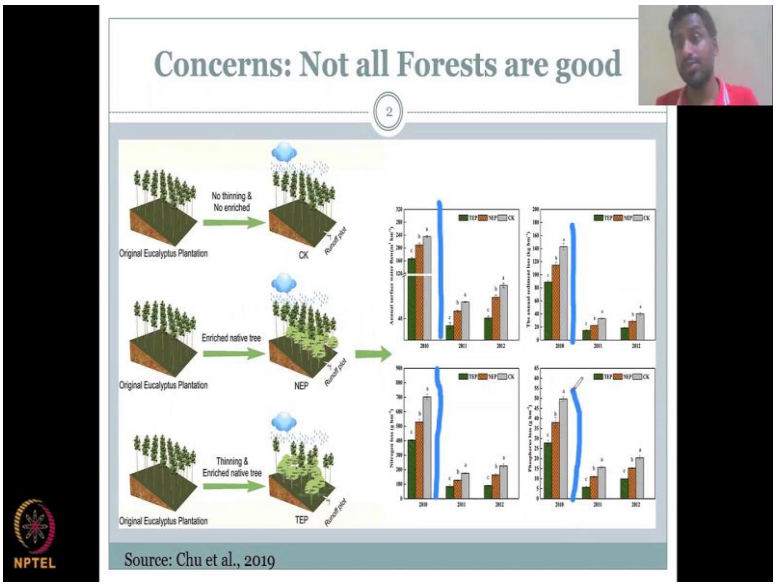

We will be looking at a natural forest, and show how trees can improve the water quality and soil quality. But also, this study by Chu et al., 2019 shows that not all trees are good. You can plant eucalyptus as I said. But eucalyptus, by itself is not a native for most regions. So let us see, when you have an original eucalyptus plantation, this is the study they started, they are starting with a forest which has eucalyptus plantation.

And they want to improve the water content in the soil, the soil quality, which is nutrients, and also see how it is going to be beneficial for the rural environment. Just bringing a forest would definitely improve the water, but if you do not pick a good forest, it will actually backfire, which means, it will cause more damage than initially was. Let us look at an example, you take there is three experiments.

The first experiment, you take an original eucalyptus plantation, and just let it rain and then you look at the runoff. So, when a rainfall happens there is some runoff, which is collected which is the water from the watershed is collected in the stream or river, and you could see that the annual water flow is high, which is the grey colour.

Loss of water is high, loss of sediments is high, along with sediments, nitrogen and phosphorus is also lost. So, once all these are lost, then you do not have much forest to develop. What would be the case without a trees? This will be much, much higher. Because there is no trees, all the water will come down, the water will take the sediments out.

So, it will be soil erosion. So, it will be very, very high. All these will be very high in terms of no forest, just example, I am saying. However, between the forest, you can have different trees that behave differently, and conserve differently. The first is you have an original forest, which has been converted into eucalyptus trees, why eucalyptus? I am telling about eucalyptus a lot.

So, one should ask me why. Why, because eucalyptus grows easily in less maintenance, and grows very fast. Within five years, you will almost see a mature tree; it sells very good the tree, the wood sells good price. And it is also medicinal value. Eucalyptus they leaf, they use it for all these medicines, cold medicines. So, when you do not have any management on the forest, then lot of runoff is coming off, water is lost.

However, when you put native species inside, enrich native trees, which means in between and in some locations, you are putting wherever spaces, you are putting the native trees and letting them grow. So, the light green are the native trees. The eucalyptus is very, very long, it just grows tall, and it would prevent other trees from growing because it is tall, it can shade the sunlight. And so, the other tree, small trees cannot grow quickly.

So still, when you enrich the native tree, which is, for example, neem, then you would see that the soil loss, the water loss, the soil loss, the nutrient, which is nitrogen, phosphorus loss is coming down, the orange is coming down compared to the grey one. So, it is good, very good, your losses are coming down. And between the years also the losses are coming down, which could be an impact of growing a forest.

