Soil and Water Conservation Engineering
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Lecture - 02
Soil Erosion - Causes and Types

Hello friends. Welcome back to NPTEL online certification course on Soil and Water Conservation Engineering. I am Rajendra Singh, Professor in Agriculture and Food Engineering Department IIT, Kharagpur and we are now week - 1, lecture - 2 and the topic is Soil Erosion, Causes and Types.

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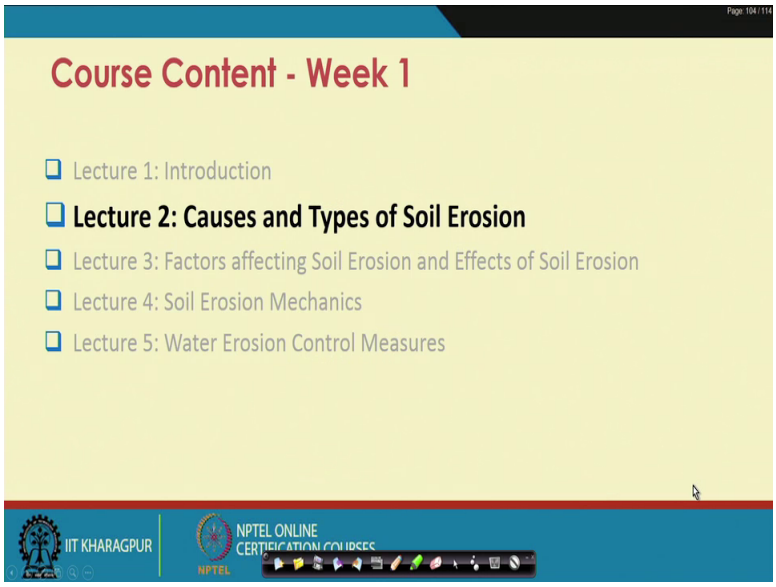

Just to give you an idea, that in this week we started with introduction in the previous lecture, this particular lecture is on causes and types of soil erosion and lecture - 3. We will go through factors affecting soil erosion and effects of soil erosion, lecture - 4 will be on soil erosion mechanics and lecture - 5 on water erosion control measures.

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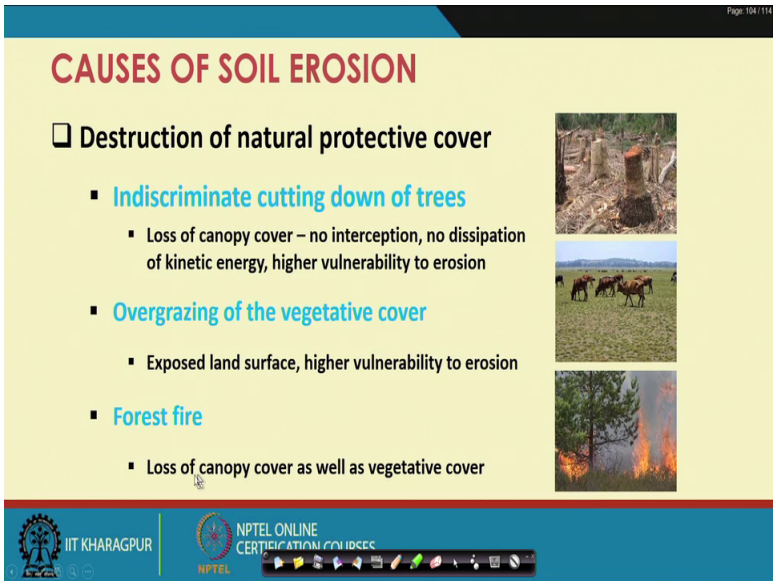

Now, coming to causes of soil erosion; the one of the foremost reasons of a causes of soil erosion is destruction of natural protective cover and that happens to by indiscriminate cutting down of trees and what happens is that when you cut down the trees. Then, obviously, we also lose the plant canopy. And, basically when plant canopy is not there though there will be no interception of falling rain fall and of course, in the process there will be no dissipation of kinetic energy, that simply means that when the raindrops will read the soil surface they will have a higher velocity and higher level of kinetic energy and because of that the soil will be highly vulnerable to erosion.

Now, the other reason is overgrazing of the vegetative cover if we allow overgrazing of vegetative cover then a similar effects takes place. That means, what we do in the process is that we expose the soil surface and once the soil surface exposed and when the raindrops take raindrops fall on the soil surface with higher level of kinetic energy. And obviously, the erosion there is a higher chances of erosion.

And, the third reason is forest fire which obviously, occurs only in forest areas and during summer season, but here also we lose canopy cover because in the forest fire the plants or trees are completely are the leaves are completely burnt and also not only canopy cover, but also the surface whatever vegetation is there on the surface that is also lost so; that means, it is combination of indiscriminate cutting down of trees where we lose the canopy and overgrazing a vegetative cover where we expose the land surface.

So, in forest fire we have a combination of this and that simply means that kind of area is highly vulnerable to soil erosion.

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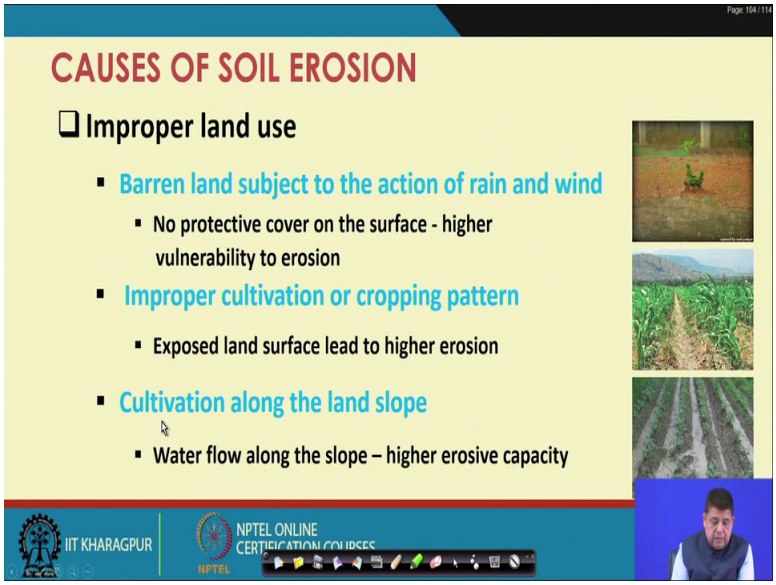

