Conservation Geography
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Module - 6
Physical Geography in the Indian context
Lecture - 18
Drainage Systems

Namaste! We carry forward our discussion on Physical Geography in the Indian context and in this lecture we shall explore drainage systems.

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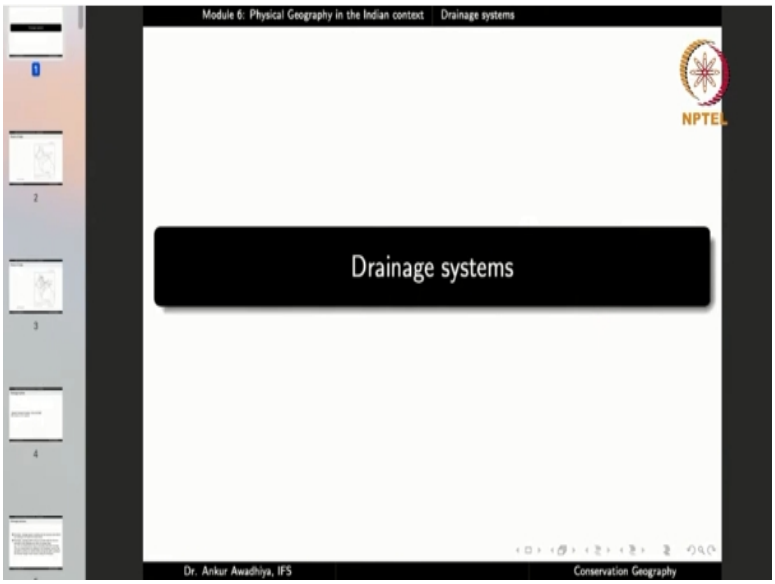

When we talk about drainage systems, we are interested in the rivers. So, if we consider our country, we have a very distinct geography, the north of the country has the mighty Himalayas which are the young fold mountains, which travels in the west to east direction and then they turn a sharp turn towards the south and then south of India we have the peninsular area which has a plateau-like region.

On both the sides, on both the eastern as well as the western sides we have a range of mountains, the Eastern Ghats and the Western Ghats and we also have a large number of smaller hills, plateaus and other geographical features. Now when we are discussing drainage systems, we are asking the question how do rivers move, what sort of patterns do they make.

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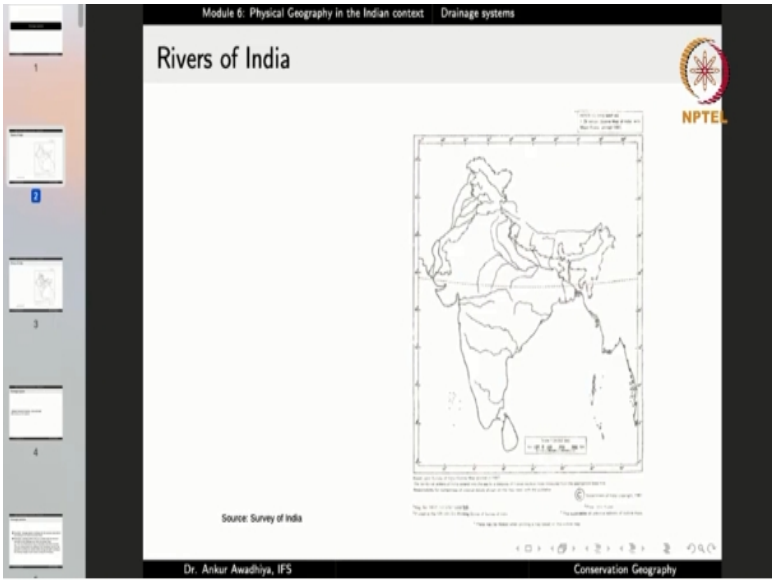

So, if you look at our rivers, we find that these rivers are either draining into the Arabian Sea or they are draining into the Bay of Bengal, so these are the two water bodies that primarily have the drainage of Indian rivers.

A lot of our rivers move from north to south, but we also have a large number of rivers that move from south to north, like these rivers, some rivers move from west to east, some rivers move from east to west. Now the question is why do we have these sorts of patterns?

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So, let us begin by discussing what rivers do we have? So let us zoom in this image, so our rivers can primarily be divided into two categories, we have the Himalayan drainage and we have the peninsula drainage.

Now, in the case of Himalayan drainage we have the reverse Indus and its tributaries, so here you have the Indus river then you have Jhelum, Chenab, Ravi, Beas and Satluj, so these are the six rivers that form a part of the Indus drainage system. Then we have the Ganga drainage system, so here we have the Ganga river, its tributary the Yamuna, another tributary which is Ghaghara, then you we have Gandak, we have Kosi.

Yamuna itself has other tributaries such as Chambal, Betwa, and Son, here we have the Tsangpo river which on coming into India becomes the Brahmaputra river and Brahmaputra and Ganga both meet together and then they drain into the Bay of Bengal and they form the Sundarbans delta.

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Then we have the peninsula drainage, the peninsular drainage is comprised of the drainage patterns of Mahanadi, Godavari, Krishna and Kaveri so these are the four main rivers in the peninsular drainage and then we have two rivers that are unique rivers in the sense that they have a drainage in the Arabian sea, so all of these rivers were draining into the Bay of Bengal but these two rivers Narmada and Tapi they move from east to west and they drain into the Arabian sea, similar to the Indus river. So, these are the various rivers of India.

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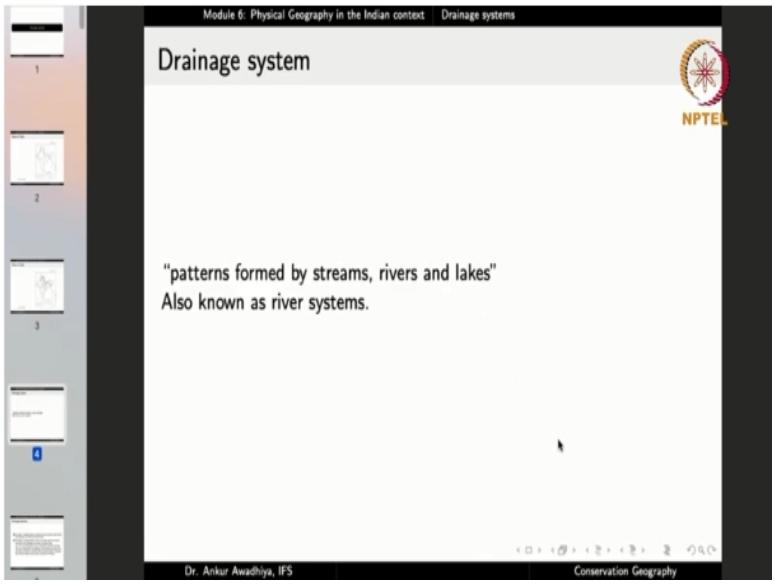

Now, when we talk about drainage system, drainage system can be defined as patterns formed by rivers, streams and lakes. So, here we are interested in the patterns, that are formed by streams, rivers and lakes, that is what is the shape, what is the size, are there specific patterns in which we can classify these shapes and sizes. Now these are also known as river systems.

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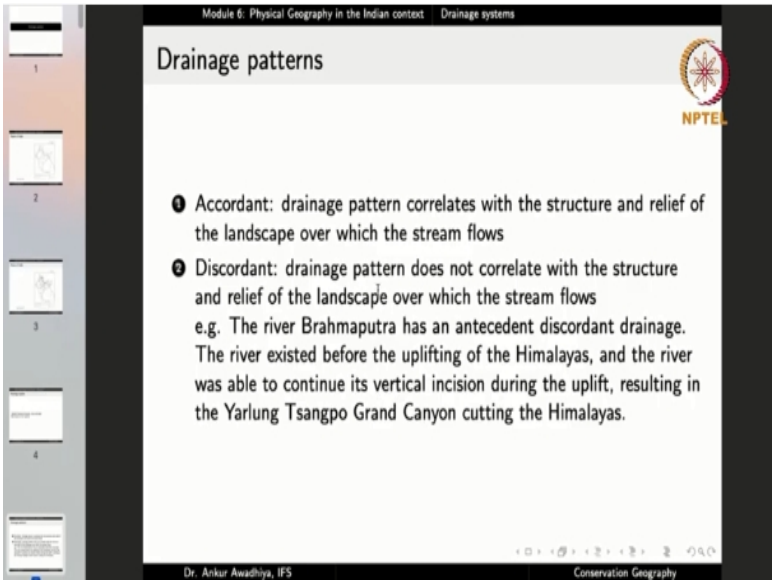

And we have two major kinds of drainage patterns, we have the Accordant pattern and the Discordant pattern. Accordant pattern is the drainage pattern that is correlated with the structure and relief of the landscape over which the stream flows. So, essentially, it maintains a coordination with the structure and relief of the landscape.

So, essentially if you have a river that follows the slope of the land then we will say that it is an accordant pattern, so if we talk about a river that is flowing, rivers tend to move from a higher elevation to a lower elevation and you will never find a river that flows from a lower elevation to a higher elevation because the movement of water in the case of a river is primarily governed by gravity and so it moves from a height to a lower height.

Now, when we talk about an accordant pattern, then the river is following the landscape, if the landscape is tilted in a particular direction then the rivers will also be flowing in that particular direction, so they maintain an accord with the landscape and especially the structure and the relief of the landscape.

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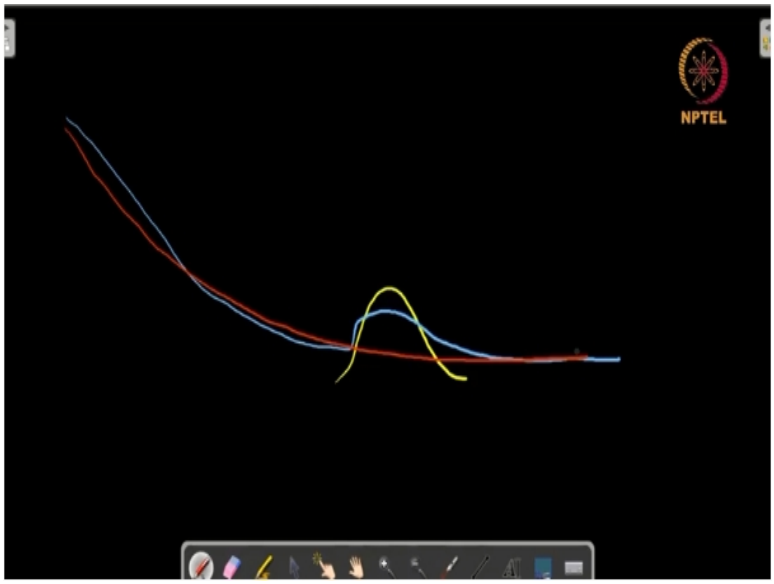

We also have discordant patterns, where the drainage pattern does not correlate with the structure and relief of the landscape over which the stream flows. For example, if we have a situation that there is a river that is flowing and it encounters a hill, so in the case of an accordant pattern the river will make a turn and it will go around the hill and then it

will probably continue its pattern or its movement but in the case of a discordant pattern we will typically observe that the river has actually moved through the hill by creating very deep valleys.

Now, in the normal sense we do not expect a river to perform a very great amount of cutting if it encounters a hill the easy way is to just bypass the hill but we can observe a discordant pattern in situations such as if there is an uplift that is going on.

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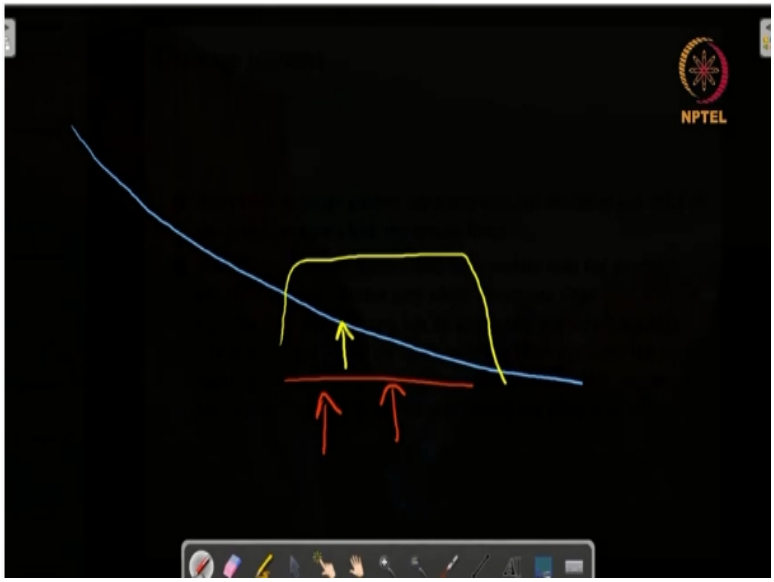

So, in this case it is possible that the river was flowing like this following the earlier slope of the land but then there was an elevation of this portion, so this portion started to move up because of say tectonic forces. Now when the landscape is changing, when a certain portion is moving up or down then the rivers have got two options, one is that once you have this area that has been elevated then the river can change its direction and become an accordant pattern.

So, in this case the river will flow according to the landscape and because there is something that has come up in between so the river will change its flow. So, in this case the landscape will direct the flow of the river but in certain other cases especially in the case of very large rivers, the rivers what do they do is that when this landscape is moving upwards then they carry on their erosion.

And in certain cases they are able to erode at such a high speed or such a high intensity that when this landscape is moving up they are continuously eroding the area and so they will create a very deep valley typically a v-shaped but in certain cases also an I shaped valley so this is an example of a discordant pattern and we observe discordant patterns say in the case of river Brahmaputra.

So, the river Brahmaputra has an antecedent discordant drainage, so it is an antecedent drainage, antecedent means that it came before the landscape came into existence, so the river existed before the uplifting of the Himalayas and the river was able to continue its vertical incision during the uplift, meaning that it continued to cut the mountains vertically through the process of erosion resulting in the Yarlung Tsangpo Grand Canyon cutting the Himalayas.