As I said, just growing a forest, you could see all of this coming down. From here to here, all of this is coming down, and also depends on the natural condition for that year. The last experiment is where you create space, you create space for the native trees to grow, which is called thinning, what is thinning is, you are removing some trees out of the forest, you are removing the eucalyptus trees, so thinning and enrich native tree.

So, you are thinning the trees, you are cutting down the number of eucalyptus and replacing them the same spot with the native trees. If you do that, then most of the water is stored, you see the green colour, that is the TEP, where you have thinning and enriched native plantations, you could see that, all the plots that the least loss of water, sediment, which is soil, and nutrients of nitrogen phosphorus occurs in this plot, where you have cut down some of the eucalyptus trees and replace them with the native trees.

The important factor here is, why, you just remove all the eucalyptus trees and put your native trees, you still have the eucalyptus because of the economic value. So, there is this is what I am saying is a balance. If you convert everything to forests, and wherever the food grow, is the question. So, you need to balance with nature, it is not good to completely kill all the trees and convert it to rice.

And also, it is very hard for people to change from rice to something else, if you do not grow rice in an agricultural forest, I say agricultural forest land, which means a forest land which has been converted to a agricultural field. So basically, you are getting into trouble here, because on one hand, you want to conserve nature. The other hand, you have to feed rice. So, there is a give and take.

And that is what this last experiment is explaining. I am not asking you to cut out all your economic cost, all your profits, do some profit, but also do a lot of native species also, so that your profit continues. In these two steps, your profit will not continue. Maybe in the second one, but in the first one sooner or later, all the sediment is lost. All the nutrients will be lost, your trees will die. So, it is better to keep these native trees and sustain the water, sustain the nutrients and the sediments.

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Forest for water conservation: Let us see how forests help in water conservation. What are the different types of increasing the forest cover? We said afforestation, conversion of barren lands to forest, we said reforestation, conversion of a degraded forest into a forest. And agroforestry, this is a new term we want to see.

Wherein agroforestry is the art of, or process of having forest and agricultural activity coexisting in the same location. And all these three have been promoted widely by the government. For example, in the Gange's mission, to clean the Gange's, and improve the quality of Ganga's water and the land surrounding it.

There has been tremendous support by the government by helping to increase the forest cover. They have already planted 2760 hectares of land in 2016-17 and another 8000 hectares of land during 2017-18. So, all this needs a lot of budget, which has been given by the government through the Namami Gange Programme.

What is more needed is people to voluntarily come and practice these different methods. Because it has been widely documented that forests can improve the soil quality, the water quality, and bring back more benefits to the society. Now, let us look at the agroforestry in detail because we have already looked at afforestation and reforestation. Let us look at agroforestry.

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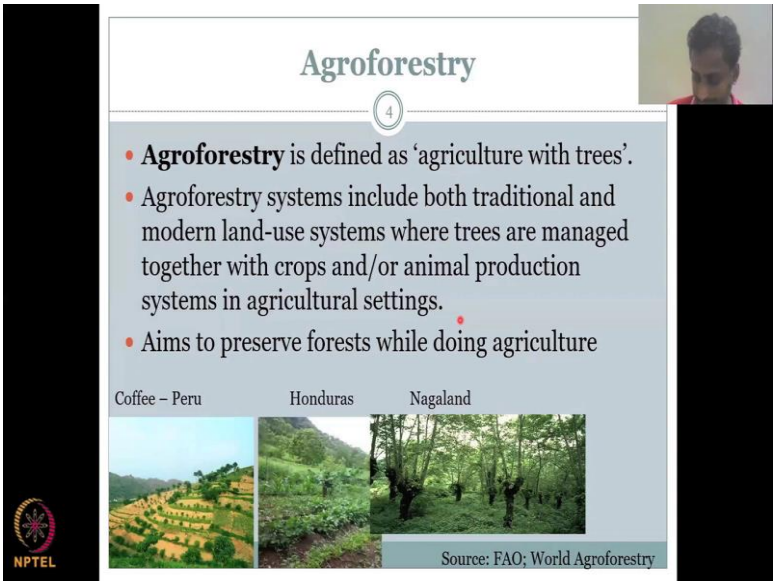

