Photogeology in Terrain Evaluation (Part – 2)

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Lecture – 20
Exercise on Morphometric Parameters and 3D Observation of the Earth Surface Features

Welcome back. So in the last lecture you were looking at the soft copies of aerial photographs and satellite images from different regions to identify different structures and landforms. In this lecture, I am going to show you hard copies of the aerial photographs and some satellite images. So let us move on to photographs.

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So here are some aerial photographs. So these are in the base scale like black and white images where this photograph shows some typical geomorphological features and geological structures, okay.

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Similarly, this photograph is also showing some prominent features like this, here you can identify a (()) (01:10) structure, okay and some traces of the folding and some dissected hills and alluvial plains.

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Similarly, this photograph was also shown in the lecture and this photograph is typically related to Karst topography where you can find that there are number of sinkholes, potholes, some caverns, some dissolution structures, some rounded subdue type of topography, okay. So this kind of topography is typical to Karst environment and which is basically related to limestone and dolomite rocks. So where we have some calcitic rocks, chances of formation of such kind of subdued topography which is known Karst topography.

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Here is again another photograph showing the Karst topography, okay. It is basically related to groundwater. So it is erosion and dissolution by groundwater which is actually underground. So if you see the potholes or sinkholes, then you can identify that it is filled with some water which is represented as black colour of dark colour, okay. So the water bodies are generally represented as light colour on the grey scale images.

So these all the potholes or sinkholes are filled with the groundwater. So groundwater seepage is through the underground beds or strata and the, this groundwater is dissolving the sediments which is lying at the surface (()) (03:07) level and that is why there are formation of some caverns and this kind of features.

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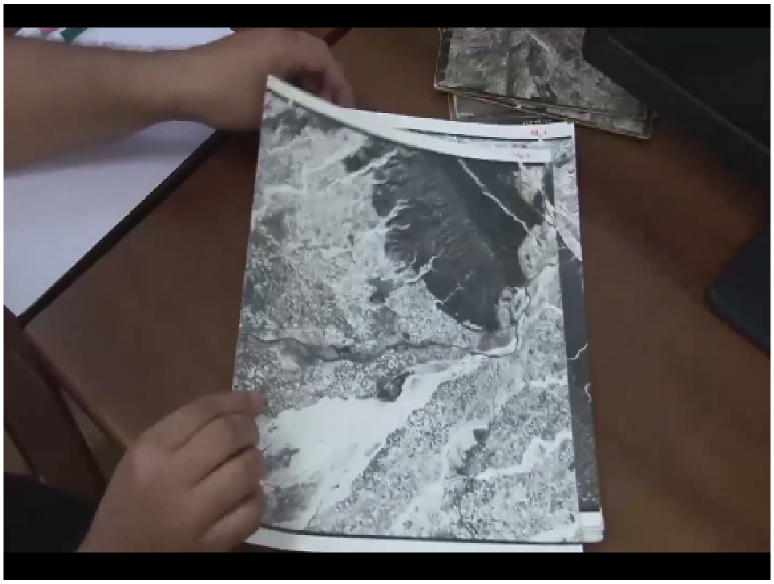

Next I will talk about some other images which are also in black and white mode where you can identify various features.

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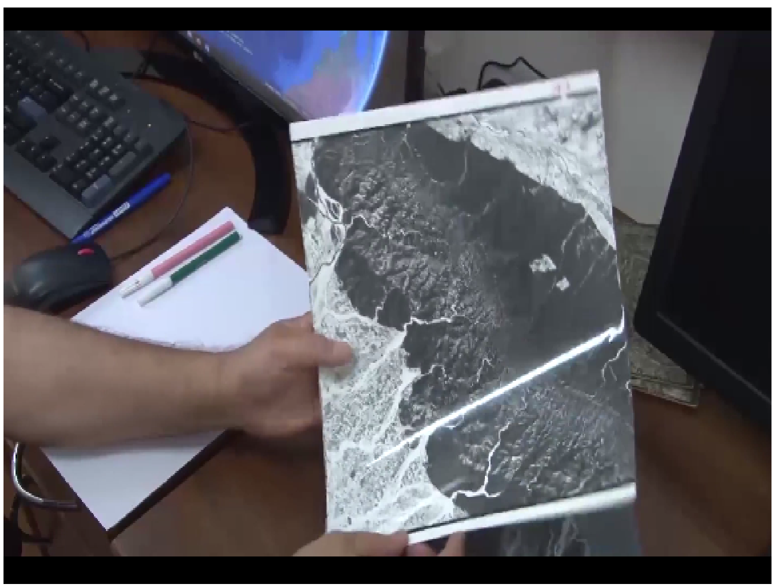