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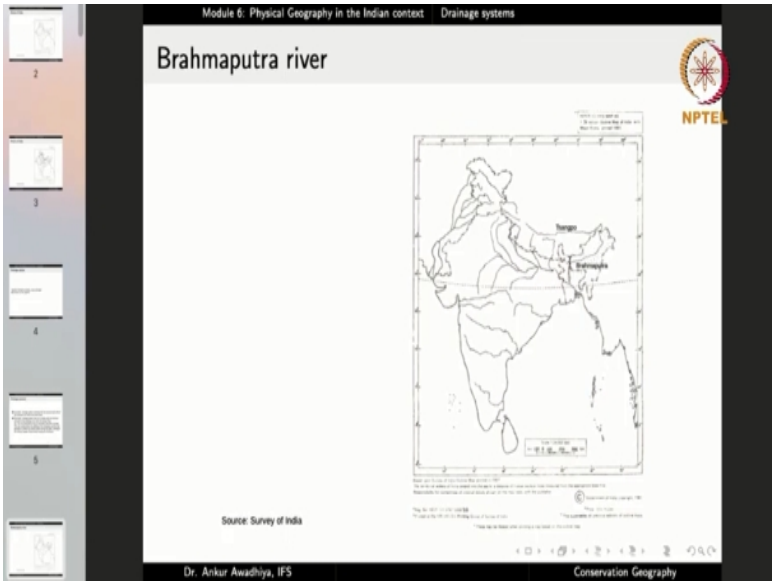

So, this is the Brahmaputra river and here it turns, it moves from west to east in Tibet and China and then it makes a sharp turn to the south and then it changes direction and it starts to move from east to west and then it flows south and then it joins the Ganges and makes the Sundarbans delta.

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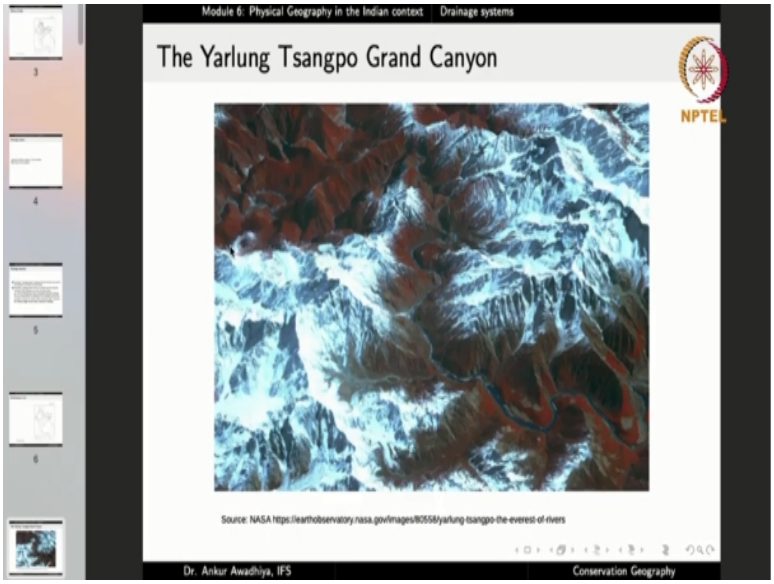

So, if you look at the Yarlung Tsangpo Grand Canyon, so this is how it looks like, so you have these Himalayas, this peak is the Namcha Barwa and here you can observe that in place of shifting away from this area which is a highland it continued to cut through these areas.

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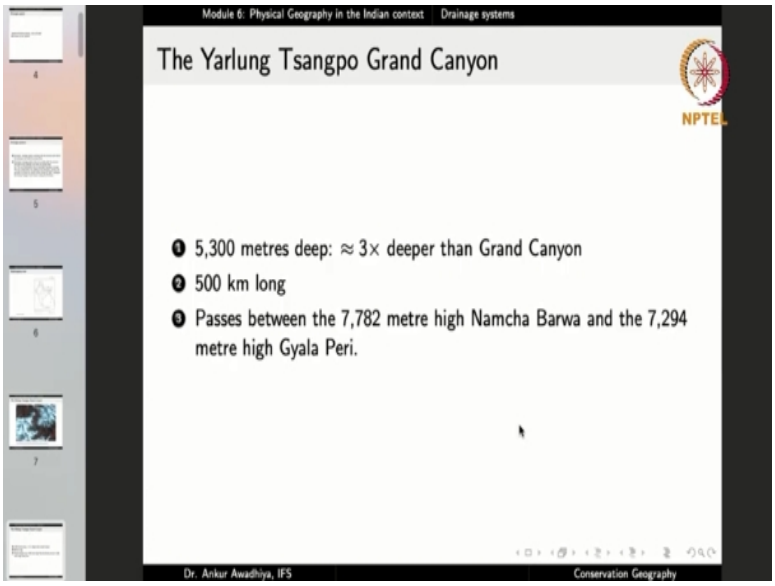

And the Grand Canyon is 5300 meters deep, so roughly 5.3 kilometers in depth which is roughly 3 times the depth of the grand canyon in the United States. The canyon is around

500 kilometers long and it passes between the 7782 meter high Namcha Barwa which is the point where the Himalayas take a southward turn and the 7294 meter high Gyala Peri. So, these are the two peaks this is Namcha Brwa and here we have the Gyala Peri.

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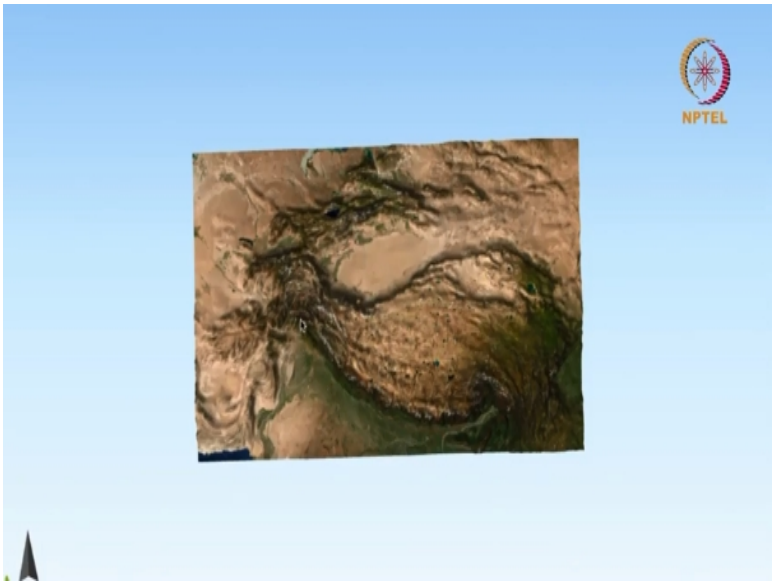

Now, if we have a look at the 3D map of this area, so this is the 3D map so this is the chain of the Himalayas and we are interested in this region.

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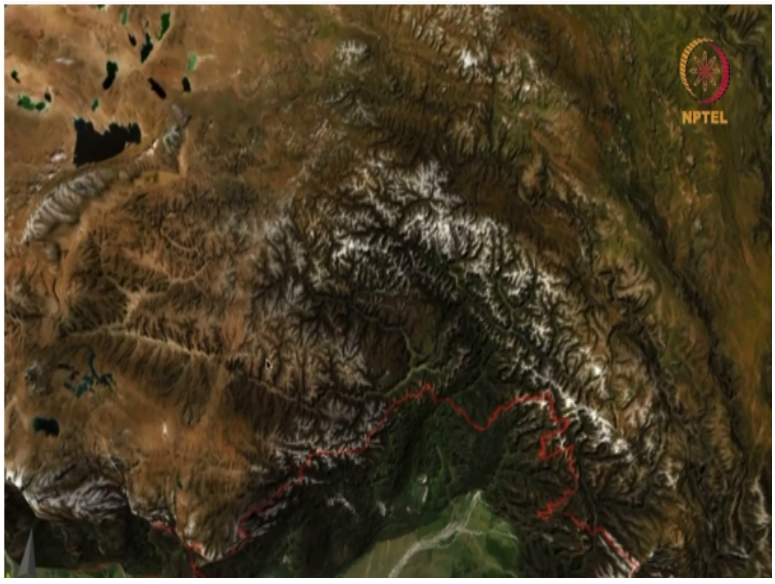

So, let us zoom into this area and here you can observe that here we have the Tsangpo river, it moves like this makes this turn and then it moves downwards and then it becomes the Brahmaputra.

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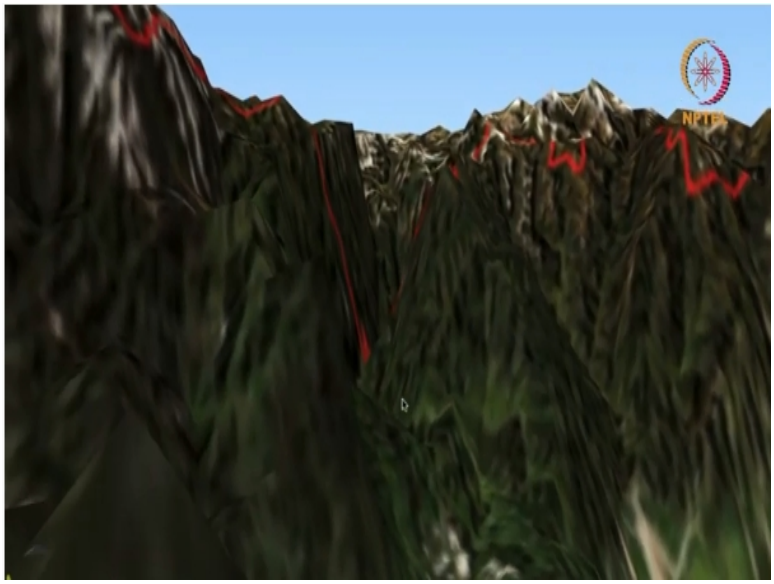

Now, if we look at this area in more detail so this is how this canyon looks like, so this is the sort of cutting that this river has done. So, we have these high peaks and through or in between these peaks this river is flowing. So, this is the kind of canyon that is it has created because this is an antecedent drainage.

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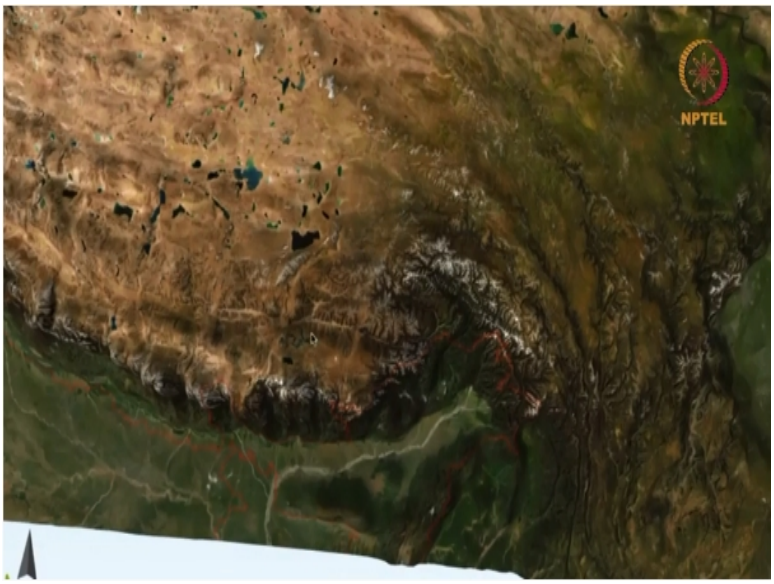

Meaning that before the Himalayas came into existence, so let us now zoom out so before the Himalayas came into existence this area was the Tethys sea and the Brahmaputra river was flowing like this, so considering that we do not have the Himalayas here the Brahmaputra river would have fallen into the Tethys sea but when the Himalayas came into existence then the river Brahmaputra continued its movement in the same direction and then when the Himalayas were rising the cutting activity of the Brahmaputra river was greater than the rate of this uplift and so it created these deep canyons.

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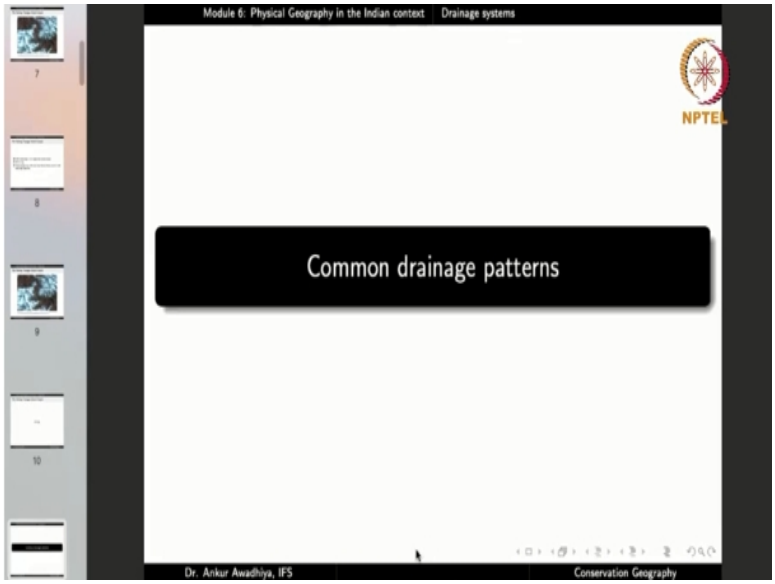

Now, let us have a look at some common drainage patterns.

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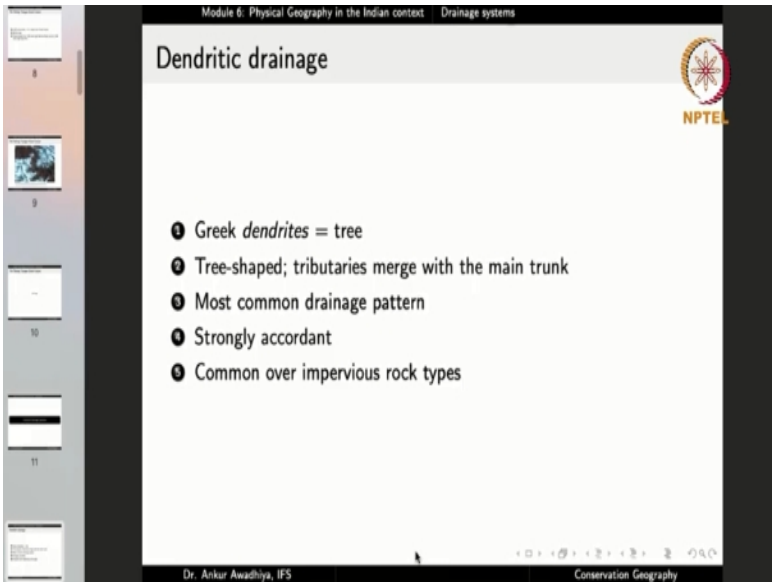

What kinds of drainages do rivers make. The most common drainage is the Dendritic drainage, the term comes from the Greek word dendrites which means a tree, so this is a tree shaped drainage where tributaries merge with the main trunk.