So, what is agroforestry? Let us define it quickly. It is defined as agriculture with trees, which is very simplify explanation by the FAO, and World Agroforestry. What happens is, you have agriculture and trees, the forest trees, which are growing and that is where the forestry comes and the agro comes, agro comes in front which means more or most of the land.

So, if someone can ask, is it percentage 50 percent agriculture, 50 percent forest, it depends. There is no set rule, but at least you should have 30 percent of forest, still most of the land is agriculture, or food products are grown because to sustain the human population, they do a lot of agriculture.

Let us look at some of these examples where agriculture is existing with trees. Here in Peru, you have these mountain slopes, if you just have coffee plantation, then when a solid storm comes in, or soil erosion happens, all of these soils are washed away. This is what happened in in Kerala recently, lot of landslides because there is no big forest cover which is holding down the soil.

So, what in Peru they have done, they have planted trees and forest along the bands. You can see the forest trees along the area, is not fully clear, and then they put coffee. So, coffee grows in between the forest. In fact, there is something called shade grown coffee. For the shade grown coffee, the shade is given by the trees.

It has better taste as per coffee connoisseurs. It is very expensive, and it is health cautious, and nature cautious because you are not cutting down the trees. You are not displacing the

trees to grow coffee. Coffee takes a lot of land. You are growing coffee with the trees, which is important. Especially in the rainforest regions, tropical regions of Vietnam, Amazon, et cetera. India, in India's Coorg, you go there you could see that most of the land is coffee plantation, no forest, but that is what we are trying to promote in agroforestry.

In Honduras and the Nagaland, you could see that in between the forest they are growing some food crops, some spinach and other things that can be sold for a livelihood, and also subsistence farming, which is just for their livelihood, the farmers, the local villagers, they grow it and then they eat it so it is not much for sale. Still, they healthy. They get the food requirements and nutrients.

They can also grow some grass, and some other fodder plants for the cattle and chicken. So, agroforestry system includes both traditional and modern land use systems, where trees, the forest trees grow along with crops and or animal production systems in agricultural setting. So, what is the animal production?

That is where the fish, the grazing, everything happens. So, if you have these forest, and along with that a small pond where your fish is growing, your chickens are kept or your goat, sheep, and cattle are grazing, all these is including in the agroforestry. Because either you are using the land for agriculture or animal production is the same in under the agriculture band. As long as you do not cut down the trees, they are okay. So, it has to coexist, aims to preserve forests while doing agriculture.

So, the catch is, is the forests giving the nutrients to the agriculture or agriculture is also helping to a forest. And in a degraded forest land, lot of studies have found that these sustainable agricultural patterns, so of having some grazing, some controlled grazing, and letting animals go into the forest for food and agroforestry activities has increased the forest cover. Because you are maintaining the land, you are maintaining the water in the crop. So, for that, the trees also take water, the trees also take nutrients and grow well.