Now, in the next cause could be the improper land use and improper land use could be the barren land subject to action of rain and wind a land which is left open without any kind of cultivation activities that is referred to as a barren land and in such land, because there is no activity taking place there will be no protective cover on the surface. And that simply means, when the rainfall occurs the surface is exposed completely due raindrop impact or if there are there are loose particles on the surface. Then, wind will have a tendency to take away the soil particles that simply means a barren land is always highly susceptible to erosion. Then when some land is under cultivation.

Then, if we use the improper cultivation or we use improper cropping pattern then also we expose land surface. And what happens that if we select cropping pattern in such a way or if you do not cultivation in such a way where we in between rows, we allow lot of exposed surface area. Then obviously, if the rainfall takes place one the that particular area then there will be erosion and also because there is the export surface water flow will take place in there and that means, there again there will be higher chances of erosion.

The other improper land use could be the form of cultivation along the land slope. So, if we cultivate along the land slope so, obviously, in between the rows there be some space

for water flow and because of slope this flowing water will have a very higher velocity and because of high velocity will have higher kinetic energy and it will be having erogic I mean erogic capacity will be much higher.

So, that is why any kind of improper land you may be in the form of barren land, be in the form of a improper cultivation of cropping pattern or cultivation along the land slope all make soil susceptible to erosion.

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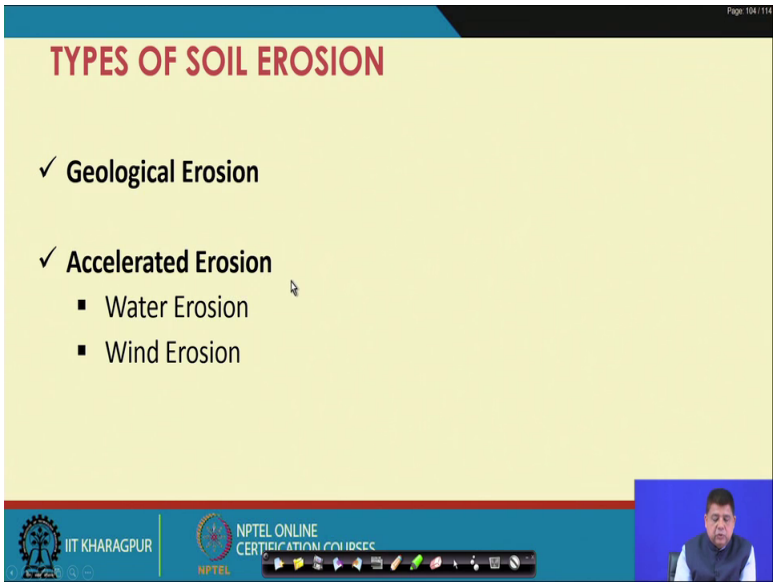

Then, coming to types of soil erosion: Soil erosion can be broadly classified into two categories that is geological erosion and accelerated erosion and then accelerated erosion can be further classified into two categories water erosion and wind erosion. Of course, we saw that water and wind are agents of erosions. So, based on the agents acceleratory erosion could be classified as water erosion and wind erosion. So, do remember that overall soil erosion is classified either as geological erosion or accelerated erosion and acceleratory erosion is further classified is water erosion and wind erosion.

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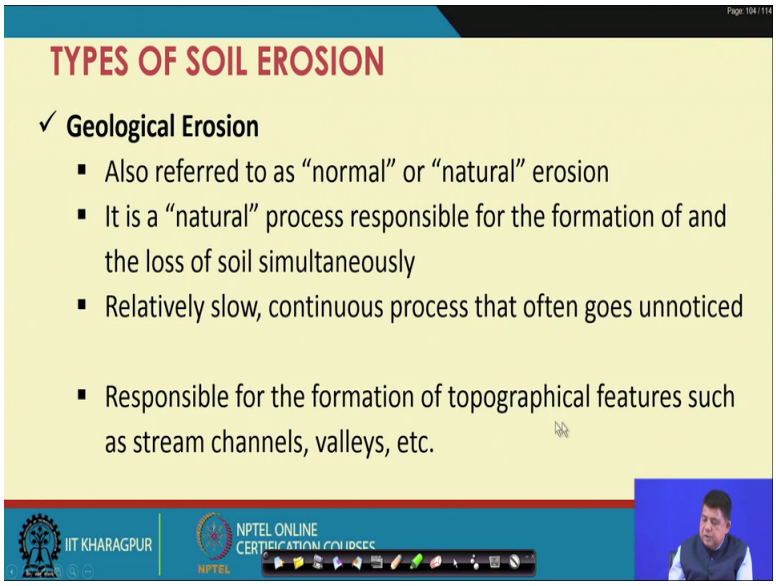

Coming to geological erosion; geological erosion is also referred to as normal or natural erosion because basically is a natural phenomena. And, it is a natural process responsible for the formation of and the loss of soil salt simultaneously. So, basically we know that it is the weathering of rocks that is responsible for formation as well as the soil loss. So, basically this is natural we say it natural because the formation of soil, as the loss of soil there goes simultaneously and they are more or less ballast. So, that is why it is referred to as a natural process.

And, it is very slow process and continuous process and that goes often unnoticed. So, it is so slow and continuously occurring that we do not find any change without naked eye and that is why is very difficult to notice any kind of geological erosion. And all the topographical features that we see on the land surface like stream channels valleys and so on all these are formed because of this geological erosion.

So, basically geological erosion is normal and natural erosion is a very slow process, and is responsible for creation or formation of all the topographical features we see on the land surface.