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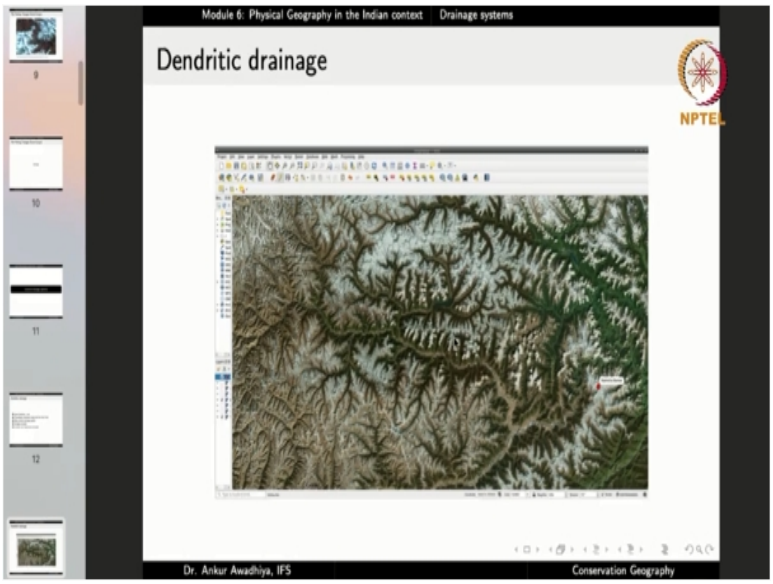

So, this is how it looks like, so in this case you can consider that this is a tree and in this tree you have all these different branches and each branch has its own sub branch and the sub branches have their own sub sub branches. So, it looks very much like a tree with a main trunk and a large number of branches. So, this is a Dendritic drainage, so in this case it is tree shaped the tributaries merge with the main trunk, it is the most common drainage pattern, strongly according in a number of cases.

So, for instance in this case this is again our Brahmaputra river and if we consider this portion where it has not yet cut through the Himalayas this is a strongly accordant pattern, which means that it is flowing according to the landscape, according to the structure, according to the slope of the landscape and only when a river is according does it show a true dendritic pattern.

So, this is a strongly according dendritic drainage pattern. It is common over impervious rock types, why impervious? Because if the rocks are pervious, meaning that they permit water to enter inside in that case it is very easy for the rivers to erode the land but in the case of impervious rocks that is not the option.

So, the river has got nothing else to do but to follow the slope and the structure of the landscape and, so dendritic drainage pattern is very commonly seen in the case of impervious rocks or rocks that do not permit water to enter inside them non-porous rocks.

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So, this is the dendritic drainage, this is another example, now in this case these are all different tributaries of Ganga and here again you can observe that this is a main branch, or the main trunk then you have the branches and you have a large number of sub-branches, here again this pattern looks like a tree, this looks like a tree and so on.

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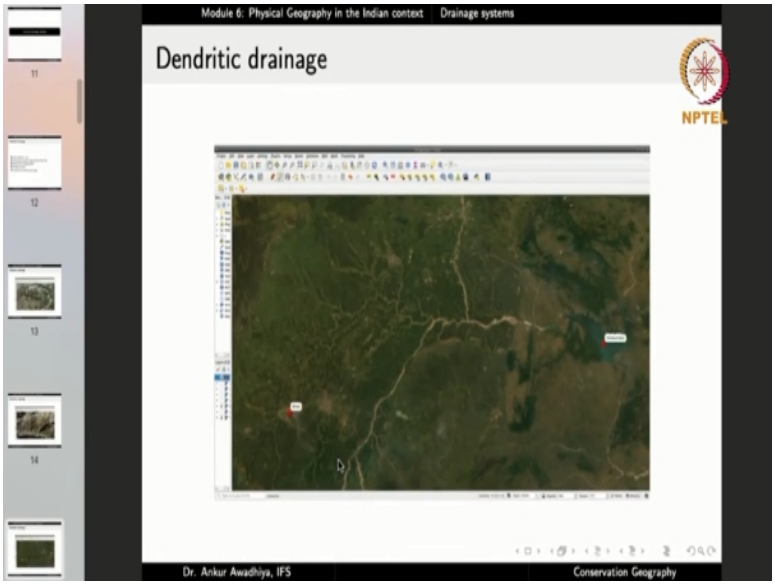

This is the Mahanadi river and in this case as well you can observe that this is the main branch and then we have a sub branch here, a sub branch here, a sub branch here and all of these are having their own sub sub branches.

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So, like if we zoom into this area this is a branch and then this branch has its own sub-branches, this sub-branch has its own sub-sub-branches, so it looks like a tree and so this is the dendritic drainage pattern.

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This is another example here again you can observe that if you consider this to be a tree then this is the main trunk, these are the branches, if you consider this to be the main trunk you get a large number of branches. So, anywhere you find a tree like drainage it is a dendritic drainage and in a number of cases it shows that the stream is flowing in an accordant pattern through impervious rocks.

Now, there are some examples in which case you can have even a discordant pattern that shows such drainage but that is very few and far in between, so the common thing to remember is that dendritic drainage pattern looks like a tree, you have a main stem, a large number of branches, each branch has its own sub-branch and so on, it is found in non-porous rocks, impervious rocks and in this case the river follows an accordant pattern, meaning that it flows according to the landscape.

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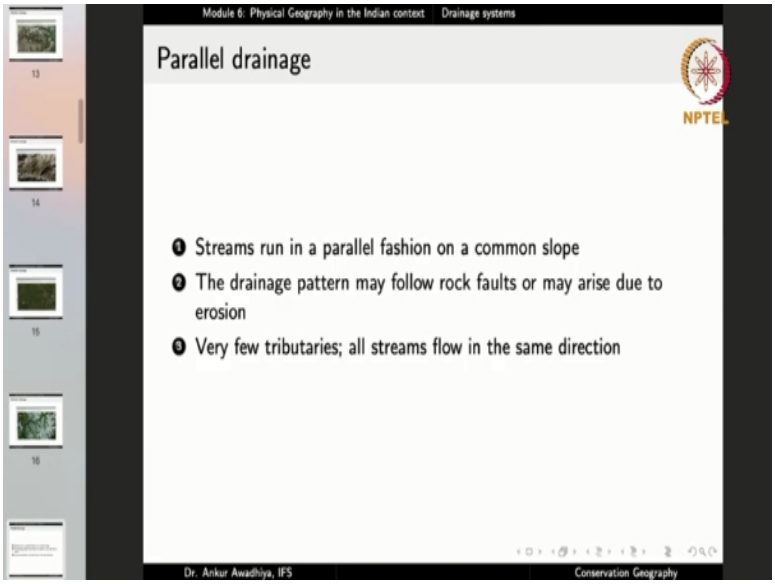

Now another drainage pattern is the Parallel drainage, in this case streams run in a parallel fashion on a common slope. The drainage pattern may follow rock faults or may arise due to erosion, there are very few tributaries and all the streams flow in the same direction.

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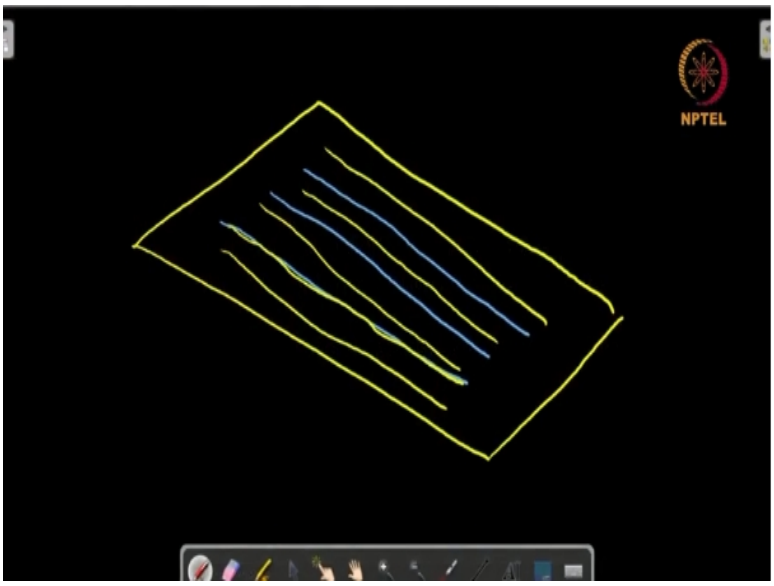

So, what happens in this case is that if you have a land that is greatly sloping in one direction. So, suppose, this is the piece of land and the slope is high, so in that case if you

say release some water here it will move along the slope, if you release some water here it will move along the slope, if you release some water here it will move along the slope and in this case all of these different streams they will appear parallel, so this is a parallel drainage.

In this case the streams run in a parallel fashion on a common slope, so this will be found in those areas that have a slope and all of the streams are on the same land with the same amount of slope, it will not be found say in a flat area.

The drainage pattern may follow rock faults or may arise due to erosion, so it is also possible in certain cases that the rocks themselves have faults that are parallel to these and so it is possible that this stream is just following a rock fault, so that is also possible but not necessary. So, you can even have a parallel drainage in an area where you do not have the rock faults, there are very few tributaries and all the streams flow in the same direction.

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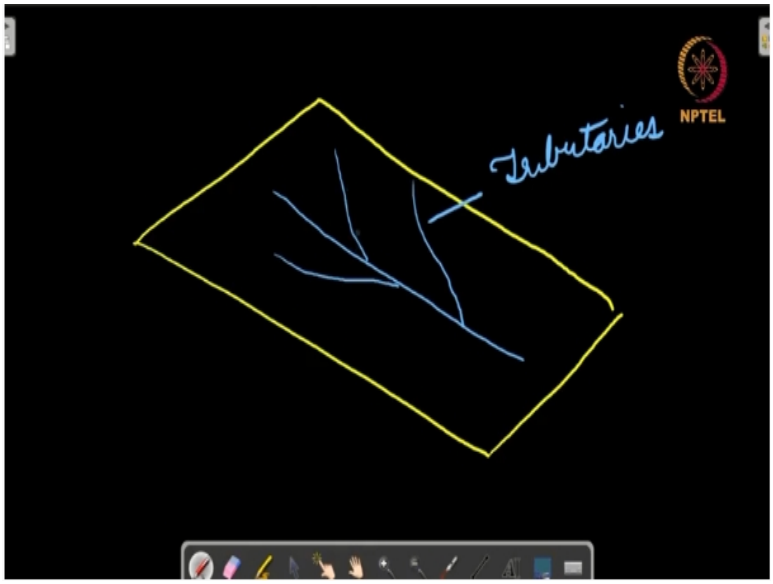

Now, why very few tributaries? Because when we talk about tributaries in that case there should be streams that are meeting with each other, meaning that you have a stream that goes like this and then another stream that joins it like this, another stream that joins it like this, another stream that joins it like this, so these are all different tributaries. So,

tributaries are the streams that join the mainstream but then for a stream to become a tributary it should be joining the main stream and this typically occurs at an angle.

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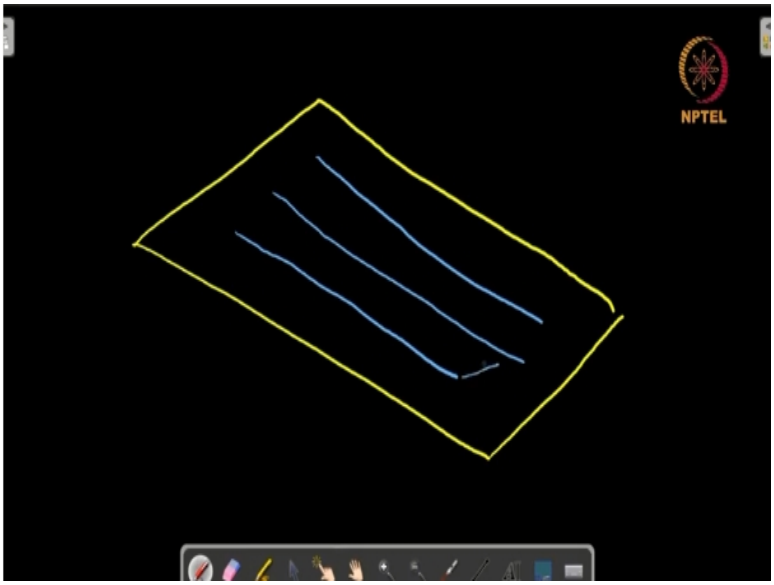

But in the case of the parallel drainage, you have a situation where all the streams are parallel, so if the streams are parallel, they are never going to join each other and so either you find no tributaries or say once in a while because of a small amount of slope some streams might join but that is the exception not the norm.

So, in parallel drainage streams run in a parallel fashion on a common slope either following the rock faults or arising out of erosion over long periods of time, very few tributaries and all the streams flow in the same direction.

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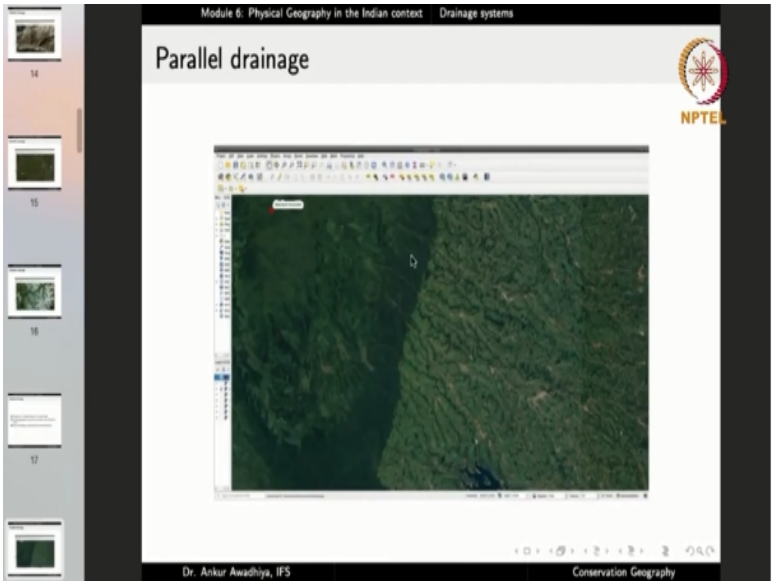

This is an example, so in this case you have all these different streams that are flowing like this, because this area is a highland, this area is a low land, so you have a slope in this direction and all these streams are following this slope.

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This is another example, now here this portion is a highland, this portion is a low land and all of these streams are moving in a parallel direction.