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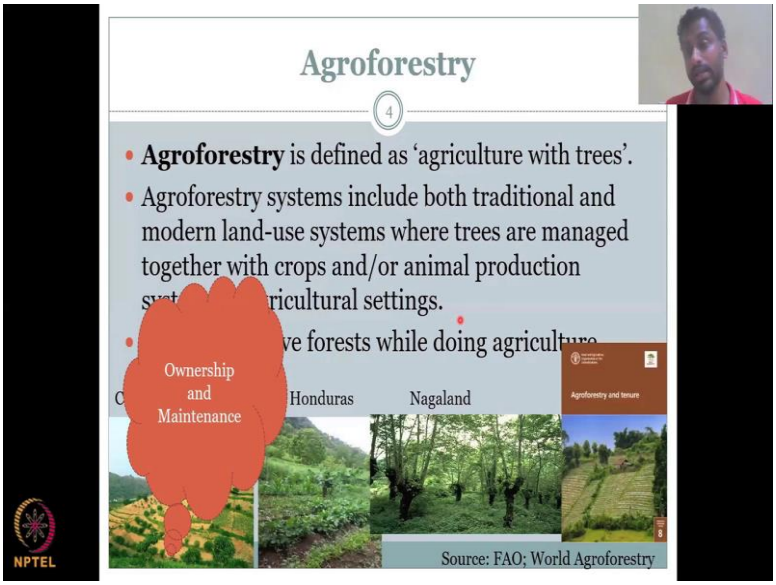

More information can be sought from the FAO's book agroforestry and tenure, which is also by the World Agroforestry. Very, very big institutions that work on agroforestry because you cannot just keep on cutting down the forest for agriculture. Yes, we need to eat. But we cannot just wipe out the forest. So, there should be a balance and that balance is agroforestry.

Most importantly, with agroforestry, there has been a lot of ownership and maintenance because now, people take ownership of the forest. Initially the forest was no man's land, anyone can go in, anyone can do whatever they want. But now you can actually put an ownership, so someone is cutting down a tree, the people who run and say, how can you cut the tree?

You cannot cut the tree, and the people are always there. You do not need a forest officer to maintain the forest or the animals et cetera. Because of the people are always there taking care of the agricultural lands is very hard to do any illegal activities.

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Cooperatives, communities and NGOs play a vital role in converting land to forest through agroforestry, reforestation and reforestation. Afforestation, they would take the saplings and go and planted and then increase the forest cover. And reforestation, they will have to do some management of the land, converted back into a forested land through vegetation. And we just saw agroforestry, where there is already forest, you can in between grow crops.

What is needed, what is needed at the local rural village is quality nursery, the nursery, where we have healthy native species of plants and trees, as a sapling. And water conservation networks are put in these nurseries to provide water at a very sustainable fashion like drip irrigation. And it is mainly managed and maintained by NGOs, scientists, et cetera.

Then they give these to these villages. And mostly women are doing very well in these kinds of activities, agroforestry. Because they do not have to, they cannot manage the whole land. Maybe they do not have time. Or they are getting so here you can see the it is very old. Not just manage entire land, but she can manage the water for her crops.

And since the trees are already there, the trees would take up the water, excess water from the crops and see how the tribal woman is handling the drip irrigation system, in a horticulture area. Horticulture is where you have lot of fruit trees and stuff. So, when you have fruit trees, it does not count as a forest.

So, make sure that still forestry is needed, and wild native forest tree is needed. So, you could see that, amla plots under horticulture has been higher in these agroforestry regions, 40

percent more at this progressive farmers where they control the water, they control the fertilizers, and more importantly it has grown along with the forest.

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This I would like to recap of week 10, wherein until the last slide, we have been looking at mechanisms, the green nature-based mechanisms to improve the water conditions in the village by improving the forest cover. And we have shown that the forest cover can reduce the surface runoff, reduce the sediment loss and nutrient loss, nitrogen and phosphorus.

We discussed on natural water harvesting structures, compared to week 9, where we looked at engineered water structures, we are here looking at nature-based structures. As the name comes it is either used from nature products merged with engineering products or it is totally inspired from nature. And figure you see at the bottom is from the beavers, which are making their own small check down.

Wood, some soil plugs, and some saplings. And what is the learning from these exercises water can be easily stored in small check dams, size of a beaver dam, and the forests can evolve. These slowly closing of water can actually aid in creating different pathways for water, and then improving the forest cover. Less constructed, clear and manage. So, what is the nature-based solution?