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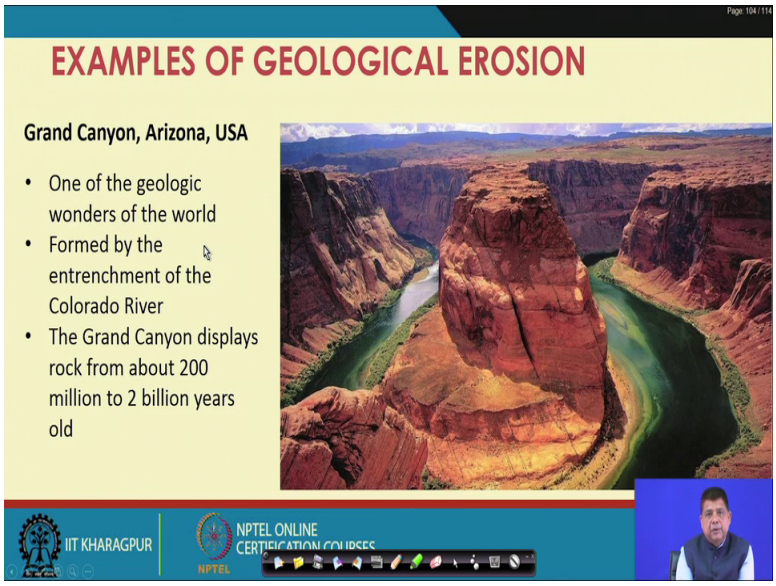

And, there are certain great examples of geological erosion around the world one of the greatest example is Grand Canyon in Arizona, USA and which is referred to as one of the geological wonders of the world. And, basically this Grand Canyon is formed by the entrenchment of Colorado River as you can see here the Colorado River is I mean it has been it is bifurcated in two tributaries as you can see at least. And the important thing is that all the historical part is that that the Grand Canyon. This, say that the Grand Canyon displays rocks from about 200 million to 2 billion years old. So, that simply means is a place of history where you can see rocks that are 200 million to 2 billion years of age.

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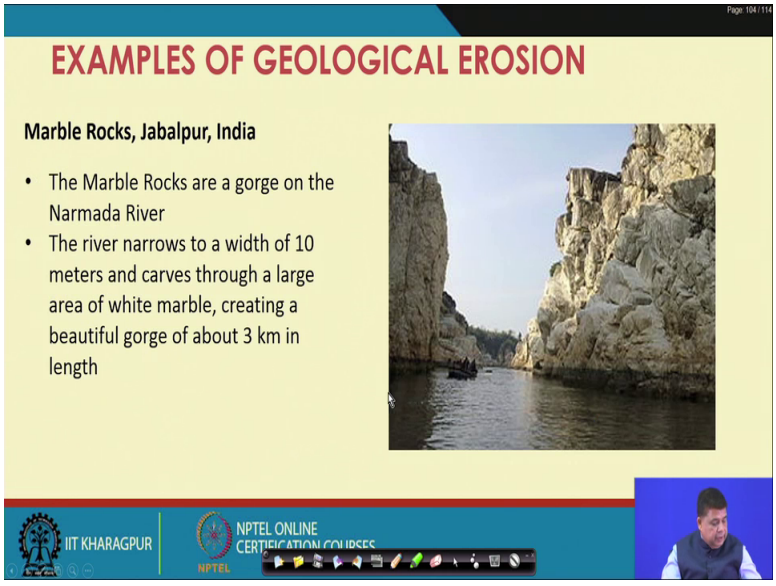

There are several other examples if you look in India then also we have a great example in the form of Marble Rocks, Jabalpur Madhya Pradesh in India and marble rocks basically are a gorge on Narmada river and here the river narrows to almost a width of 10 meters and carves through a large area of white marbles creating a beautiful gorge of about 3 kilometer in length.

So, as you can see here with the Narmada river flowing and either side you can see this marble rocks and this spectral phenomena is over 3 kilometer of lengths. So, if you get an opportunity go there and do remember that it is a geological erosion wonder existing in India.

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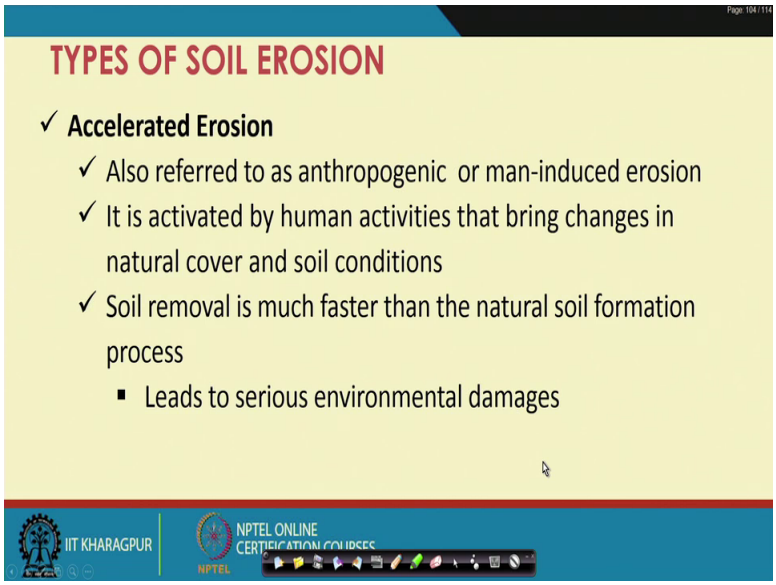

If we come to the other part that is accelerated erosion, then acceleration is just reverse of that and that is why it is referred to as anthropogenic or man-induced erosion; that was natural, geological was natural; this is man-induced and it is activated by human activities that bring changes in natural cover and soil conditions. Just now we saw what are the causes. So, if you cut the trees is indiscriminately, if you improperly cultivated land if you open the land barren keep the land barren. If you cultivate along the slope, I mean in there are several ways humankind impacts erosion and bring changes in natural cover in soil conditions which result in accelerated erosion, with the name itself says that it is much faster.