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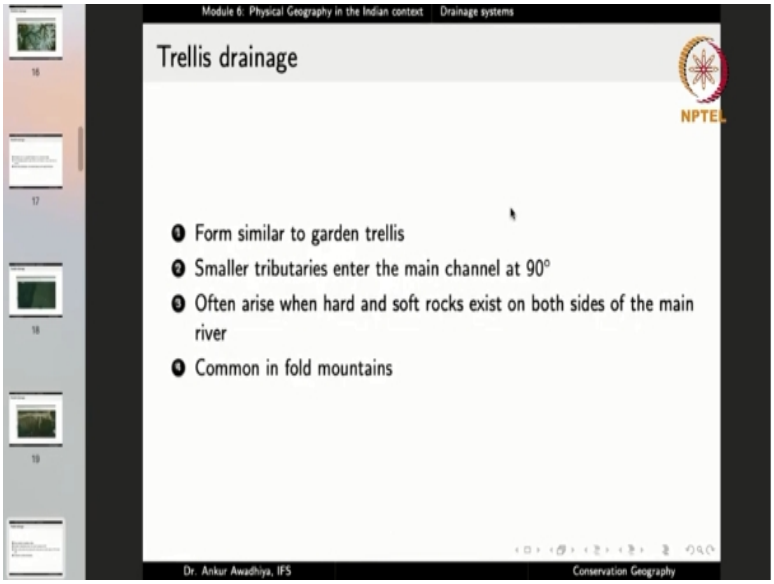

Next, we have the Trellis drainage, trellis refers to the structure of a garden trellis, so what is a garden trellis? If in your garden you have the climbers, so climbers need to be provided with certain amount of support.

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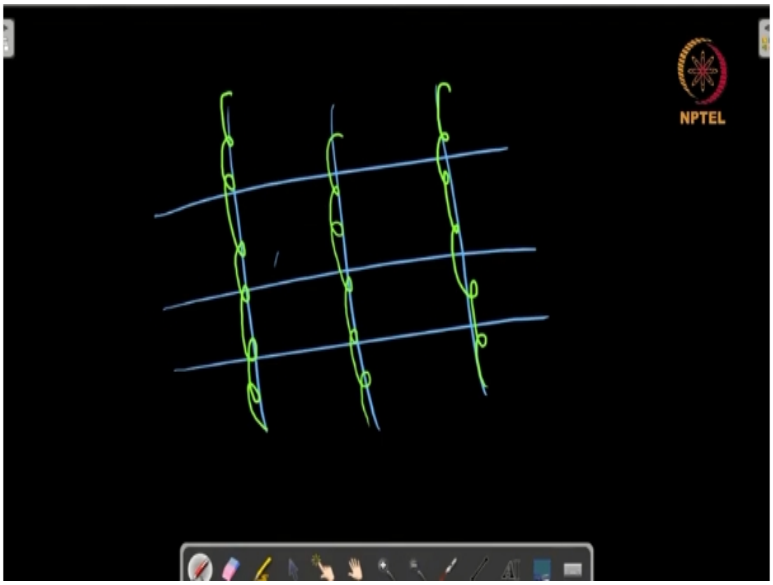

And typically, the support is provided in the form of a pattern that looks like this, so you can have this structure and if you give it to the climber then the climbers will climb like this, so this is a trellis pattern. So, in the trailer pattern you can have vertical rods or you

can have horizontal rods. Now similar to this you can have a trellis drainage pattern in which case the smaller tributaries enter the main channel at 90 degrees.

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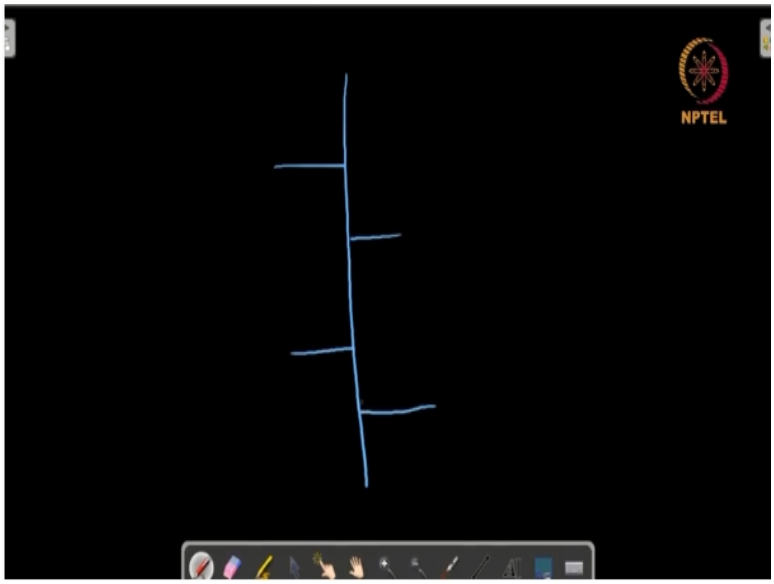

So essentially what is happening here is that if you consider a trellis drainage then you have a main stream and you can have these other tributaries that are joining it at 90 degrees. So, this is a trellis pattern, so smaller tributaries enter the main channel at 90 degrees, it often arises when hard and soft rocks exist on both sides of the main river and it is common in fold mountains, so this is often determined by the rock types that are present.

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So, this is an example, this is an example from France and in this case you can observe that if this is the main stream here you have a tributary that moves like this goes 90 degrees and joins it, here you have a mainstream everything is joining it at 90 degrees and if you look at the sub streams for this stream you again have these 90 degrees. So, this is looking very similar to a garden trellis, here again this is the main stream, the tributaries join at 90 degrees its tributaries also join at 90 degrees and so on, so this is a trellis pattern.

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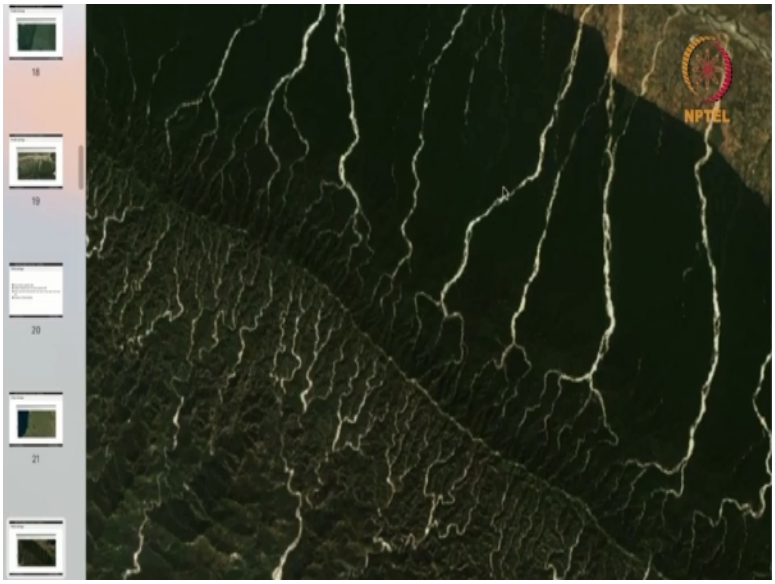

This is another example, so in this case you will observe that the main streams have the tributaries that are joining at 90 degrees, their tributaries are also joining it at 90, degrees and so on. So, this looks very similar to the pattern of a garden trellis.

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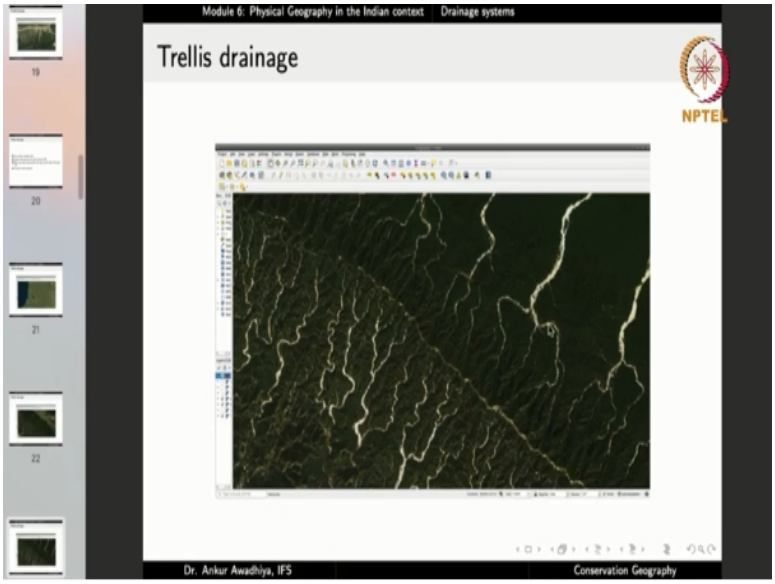

This is a zoomed-up image of this, so here again the mainstream tributaries is joining at 90 degrees other subtributaries also joining at 90 degrees on both the sides.

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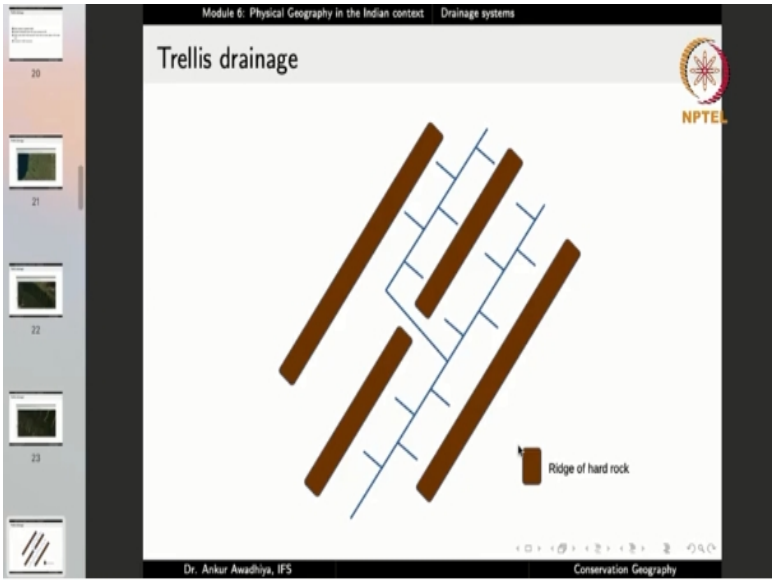

This is a trellis drainage, now why this trellis drainage arise? It arises when you have an area with hard and soft rocks, now if you have hard rocks like this then the river is not able to cut through them, so the river has got no other option but to run parallel to these rocks.

Now, if these rocks are parallel the streams will move like this but if there is any gap in between then these streams can join together, so in this case this becomes a tributary of the mainstream and similarly you can have rocks on the other sides as well or it is possible that here we have a slope towards this tributary and so all these streams are parallel and there they are going towards a common drainage area which is this tributary.

So, we find a trellis drainage in areas where typically we have hard and soft rocks, now the river is not able to cut through the hard rocks so it only moves through the soft rocks, whenever there is a gap the river may join another stream and become its tributary and typically in the case of the tributaries you have slopes on both the sides because of which their subtributeries also join them at 90 degrees.

So, this is a trellis pattern and as you can very well understand this is an accordant pattern, it moves along the landscape, in this case the rivers are not cutting through the

landscape in whichever way they want they are following the landscape, so this is the trellis drainage pattern.

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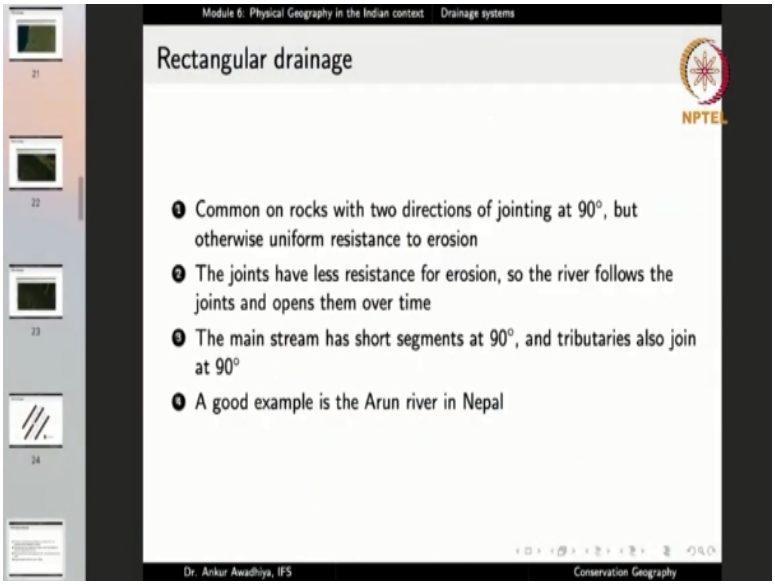

Next, we have rectangular drainage, it is common in rocks with two directions of jointing at 90 degrees but otherwise a uniform resistance to erosion.

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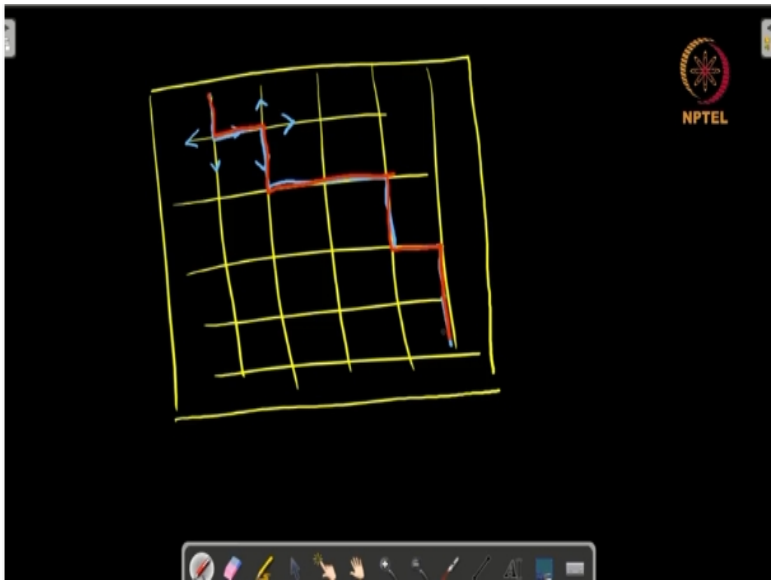

Meaning that you will find it in such rocks where suppose these rocks suffered a fracture in this direction, so these are all different fractures that have developed but then it also suffered fractures in these directions. Now once you have such a pattern and otherwise the rocks are very hard, so now what options do the streams have? So, if a stream moves like this it is not able to cut through the rocks, it has to follow this fault and then here the stream has got now three options it can move in this direction, it can move in this direction or it can move in this direction.