It is less, it is not zero construction, it is less constructed, less clearances and managed. Do not ask me what is clearance? Is it a percentage? 10 percent of a land cannot be cleared those

kind of things, people always get around with those numbers. So, it is better to leave it as a qualitative statement, less, has to be less you cannot have a lot of construction.

As soon as you understand that, nature-based solutions are the best to conserve nature, you will definitely look at trying to reduce as much the construction as possible. So, in IIT campus, IIT's are known for its very beautiful natural settings, forested kind of an environment. Lot of trees, plants, animals, birds, and in between them they would have built the buildings, not clearing all the forest.

So, this is where you could understand that, you could still manage between both, less constructed and less clear and manage. The first example we saw that dam may not be fully leak proof, it is also okay to have a leaky dam, which can improve the water's supply in downstream regions. We looked at wooden check dams, and leaky dams et cetera.

We looked at rainwater harvesting structures, like the recharge pits, and small farm ponds, and we looked at most importantly rain gardens, in the farm ponds you just dug some land and led the water channel and come in without much construction. But in the rain gardens, you had local native species of trees and plants like big shoots which would slow down the water, and let the water infiltrate, rather than converting it to river, and stream networks, runoff.

So, you reduce the runoff through more water into the ground through agriculture. And it is not nature-based purely systems, it does have some construction. Rain gardens have been widely used across the world. I have shown you some case studies. And rain gardens can we be of wetland type, where you have some construction of the surrounding, and let the plant take up the polluted water and converted into good water.

The land management scenario, we looked afforestation, reforestation and agroforestry. In the afforestation, we looked at conversion of barren lands, we looked at the Miyawaki foresting technique, which is applicable to afforestation, reforestation. We looked at reforestation, where females have been starting to look at these forest, because it is easier for them to maintain a forest than agriculture land.

And as the Miyawaki pattern explains after 3 to 4 years, you do not disturb the tree, just let the tree grow and it will grow into full livelihoods options. Community participation is the key of all the examples I showed. Unlike the all water harvesting systems, and in house water

purification networks, it is more important to have a community participation because everyone can take part, everyone can understand the importance of forest, and the green cover because everyone understands the importance of water.

We looked at some community participation activities where they have converted deforested slope into a forested area, through the NM Sadguru Foundation. They got the saplings at a lower price or even fee, and then they were given the tutorials how to manage the plants. Then after 2 or 3 years of maintenance, and managing the plants, the trees have grown and become a full florist.

Now within the forest, you can go back to agroforestry uses like amla, mango, et cetera, which fetch a good price in the market. So, it is not like you are going to suffer a big loss by converting your land to forest, you will also achieve some economic stability if you manage it properly. And this has to be told to the farmers. There is a myth that if you have forest, all the land will be taken up.

No, if it is a forest, they will ask you to find the exact locations of native species, native animals in a forest where they can be protected. There is something called conservation forest, from the British period. Mostly conservation forests have been prohibited for public to use. And those are the lands where you can go and get the native species of plants and trees, you can find the native animals in the network, and also use the understanding, training from these forests to apply in your reforestation and afforestation activities.

The last part is more important, agroforestry where forest and agriculture can coexist. I have shown you a lot of studies in the previous slides, where forest land has been converted into to support agriculture slightly, but also remain with the forest that has had the best implications for sustaining the forests, sustaining water, and creating an ownership in the process because it enhances ownership to bring more people into water conservation.

At end of the day, they need a profit they need food on the plate. If we keep on pushing them to conserve water, they still need food on the plate. So, you could say with these examples, the agroforestry examples, that you can conserve nature; you can conserve water and soil, and still get a good income for your livelihoods.

With this, I would like to stop week 10 lecture. We have come across major sections in this rural water resource management course. In the remaining courses, I will be showing some

case studies, some data that you could use for rural water resource management. And more importantly, we will just quickly look at what has been taught.

And the key understandings that come out should be, what resources are there. It is up to the rural communities on how they use the water resources for sustainable development. I will see you in the next class. Thank you.