And, soil removal here is much faster than the natural soil formation process. We saw in the case of geological erosion that it was slow process and the soil loss and soil formation was almost balanced. But, in this case solve removal is much faster than the natural soil formation process and that is why it is more clearly visible to naked eye, all around us we can see some kind of erosion happening. And of course, if erosion takes place it leads to serious environmental damages that will as we move in the course we will see we will get the elaboration on this.

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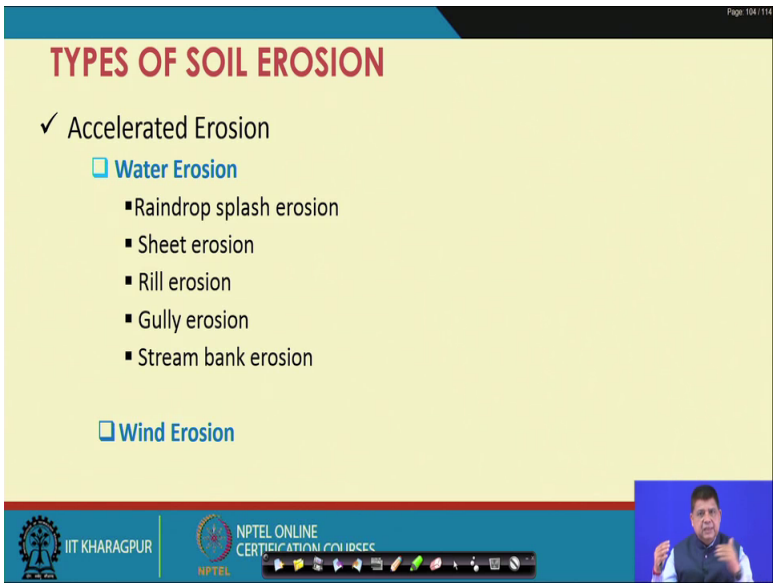

Remaining in types of soil erosion we already saw that accelerated erosion can be of two types water erosion and wind erosion based on the agents of erosion. And, water erosion can be further classified into five groups. The first one is raindrop splash erosion, the second is sheet erosion, third is rill erosion, gully erosion and stream bank erosion.

So, erosion if you see we classify once again broadly it is geological erosion and accelerated erosion. Accelerated erosion - water erosion, wind erosion and within water erosion they are five types that is raindrop splash, sheet, rill, gully and stream bank erosion. So, these are the types of erosion which you are expected to remember that what are the types of erosion and you should be able to recall immediately.

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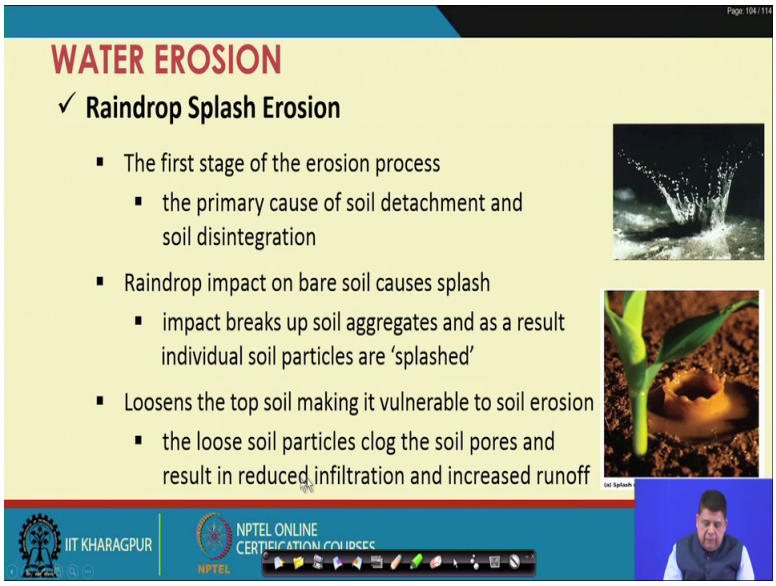

To start with the first one that is raindrop splash erosion, this is the first stage of erosion process and is the primary cause of soil detachment and soil disintegration. So, what happens is that, when rain takes place the raindrops they impact the bare soil, wherever bare soil is there, be it barren land, be it improperly cultivated land wherever we get bare soil it basically it impacts with high kinetic energy and that causes splash basically. And in this process what happens the raindrop impact breaks up the soil aggregates and a result individual soil particles are splashed. As you can see that their when the raindrop takes place it is a soil surface, then obviously there will be some kind of a splash and because of that the loose soil particles will be taken care of.

In this process another phenomena takes place that the soil particles which are there on the top, they are of course, they can be carried away by flowing water when in subsequently and of course, what happens that the loose particles also clog the soil pores, the soil surface the pores on soil surface; as you remember we the previous lecture we saw something called infiltration. So, whenever that happens that infiltration takes the soil pores are blocked then obviously, infiltration reduced gets reduced and that results in increased run off, when the runoff is more the loose soil particles which are there on the soil surface they will be taken away. So, this is what this is referred with raindrop splash erosion.