Suppose the stream takes this direction because it is following the slope, now here again the stream has got three options it can move like this, like this or like this suppose it takes this route. So, similarly, in every location we can have a situation where the stream is moving at 90 degrees at each turn.

So, this is a rectangular drainage pattern, so in the rectangular drainage pattern the rivers or the streams they move at 90 degrees, 90 degrees, 90 degrees, 90 degrees then again, a 90 degree turn, a 90 degree turn, a 90 degree turn and so on. So, this occurs in those rocks that are very hard, so they are not very easily susceptible to erosion by the rivers but they have a large number of joints or faults.

Now because the joints have less resistance to erosion so the river follows the joints and opens them over time, so if the river is moving like this with time because the joints have less amount of strength as compared to the other rocks, the river will go on opening these joints. So, the river will become deeper and deeper and the joints will become more and more open, with time because the river is also doing erosion. So, the main stream has short segments at 90 degrees, the tributaries also join at 90 degrees.

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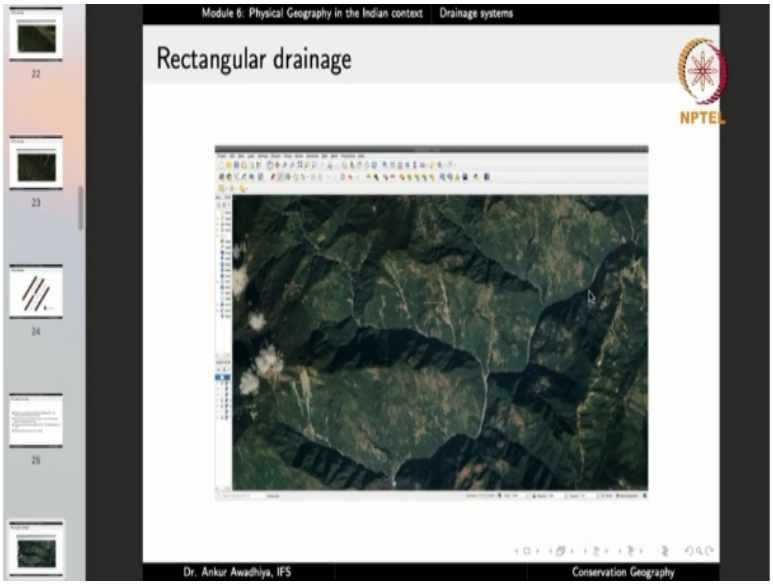

A good example is the Arun river in Nepal, so this is how it looks like, so if you consider this stream so you have a 90 degree turn here, then a 90 degree turn here, then a 90 degree turn, a 90 degree turn and 90 degree turn and so on. Now in this case the turns are not exactly 90 degrees but very close to that, if you consider one of its tributaries here again you have a turn, then a sharp turn, then a sharp turn, then a sharp turn and so on.

If you consider this stream, you have this it flows straight and then there's a sharp turn and then there is a another sharp turn, this tributary also joins at 90 degree, these tributaries also join at 90 degrees. So, you get a rectangular drainage in those areas where you have hard rocks with joints, the river is unable to erode the hard rocks so it has no other option but to move through the joints and with time it is going to erode these joints to get a rectangular drainage.

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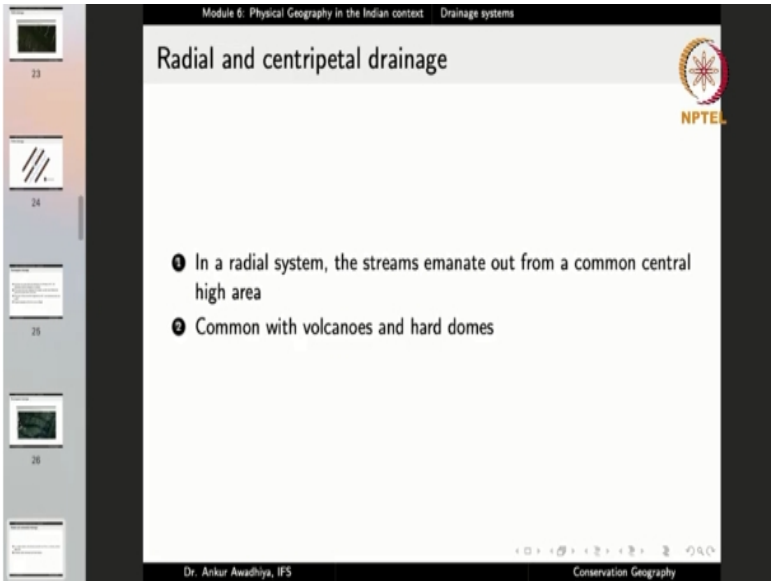

Another example or another type of drainage is the Radial and Centripetal drainage. In a radial system the streams emanate out from a common central high area such as volcanoes and hard domes.

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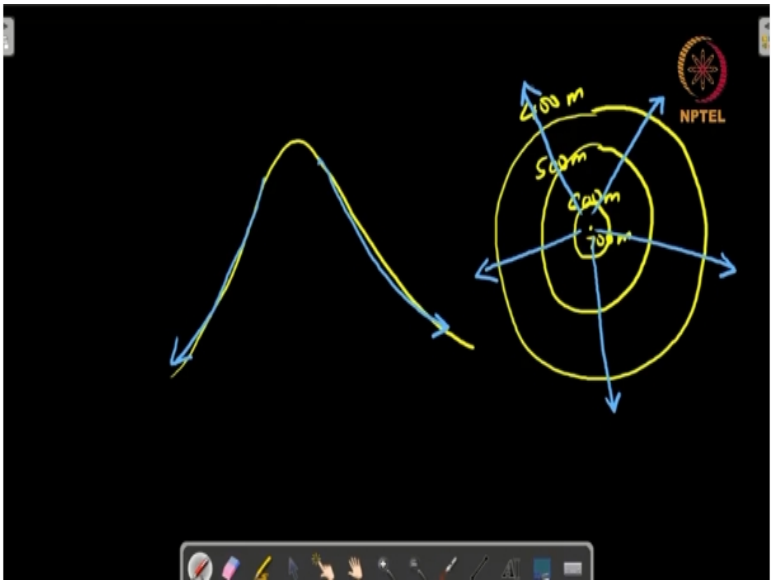

So, what happens in the case of a radial drainage is that if you have a hill that is like this, now if there is a river on this side it will move in this direction, if there is a river on or a stream in on this side it will move in this direction. So, if you look at this area from the

top and say you draw the contour lines, so this is the base then this is a central contour and then you reach to the top.

So let us say you have the elevations like 400 meters, 500 meters, 600 meters and 700 meters. Now in this case if a river or a stream is moving in this direction it will move like this, another stream will move like this, so this is the direction another stream will move like this, another stream will move like this.

So, all the streams are moving away from a common point because this common point is at an elevation and the water has to follow the slope, so in this case you get a radial drainage. So, in a radial system the streams emanate out from a common central high area and the high area is typically the peak of the hill or the mountain and it is common with volcanoes and hard domes.

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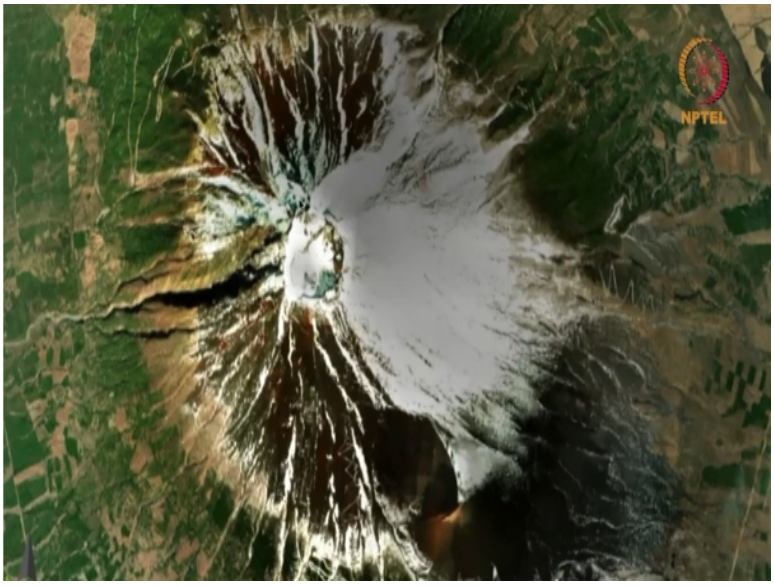

So, for instance if you look at Mount Fuji, so this is mount Fuji and in this case the streams will move like this, so you will have streams moving in this direction, a stream moving in this direction, another stream moving in this direction, another stream moving in this direction, another stream moving in this direction.

So, all the streams are moving away from this common high point, so this is a radial drainage. So, a radial drainage is common in those areas where you have a common high

point and all the streams have to move away from this common high point, so whenever you have rains here the streams will move away from this common high point.

In India the Amarkhantak range of Madhya Pradesh which is a highland has a radial drainage pattern with three rivers emanating out and moving away from this highland, these rivers are the Narmada, the Son and the Johila.

Now similar to a radial pattern we can also have a centripetal pattern, in the radial pattern the streams are moving away from a common highland, in the case of a centripetal pattern the streams are moving towards a common low land. So, in the case of a centripetal drainage the streams flow towards a central depression.

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So, this is an example, so in this case you have this crater called the Ramgarh Crater and if you look at the 3D map of this area this is what it looks like, so this is the Ramgarh Crater in the center we have a depression and around it we have these ridges which form a circular pattern.

Now, you will remember that we had a circular pattern even in the case of the Chicxulub crater which is there in South America now in the case of Chicxulub crater it was generated by the impact of a meteor 65 million years ago and the impact was so strong that it led to a large amount of extinction, particularly the extinction of dinosaurs and that

especially because this area was rich in sulphates and when these sulphates got exploded when they moved into the upper atmosphere then they blocked away the sun's heat and light for a very long period resulting in a global cooling in on the Earth.

Now, similar to the Chicxulub club crater we have the Ramgarh crater in India, in the state of Rajasthan now in the case of Ramgarh crater as well you have a central depression where the meteorite is struck and you have these ridges on the side and this also forms a circular pattern. Now in this case if we consider this portion, if a drop of water falls here it will move towards the center similarly on this side if a drop of water falls it will move towards the center, if a drop of water falls here it will move towards the center.

So, you have a common low land and so all the streams will be moving towards the center, so this is the common low line and all these streams are moving towards the center, so this is a centripetal drainage. So, we can have radial drainage and we can have centripetal drainage.

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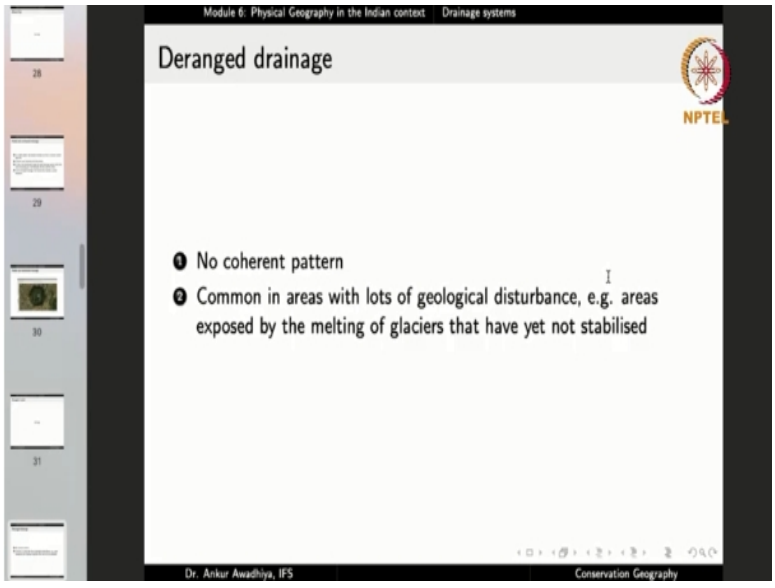

Another drainage pattern is Deranged drainage, a deranged drainage is like a mad drainage, there is nothing that follows anything, so in this case there is no coherent pattern, you cannot understand why you have this deranged pattern, everything looks out

of place. It is common in areas with lots of geological disturbance such as areas that are exposed by the melting of glaciers and have not yet stabilized.

So many large number of changes are continuously occurring in these areas that at one point of time the streams are flowing in a certain direction and then after some time the stream starts to move in a different direction because these areas have not yet stabilized, there is still some activity going on, perhaps it can be a tectonic activity or it can be the melting of glaciers or the uplift that is caused by the melting of glaciers because when the glaciers melt away the amount of load on the Earth is reduced at that location and so the crust starts to move up.

So, you can have n number of factors because of which the landscape has not yet stabilized and in these unstable areas you will find a deranged pattern. Now it is very commonly found in areas that have glaciers because in those areas we have very unconsolidated deposits that have been generated through the activity of glaciers, so we can have things like moraine deposits.

Now in the case of moraines they are not very hard, they are not very soft so it is possible that this stream is able to cut through the moraines in some locations, in certain other locations it is possible that their streams just disappear into the moraines, at the same time in the case of local depressions you will find n number of lakes that have developed in the area, glacial lakes and so you can have a stream that is flowing in a certain direction and then it encounters a lake and it drains itself into the lake. So, it becomes a very deranged pattern which keeps on changing.

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So, one good example is the Canadian shield, so here you can observe that you have this river, this is river Winisk and this river is moving like this but all around this area you have all of these lakes. Now this river has been moving in this direction and then suddenly turns, so we do not find, so this drainage is not a dendritic drainage, this is not a parallel drainage, this is not a rectangular drainage, it is not a rectangular drainage because in certain areas you find a dendritic sort of a pattern, in certain areas you find a 90 degree turn and this area has not yet stabilized, so in such areas we find deranged drainage.

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Another example is the Gangotri glacier, so we saw in the case of the Gangotri glacier that this is the glacier, the glacier used to move like this but now in those areas where it has melted you find that there are a large number of these deposits that have come up, now these deposits will make it difficult for the for the streams to follow a certain direction, especially when we look at the large scale picture when more of the glacier gets melted away then we will find all these areas will result in streams that are moving in different directions, so that is a deranged drainage.