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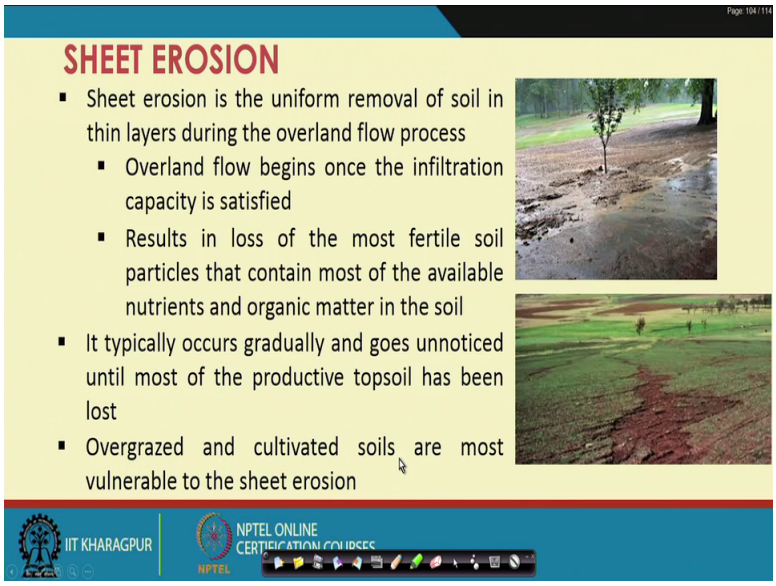

Next is the sheet erosion which is the uniform removal of soil in thin layers during the overland flow process. Now, we in the previous lecturer we say when the rainfall occurs it first satisfies the infiltration requirement of the soil and once infiltration capacity is filled up then water starts flowing on the surface in the form of overland flow and once the overland flow takes place then if there are loose soil particles on the surface then the floor will take the soil particles away.

And, what happens that in this process the most fertile soil particles that contain most of the available nutrients and organic matter in the soil they are taken away, they are lost because we know that it is a topsoil which is always the most fertile soil and because that is the soil these are the soil particles that get loosened in the process of raindrop impact and they are lying on the surface so, overland flow will have tendency to take this more fertile soil away.

And, typically it occurs gradually and goes unnoticed until most of the productive topsoil has been lost because it takes place in the form of sheet, is very difficult to really notice it. So, it go unnoticed for a long period of time unless you start seeing patches like this on the soil surface. So, that is a very slow process, but very dangerous process, because it takes away all the fertile soil away from us. And, overgrazed and cultivated soils are most vulnerable to sheet erosion that is wherever or wherever soil is exposed or soil particles are lying lose on the surface they are most vulnerable to sheet erosion.

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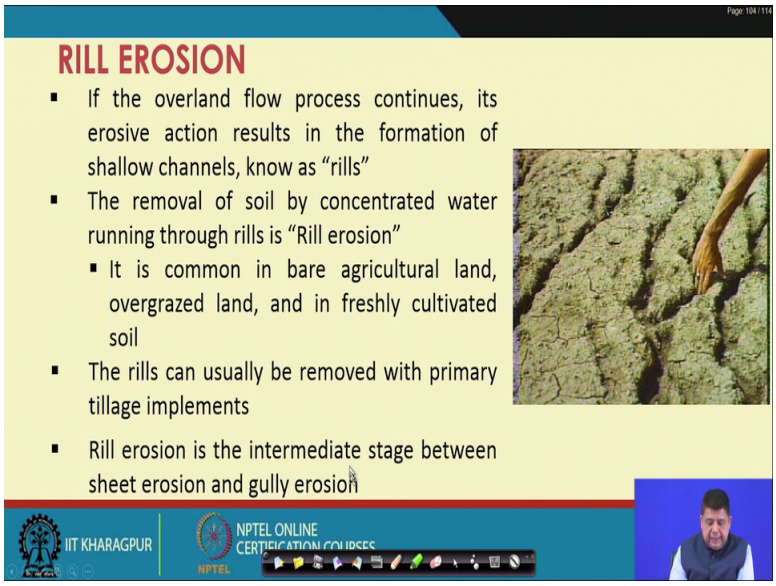

The next is rill erosion. So, if the overland flow process continuous, its erosive action results in the formation of shallow channels which are known as rills. So, we saw that first the overland flow process will take away the soil particles and it will create some kind of patches. And if we allow this to happen then formally it might result in the formation of these small rivulets or channels which are refer to as rills and once these rills are formed the water will have tendency to have a constant concentrated flow through this rills.

And that means, it will cause soil erosion there and that is referred to as rill erosion that is the third level of erosion water erosion that is rill erosion. It is very common in bare agricultural land, overgrazed land and in freshly cultivated land that is wherever soil surface is exposed wherever it is possible raindrop impact could to make impact or wherever sheet code could remove top fertile soil. Then obviously, this there the chances of rill erosion are more.

But, one good thing is that they are. So, small that they can be removed with primary tillage implements; that means, if you do simply flowing of the land then also these get smoothened out. So, these rills will be lost water flowing takes place on this surface area. So, that is a good thing is that they can be quickly taken care of by primary tillage implements. And, it is a intermediate stage between sheet erosion and gully erosion which is the most serious form of erosion.

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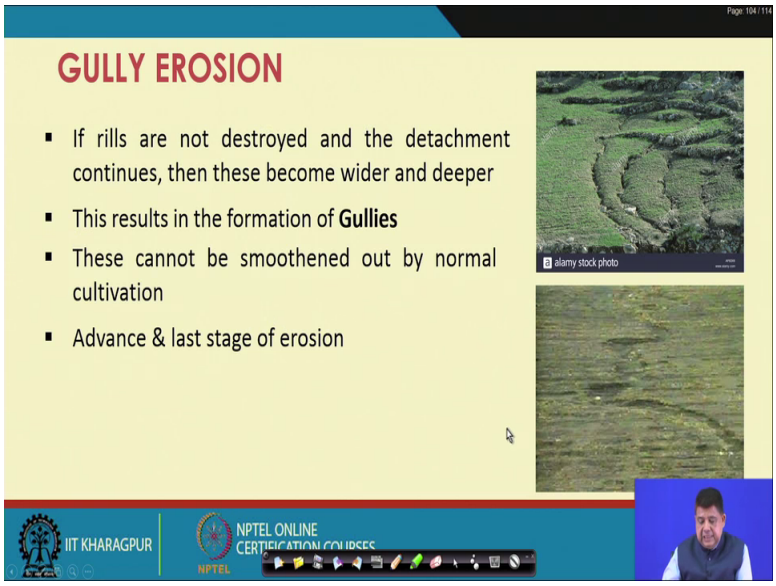

And, if rills are not destroyed and the detachment continues then these becomes wider and deeper. So, obviously, if rills we saw rills there were much finer much smaller it is much projected picture, but if you continue this then obviously, if this detachment continues then they become wider and deeper and then they result in the deformation of gullies as you can see here this deformation of gullies.

And, they are much larger than the rills and that is why they cannot be smooth and out by normal cultivation that is the importance. So, as long as it is the rill with our culture usual primary tillage implements we can take care of them, but we allow that stage to pass then probably it goes beyond control and this is refer to as advance and last stage of erosion. So, beyond that I am for a water erosion concern and the normal is the last stage of erosion.

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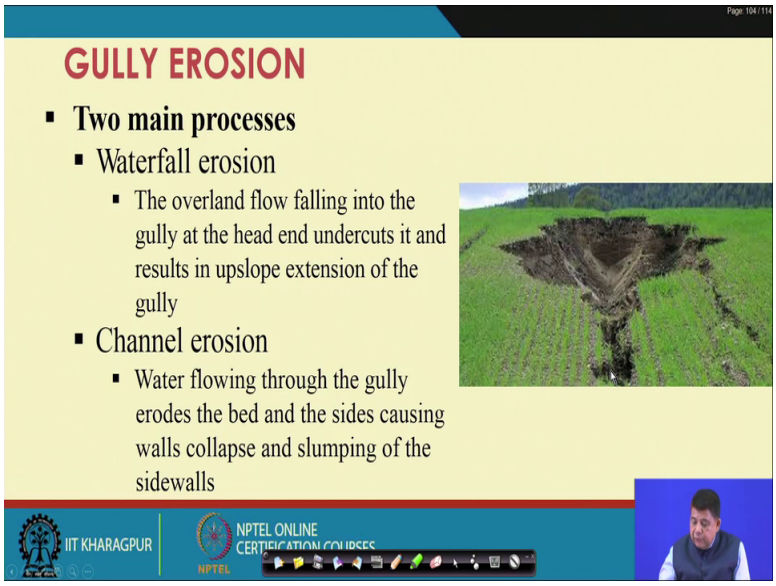

And, in the gully erosion process there are two main processes involved; waterfall erosion and channel erosion and the waterfall erosion basically refers to the overland flow falling into the gully at the head end that undercuts it and results in upslope extension of gully. So, this is the gully head and if slope is in this direction so, if water is continuously fall falls from this direction into the gully then it will have the tendency to undercut the head and thus gully will have a tendency to move in the upward direction or get extended into the upward direction and that is result because of the waterfall erosion.

The other one is the channel erosion; that water when it starts flowing through the gully it erodes the bed and sides causing wall collapse and slumping of the side wall. So, basically when waterfalls and start flowing through the gully, then obviously, it will have a tendency to deepen and widening gully. So, gully size goes on increasing if we do not take control measures to control. So, these are the two process waterfall erosion waterfall erosion which is responsible for upstream extension of gully and channel erosion that is responsible for widening and deepening of gully.

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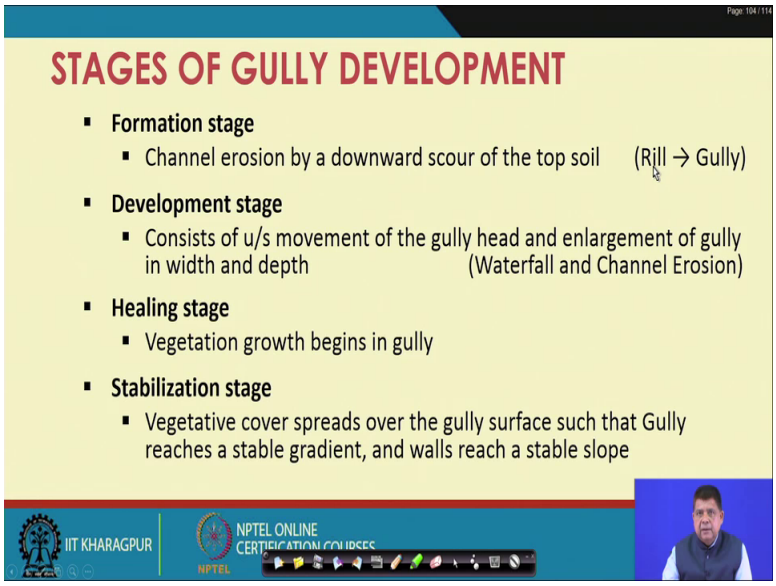

Coming to stages of gully erosion, there are four stages of gully erosion. The first one is the formation stage that is channel erosion by downward scour of the top soil and that is we already. So, that there is a waterfall erosion there is channel erosion water fall erosion is responsible for upstream extension of gully whereas channel erosion responsible for widening and deepening of the gully. So, if we allow that the downward scour of topsoil then basically that basically is conversion of rill into gully that is basically rill erosion we saw where there is small rivulets are there, so, they are converted into gully.

The next is the development stage where consists of upstream movement of gully head and enlargement of gully in width and depth. So, similar process here but, in much larger scales the waterfall and channel erosion. So, because of that white the gully extends in length as well as in width and depth. So, this is what waterfall soil erosion takes place.

Then the stage comes third stage which is refer to healing stage and that happens when vegetation growth starts in the gully. So, after certain time with gully is there it continues, but with passage of time some kind of grasses etcetera will start growing in the gully and then when if this vegetative cover it spreads over the gully surface such that gully reaches stable gradient and walls reach stable slope then it is referred to as stabilization stage. So, if we can allow this vegetation to grow then ultimately a time we will come then the entire gully cross section that will be covered by this vegetation and that simply means that that will lead to the protective cover to the gully. That means,

there will be no for the possibility of deepening and widening or cutting of the soil in the gully itself and that will be the stabilization stage.

So, these are the four major stages of gully development; formation stage where from rill to gully conversion takes place, development stage where because of waterfall in channel erosion and upstream movement and deepening and widening of gully takes place, healing stage where vegetation is starts growing. And finally, the stabilizer stage where vegetation growth has reach a level where no further gully development takes place.