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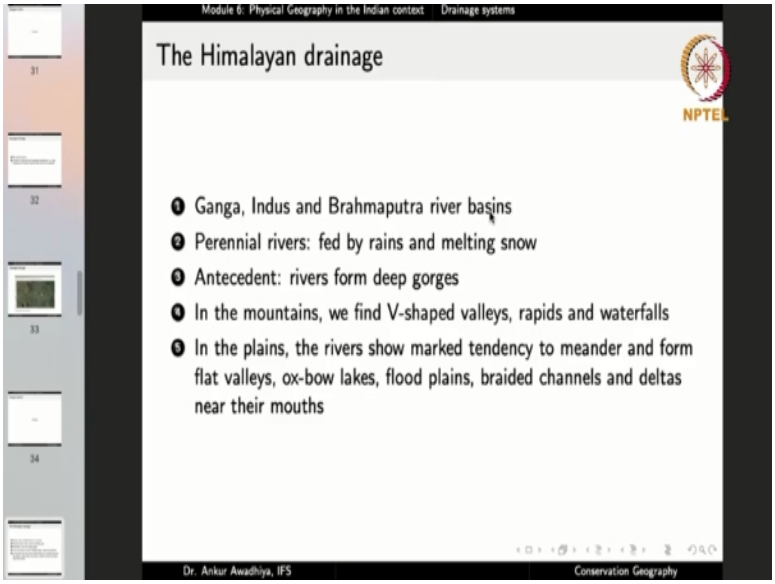

Now in our country we can talk about the Himalayan drainage and the peninsula drainage and both of them follow very different patterns. The Himalayan drainage comprises of Ganga, Indus and Brahmaputra river basins and these are perennial rivers, perennial means that they have water all around the year and this is because they are fed both by the rains and by the melting of snow.

So, in the rainy season they get their waters from the rains, in the summer seasons they get their waters through the melting of the snow and so they have water all the year around, their perennial rivers. They are antecedent rivers, meaning that they were existing before the mountains rose and so the rivers formed deep gorges. The rivers continued to move in the direction in which they had been flowing before the Himalayas came up and so the rivers cut through the Himalayas and formed very deep gorges, very deep valleys.

In the mountains we find V-shaped valleys, we find rapids and we find waterfalls and in the plains the rivers show a marked tendency to meander and form flat valleys, ox bow lakes, flood plains, braided channels and deltas near their mouths. Now why is that so? Because the Himalayas are young fold mountains, they are comprised of sedimentary rocks that existed when we had the Tethys sea in this area, now the Tethys when it got compressed by the convergence of the Indian plate and the Eurasian plate it rose and it formed a large number of folds.

Now because the rocks are sedimentary rocks so they are easy to erode and so the rivers perform a large amount of erosion and all of the sediments that the rivers carry with them in the upper areas where they have a high velocity all of those sediments are later on deposited when the rivers enter into the plains.

And when the river enters into the plains they deposit these sediments and whenever there is a deposition the rivers will change their course. And so these rivers meander a lot, and they not only meander but they also form things like flat valleys which are full of sediments, ox bow lakes when the meanders are cut off, flood plains again with lots of deposits, braided channels because the rivers are changing their course very often and deltas near their mouths where the sediments again are deposited. So, in these rivers we find a marked erosion, marked amount of transportation and a very marked amount of deposition of sediments.

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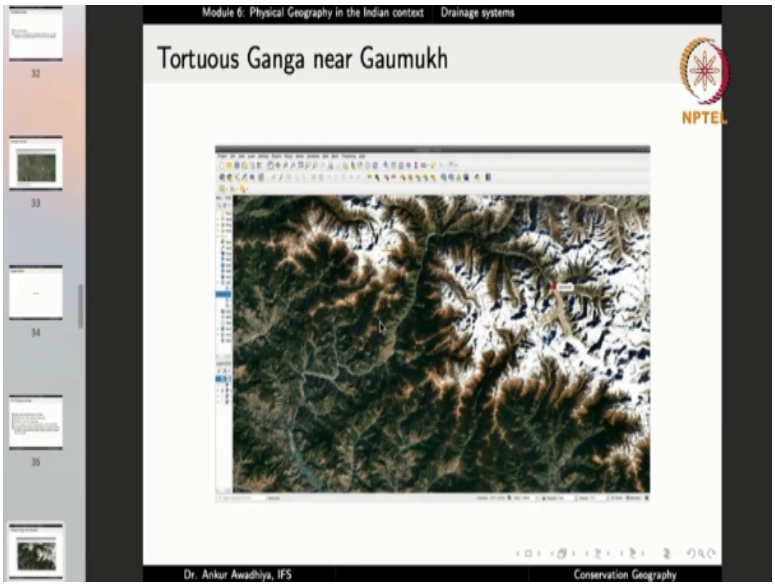

So, this is an example, if you look at the Ganga river near the Gaumukh it follows a very tortuous path because this portion is very high and this portion is a plane area.

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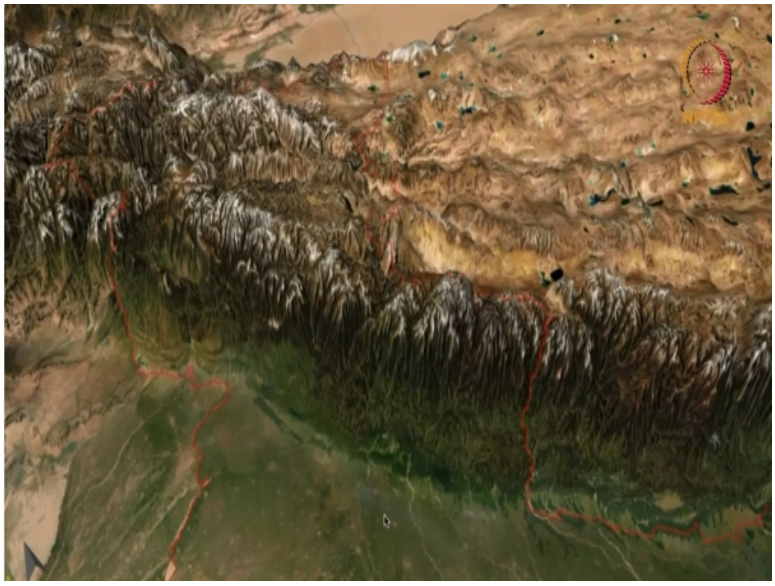

So, if I look at it in the three dimensions we will find that the river is moving through the Himalayas, so it is originating in the Himalayas in the Gangotri glacier, so let us zoom this area, yes, so in this case the rivers are originating in Himalayas which are very high, so here you find a very high amount of elevation.

Now, this image is zoomed in the z-axis by 50 times but you get the idea that you have very high Himalayas and so in this portion the rivers will be following a very quick movement, they will be having very high speeds so high capacity of erosion, high capacity of transportation but once these rivers enter into the plain areas the plane areas are very flat areas.

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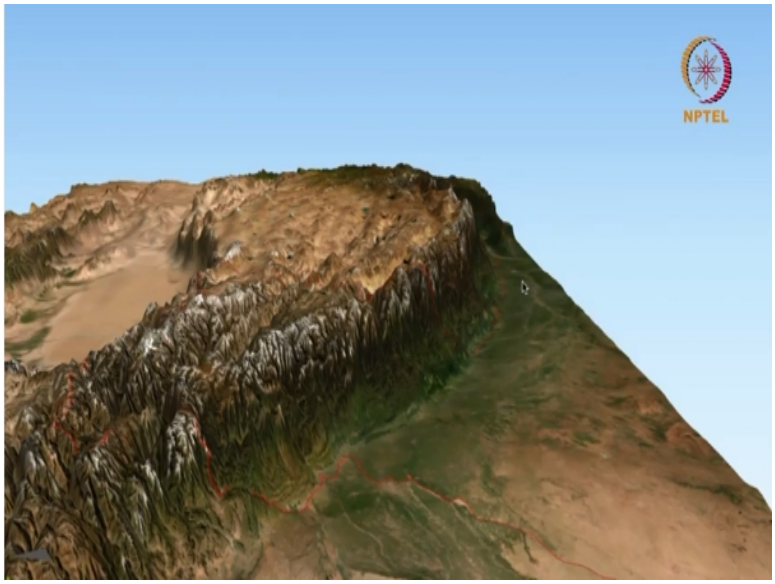

So, if we look at it in this direction now you can make a sense that this area is a very flat area, now in the flat area the speed of the river is less and less speed means less ability to erode and a lesser ability to transport and so it will perform a lot of deposition in this area and all of these northern plains are formed out of the deposits of these rivers. So, it follows the a tortuous path near the Gaumukh.

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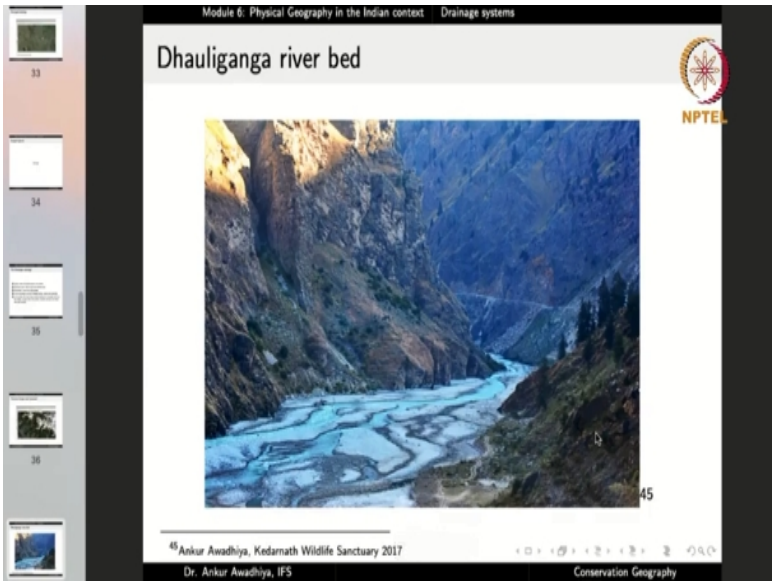

This is a tributary of the Ganga the Dhauliganga and you can look at the river bed and you can find that it has formed a very deep valley, so on both the sides you have the mountains and these mountains have been cut down by the river as they were increasing in height, as they were elevating and this is the current bed and this bed is all full of sediments.

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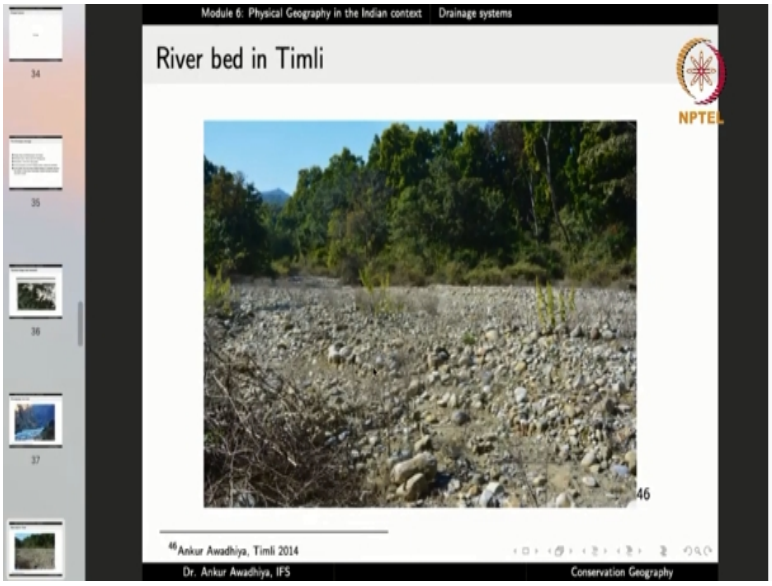

And the rivers in this area they form they have beds like this with lots of deposits, lots of rocks and typically these rocks are very rounded rocks because they have been eroded a lot.

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Then later on when it enters into the plane areas it forms a large number of braids, now braid it means that if you look at this river it moves like this but then here it had turned and it made another stream, here it made another stream, here it made another stream.

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So, we have all of these small streams that are braided together so what is happening in this case is that you have a main channel but because the rivers are carrying a large amount of sediments, when the rivers deposit the sediment here in that case the river

changes its course, so it starts to flow like this but then the typical slope is in this direction, so the stream will again rejoin the river, then it deposited some sediments here.

Now when the sediments get deposited here then we will find that it will again change the course and probably it will join the river here, then probably it deposits some amount of sediments here, now in this case the river will again change course and it will go like this. So, we get these patterns where the river is highly braided, so it will look like this, so this is known as a braided pattern and it is very commonly observed in the Himalayan drainage system.

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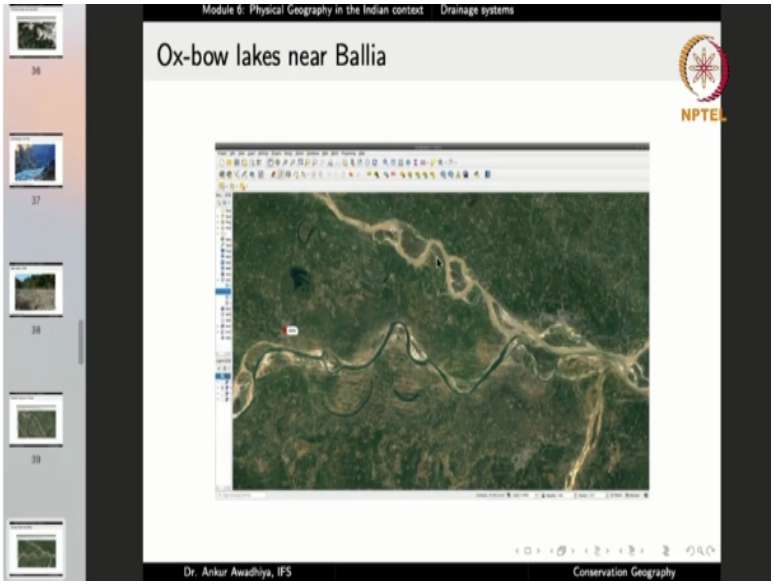

When you have these braids when you have these meanders, so meandering means that the river is flowing zig and zag, it is not following a straight path and when you have meanders that have developed to a very long distance then probably there will be some amount of sedimentation and the river will change course and this portion will become an ox bow lake, so these areas also or these rivers also show a large number of ox bow lakes.