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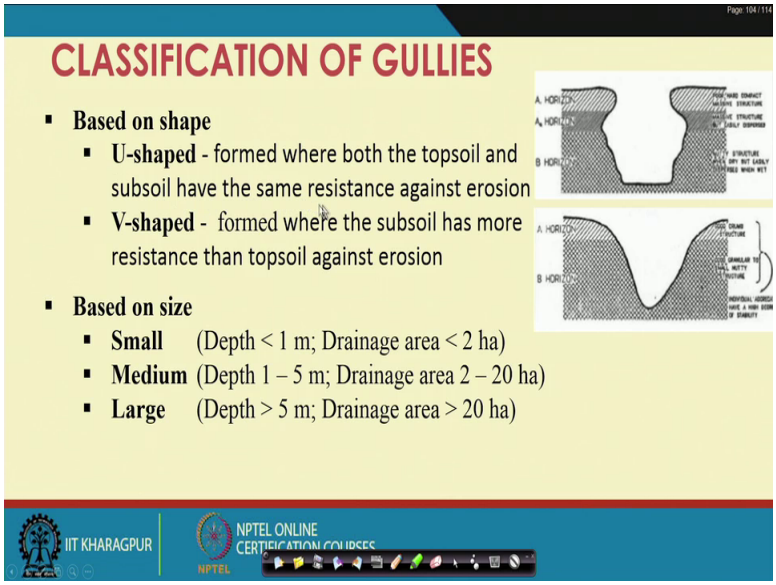

Coming to classification of gullies; gullies can be classified based on shape and based on size. So, if we take based on shape gully they are classified as U shaped and V shaped. The U shaped is formed where both the topsoil and subsoil have the same resistance against erosion that simply means that the soil characteristics along the depth or more or less same that is there for similar resistance and that is why when erosion take place it is almost uniform in safe and that is why the gully takes a U shape.

On the other hand V shaped is formed where the subsoil has more resistance than topsoil against erosion. So, if the subsoil are the bottom layers they are for high level of resistance to soil erosion in comparison to the office to topsoils then obviously, will be more erosion the top and lesser erosion on the bottom side and that is why the shape which will get is resembles later V and that is why it is V shape. So, U shaped take place

when the soil characteristics are uniform along the depth and V shaped takes place where the lower soils of higher resistance is compared to the top soil.

The based on size gully are classified as small, medium and large. And, they are referred to as a small when the depth of the gully is less than 1 meter and the drainage area that is the area that is drained that is that drains to gully is around 2 hectares less than 2 hectares. It is called medium when depth lies between 1 and 5 meters and the drainage area is lie between 2 and 20 hectares and it based on size say that size is large when depth is greater than 5 meters and drainage area is greater than 20 hectares. So, gully can be classified based on shape V shape and U shape and based on size is small medium and large.

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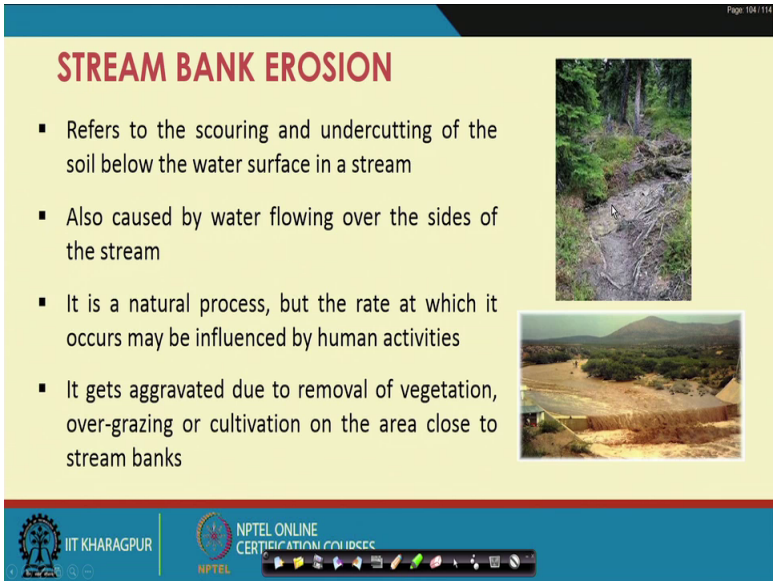

Now, coming to the last type of water erosion, that is stream bank erosion and as name itself suggest it refers to the scouring and undercutting of the soil below the water surface in a stream. So, that means, in a flowing stream it is the phenomena continues the water will have the current water currents will have a tendency to undercut the both the bed as well as sides and because of that whatever erosion takes place that is refers to a stream bank erosion. Another phenomena that is responsible for steam bank erosion is water flowing what the sides of the steam. So, if the sides of the stream if the sides of stream they are bare soils because of whatever human activities are going on a because of that

the soil is bare and if the flow comes from this bare soil to the stream joins the stream, then obviously, with it will carry lot of soil particles.

So, that is also responsible for the and it is a natural process, but rate is which it occurs may be influenced by human activities that means, very clearly if on the banks there are areas where vegetation has been removed or overgrazing has taken place or cultivation for the cultivation practices have been adopted. Then obviously, there will be loose soil particles they will be taking taken to the soil and that means, the rate of. So, rate of soil erosion which will be much larger.

So, this is the fifth type of water erosion.