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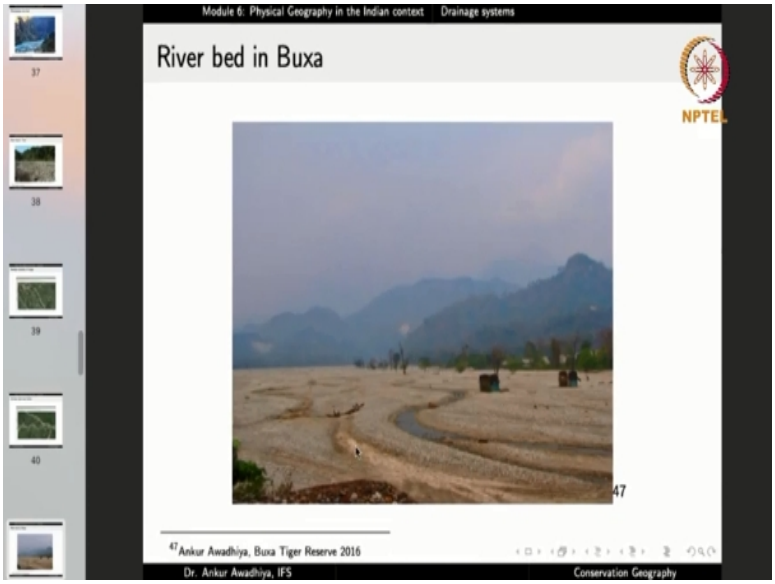

This is another example, so this is a view from the Buxa Tiger reserve, here again you can observe that the riverbed has a large amount of deposits and because it has so much amount of deposits so the river has been changing its course time and again.

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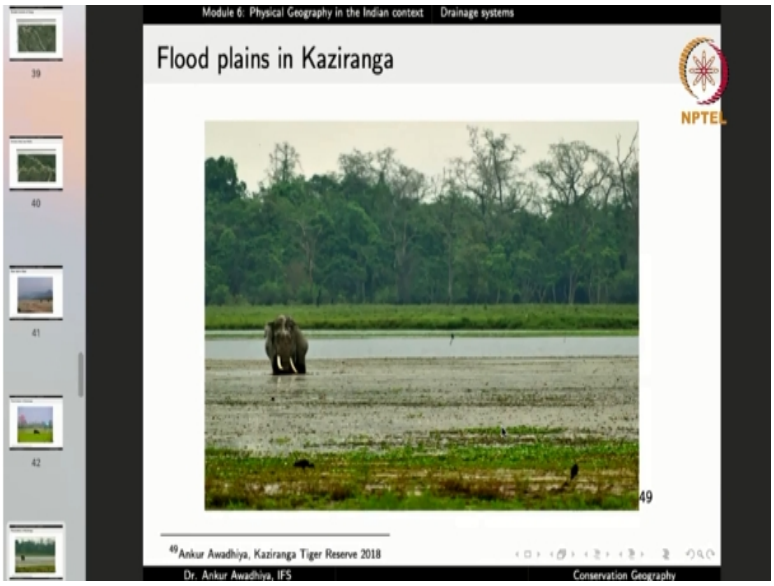

When such a thing happens it generates a very flat flood plain and these flat flood plains are a very unique habitat that we find in our country, so these are very flat areas constructed by a large amount of deposition of the sediments. Now when these sediments are deposited they are deposited in a very flat manner.

So, whenever there is a flood you will have a large amount of sediments, they get deposited they form a straight stratum, just as what we had observed in the case of sedimentary rocks and because of that you have a very flat flood plain and this floodplain will in a large number of areas it will continue to hold water, in the form of small lakes or wetlands.

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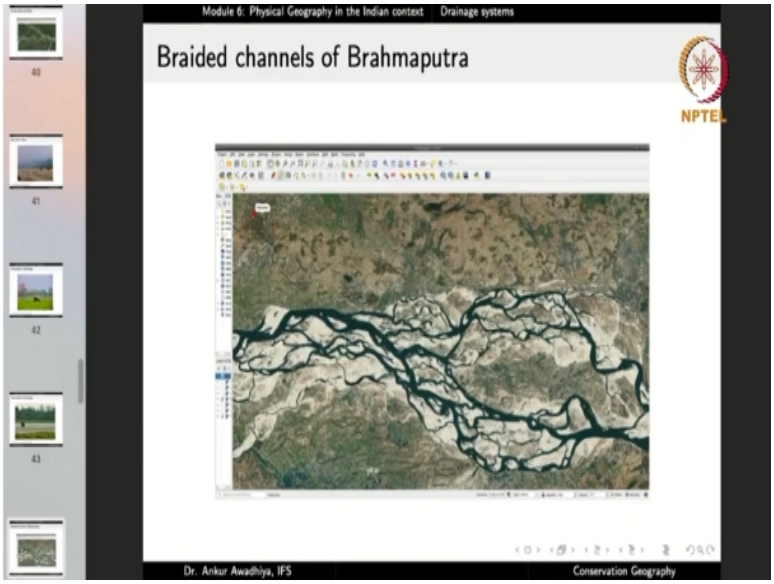

This is another example of braiding, so here we have the Brahmaputra river again an example of the Himalayan drainage and look at the amount of braiding it has gone through. So, the river splits into a large number of channels and then all of these channels join together at some point or at different points and you can observe that all of these areas are full of sediments, they are full of sand and because of the large amount of deposits that these rivers are carrying they are creating these flood planes and they are resulting in meandering and they are resulting in braiding.

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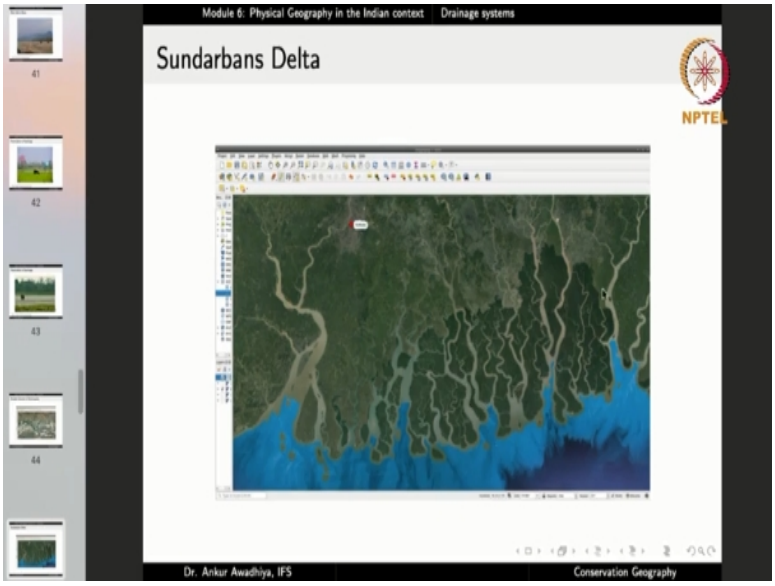

And when these rivers reach the oceans, they reach the seas they deposit a large amount of sediments here as well, so this is the Sundarbans delta where the waters of rivers Ganga, Yamuna, Brahmaputra they all move together and they deposit the large amounts of sediments that they have been carrying, so this is a common feature of the Himalayan drainage.

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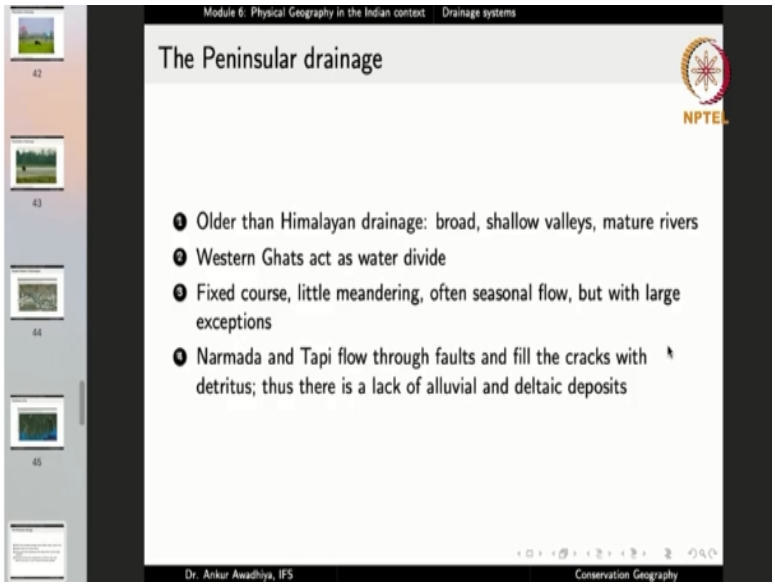

Another drainage is the peninsular drainage that we find in the southern parts of our country. The peninsular drainage is older than the Himalayan drainage, why? Because this drainage probably existed even when India was not a part of Asia, when the Indian plate was moving towards Asia even then it had certain amount of drainages and these drainages still continue.

So, these are very old drainages not like the small streams in the Himalayas, so these are older than the Himalayan drainage and they form broad shallow valleys and they have mature rivers, why broad valleys, why shallow valleys because over time they have done all the erosion or practically done all the erosion that they could have done.

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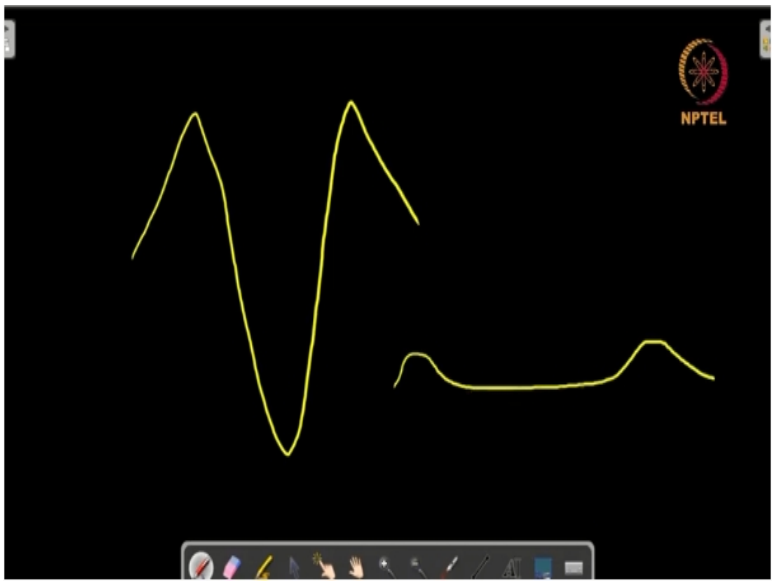

And so the rivers they are not cutting through the mountains like this, what has happened is that over time the erosions have been so much that now it is a flat and a broad valley, so there are broad shallow valleys, the rivers are mature, meaning that they have practically done all the erosion that is possible.

The western Ghats act as a water divide, meaning that on the western side of the Western Ghats we have rivers that flow towards the west, on the eastern part of the Western Ghats the rivers flow towards the east so they act as a water divide, the water that falls on the

western part moves to the west, the water that falls on the eastern part it moves to the east.

The rivers have fixed course, very little amount of meandering often seasonal flow but with large exceptions, the rivers have fixed courses, why fixed scores because they now no longer carry a large amount of sediments, they have practically done all the erosion that was possible.

So, now they are moving over hard rocks and in that case in the absence of sediments there is nothing to change their course, the areas are tectonically stable, so there is nothing to change their course and so they follow a fixed course. Very less amount of rivers breaching their banks, little amount of meandering again because they have been moving through hard rocks for such a long period of time that more or less now their courses are edged in the rocks.

So, there is little that these rivers can do to meander, meandering happens primarily in those areas that have lots of soil because of which the rivers can cut on one side and they can deposit sediments on another side.

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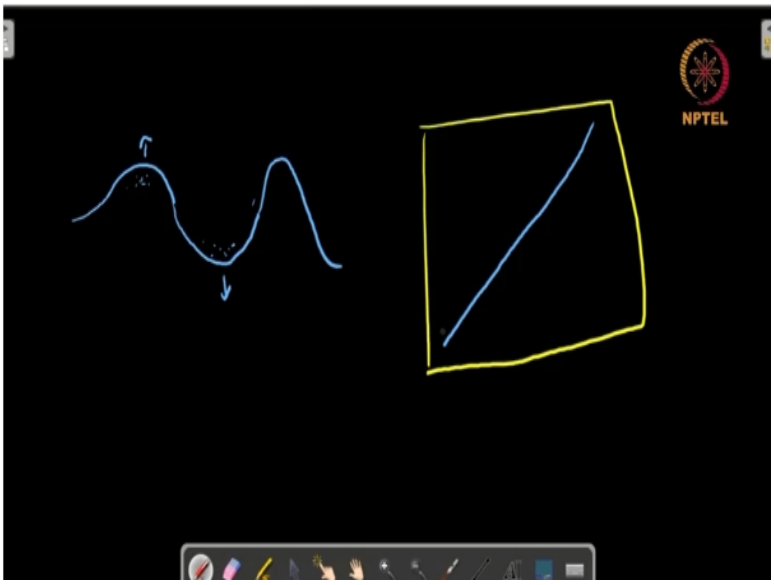

So, essentially what happens is that you have a river and this river can cut on one side, so in this case it is cutting on this side and it is depositing sediments on this side. Similarly,

if it goes like this it is cutting on this side and it is depositing material on this side. Now this is possible if the rivers are moving in a flat area and particularly in those areas with lots of soil that can be moved but if you have an area where you have rocks and because of long times of erosion now the courses have been edged in the rock, so it is now not possible for these rivers to erode the sites and create a meander.

So, they have a fixed course with little meandering. The flow is often seasonal because in the rainy season they will have large amounts of water, in the summer seasons there is no snow clad mountains to provide them with water, but these are all these characteristics are with large exceptions because there are certain areas where the rivers can change their course, where they can meander, there are in certain areas the rivers get their waters from the forest and so they are much more perennial, so there are large exceptions but more or less most of the peninsular drainage has a fixed course with little meandering and often a seasonal flow.

Narmada and Tapi flow through faults and fill the cracks with detritus and thus there is a lack of alluvial and deltaic deposits. So, these two rivers that flow towards the west they are moving through faults and they again have very less amount of alluvial and deltaic deposits.

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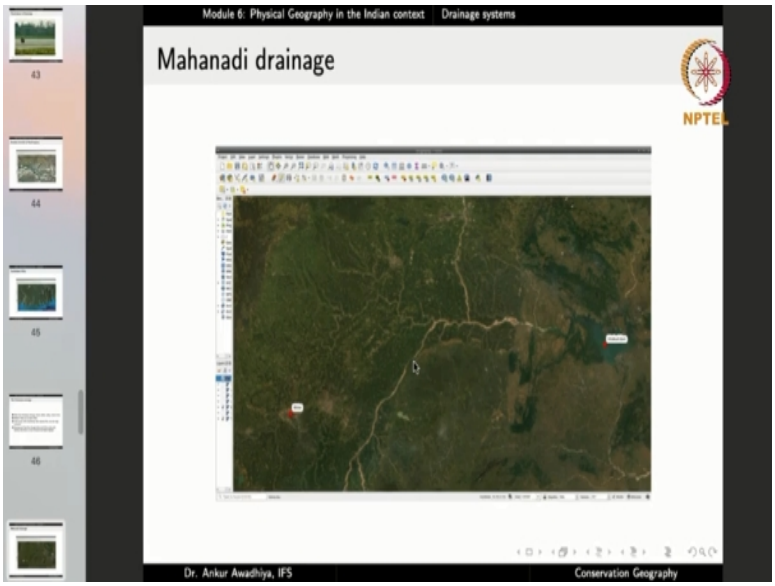

So, this is an example of the peninsular drainage, so here we can observe that there is very little amount of meandering in the Mahanadi river.