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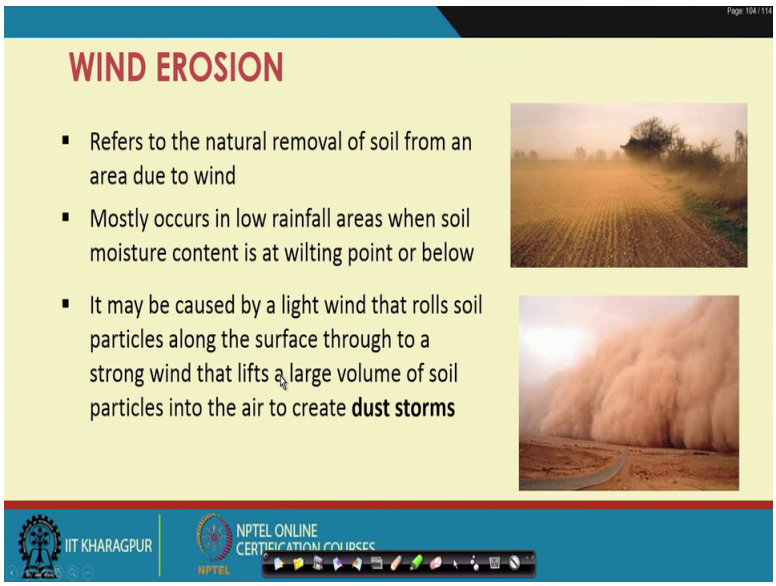

Then we come to the second agent that is wind erosion and obviously, it refers to the removal natural removal of soil from an area due to wind. So, what in the previous cases we saw it was water that was agent, in this case it is wind that is agent and it mostly occurs in low rainfall areas when soil moisture content is at wilting point or below. So, that means, wherever soil particles are dry, there will be no moisture, they are light in weight and they are loose. Then obviously, they are more susceptible to blowing away with the wind and that is why they are more susceptible to wind erosion.

And, it may be caused by light wind that rolls soil particle along the surface through to a strong wind that lifts a large volume of soil particles into air to create the system. So, if

the when the wind is light it basically results in rolling of soil particles rolling of soil particles. So, basically wind is very light and soil particle rolling then obviously, they go unnoticed we do not really notice if wind version is taking place.

But, when the strong wind is there then obviously, a large chunk of soil is lifted in the atmosphere and in the form of dust storms and then it becomes more visible and then we really see wind erosion in effect, but affectively whenever wind is blowing on an area which is dry or where loose soil particles are there, they are susceptible to wind erosion that is wind erosion takes place there almost all the time.

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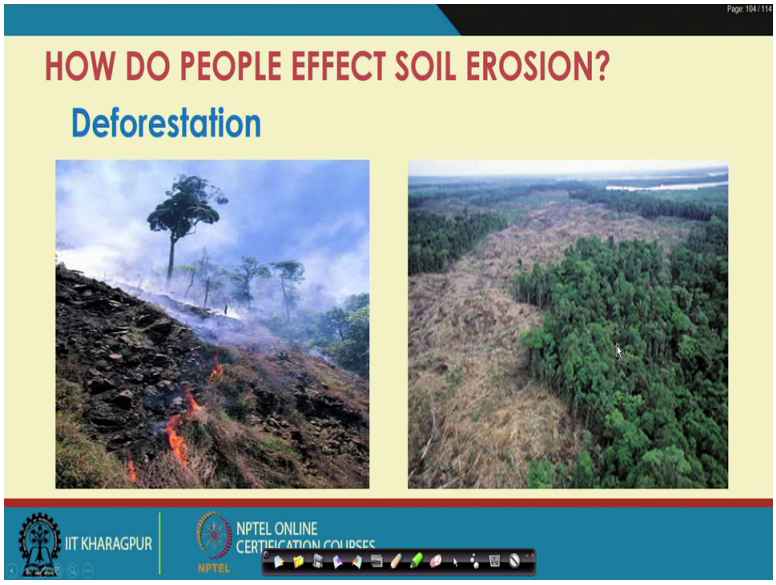

Then question comes how do people affect erosion? We have seen that people are affecting erosion, but I mean just to remind us once again how do we affect soil erosion; of course, in the form of deforestation. So, already we have seen if we deforest, that means, we are removing the canopy cover. That means, we are exposing the soil to raindrop impact or flowing water and that means erosion will be more.

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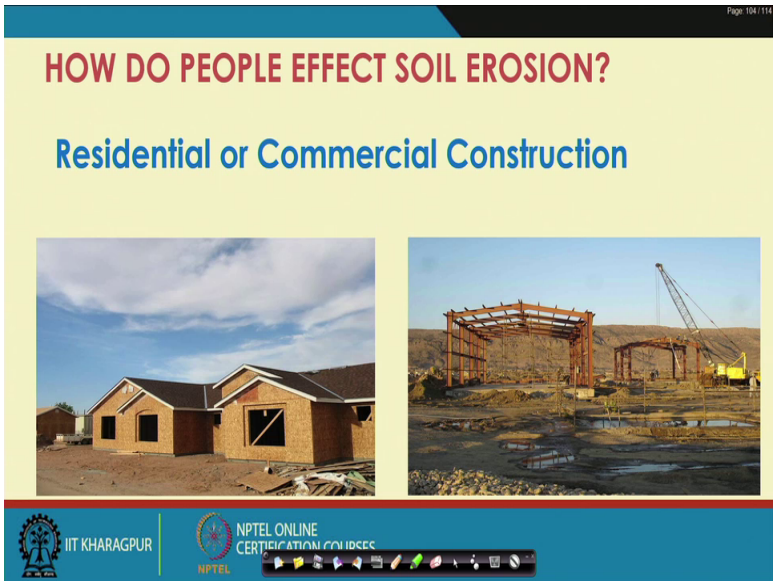

Then next way we impact soil erosion is through residential or commercial construction. All around you whenever you see some kind of construction activity going on then you will see that huge amount of loose soil particles are available. And if, that happens obviously, that area is susceptible to erosion.

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Then, again if we allow use the traditional cultivation practices like ploughing or tillage where as you can see that during the process of ploughing here or any kind of tillage operation you can see lot of wind lot of soil is already been being moved. And in this

cases as you can see that lot of soil is exposed left exposed and if rainfall occurs. Then obviously, lot of the soil particles in the in the overland flow the lot of the soil particles will be taken away in the form of erosion.

So, that is what we have seen what are the causes and what are the types of erosion in this class. And then we will further move to next step in the next lecture.

Thank you very much.