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We do get some amounts of waterfalls in certain areas such as this image from Mudumalai Tiger reserve where we have a waterfall but these are very less.

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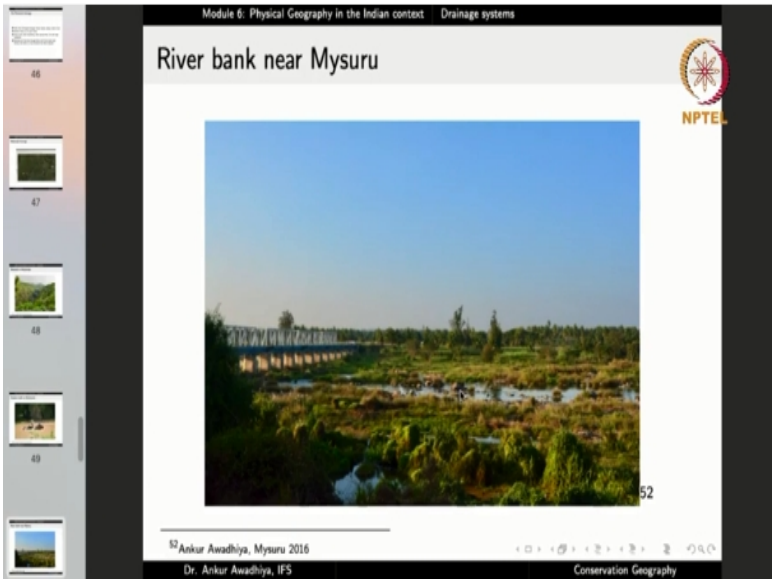

In most of the areas the rivers have already done most of the erosion, so all these areas are now more or less flat areas lots of rocks and the rivers move slowly, so this is the river bank in Mysuru.

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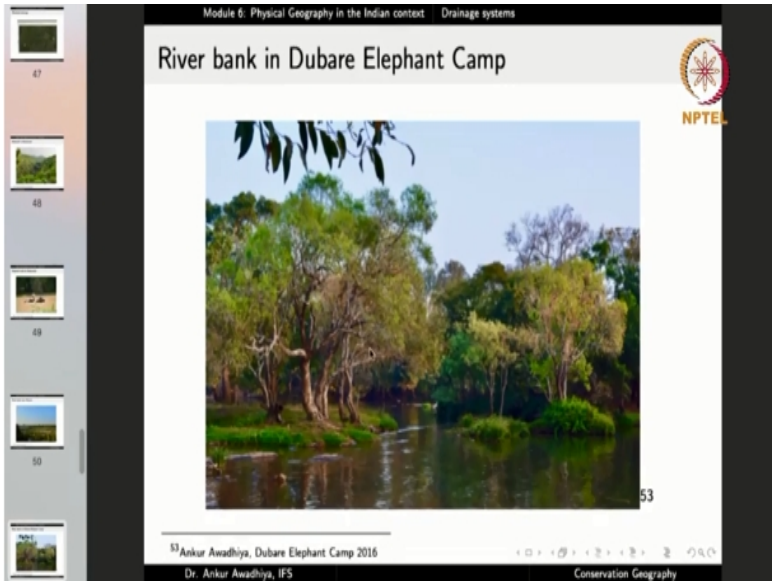

Again, another example from Dubare Elephant Camp here again you find that the rivers are flowing very slowly and in areas where there is very little amount of sediments.

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And we have a large number of dams that have been created on these rivers and dams are all the more needed because the rivers do not have an abundant supply of water in the summer seasons and so they have to be dammed so that water is available for drinking, household purposes, agriculture and other uses.

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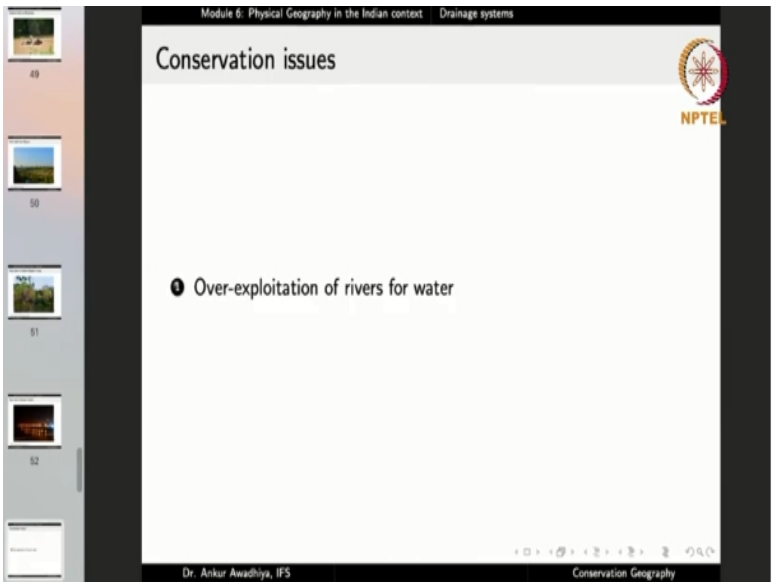

Now after the drainage let us look at the issues of conservation. The drainages have been going on for a very long period of time but now humans are impacting these drainage systems, how? Through things like over exploitation of water.

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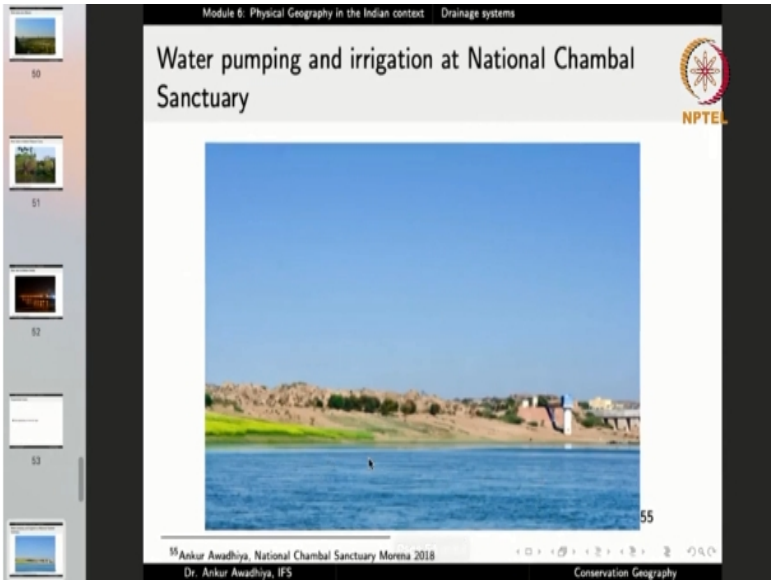

So, in areas such as the National Chambal Sanctuary, so here we have the river Chambal and here you can observe that there is a pump house, now this pump house takes the water of the Chambal river and delivers it to very far off areas such as the Bharatpur district or the Dholpur district of Rajasthan.

Now when you have a large amount of water that is getting removed from this river then where will the organisms that live in the river will go, here you can observe that there is a large amount of agriculture that is going on using the waters of this river.

Now this area is primarily a parched area so in most of the areas you would not find a large amount of vegetation but we humans have been over exploiting rivers, we are growing crops that are not suited to these areas and in this way we are using the waters to such a large extent that the species that live here such as the Gharials they are now facing a danger, they are being pushed towards extinction.

And in a large number of areas you will find the same story, that there is a river but most of the water is now being used up for agriculture or for household use even for far-off locations and this is primarily because of two reasons, we have increased our population and we have increased our demands, primarily through growing such crops that are not suited to the area, so this is a major conservation issue that we are facing now.

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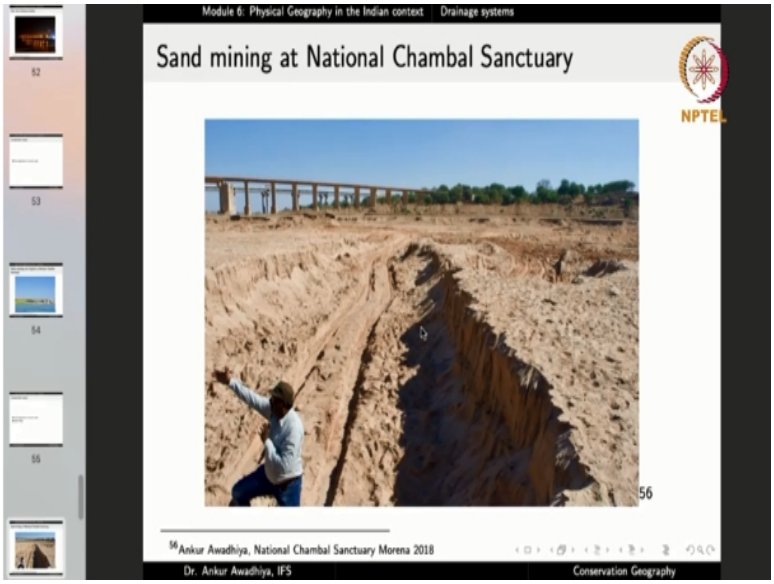

Another is sand mining, so you can look at this image all of this sand has been taken away to be used for construction activities, now even in sanctuary areas we are finding that people are doing illicit mining and once this happens where will the Gharials lay their eggs? So, when we talk about species being pushed towards extinction these are also the factors that are playing a rule.

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Fishing, we are overfishing our resources and once you remove the fishes where would the organisms that depend on the fishes go, we are not doing anything to increase the stock of fishes, we are just exploiting everything, we are just taking away the fishes, what will the Gharials eat, what would the birds eat, so in the absence of food or in the shortage of food their populations would go on collapsing. So, we are not just impacting the fish population we are also impacting the populations of the predators.

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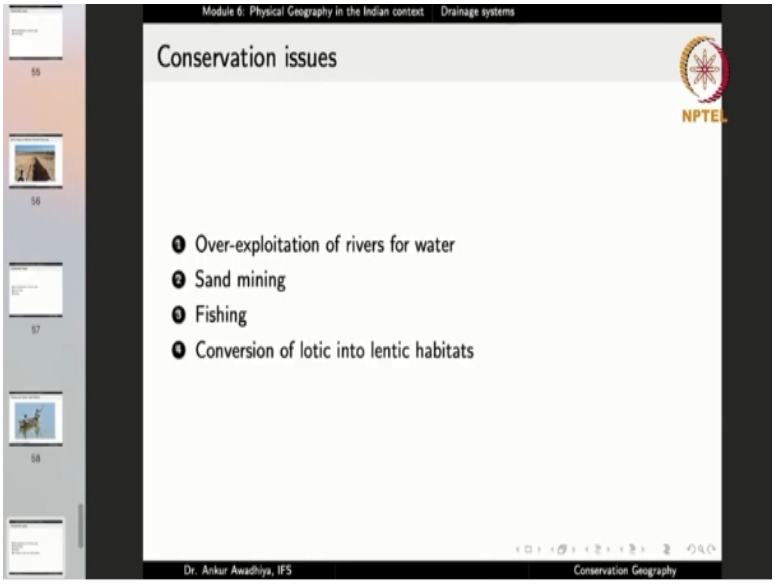

Conversion of lotic habitats which is flowing water into lentic habitats which is stagnant water such as dams.

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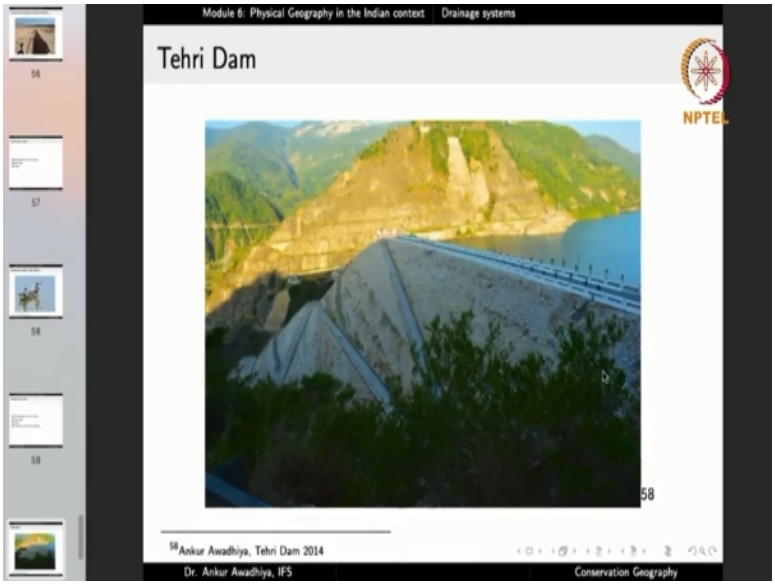

Now, the lotic habitats of rivers they provide a habitat for a very different sort of organisms as compared to a lake ecosystem, now when we construct a dam we convert a river into a lake and so this is another big conservation issue that we are facing now.

Next, we have pollution, a lot of waste is being thrown into the rivers, be it household waste, be it domestic waste, municipal waste, industrial waste you name it and we are using our rivers as our drainage systems.

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Then we have invasive species that are coming up so for instance in the Bharatpur National Park, the national park in Bharatpur we have a major problem of catfish, now catfish was introduced into the area so that people can have a cheap source of abundant protein, but then catfishes moved out of the lakes where they were being cultivated and then they moved into even the bird sanctuary.

Now catfish is a very voracious feeder and it can eat even the eggs or young ones of the birds or even the birds themselves and so now this is becoming another conservation problem that we have come up with, these catfish are not native to this area, we have brought these catfish from Africa and now they are posing a major conservation challenge.

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These are especially harmful to endangered species because in Bharatpur we have the Sarus cranes an endangered species, so while India has a large number of rivers a wide variety of drainage patterns if we do not take care of our rivers it is possible that we will soon lose them and with them a large biodiversity of our country. So, that is all for today, thank you for your attention. Jai Hind!