And these landforms are showing the fluvial geomorphology and all. Here you can see some kind of bisection of the topography. There is a drainage divide and here, on this side, you are having flows on, in this direction and where as on the other side, the tributaries are flowing in this direction and joining the, this trunk stream, okay. And this is the upland region and reverse of, flowing towards the lowland or the plainer ground, upland to down slope and forming some kind of alluvial fan and other related landforms.

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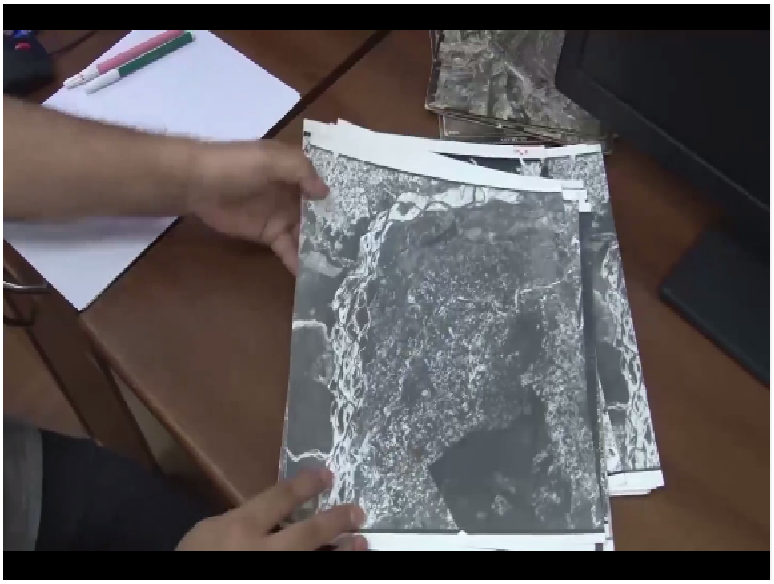

Similarly, these are all the images of different regions from India. This, on this image, you can see that there is a very typical type of river which is generally known as braided river having some short meandering channels in between this and then having some braid bars and point bars, okay. These photographs are related to major rivers and their landforms. This is just for your information how they look.

This is just for your information how they look like. Similarly, some other images on the Himalayan terrain.

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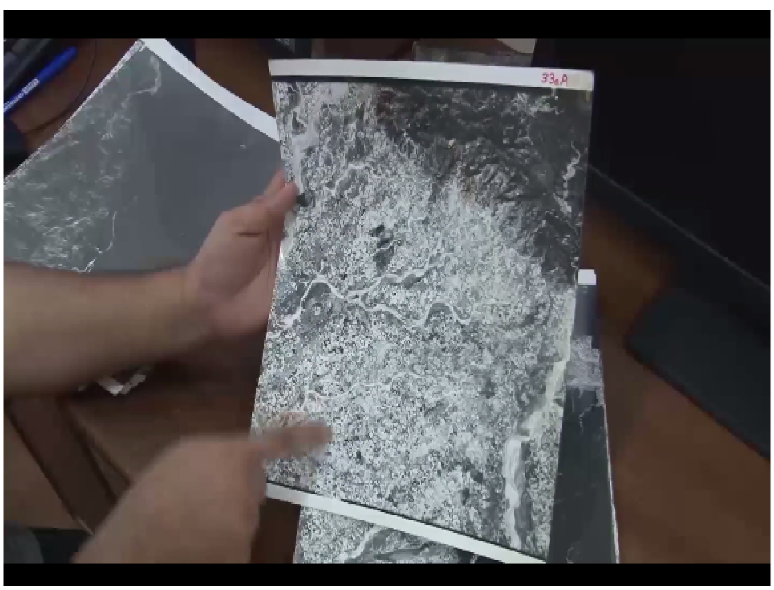

Here you can identify number of tributaries and main streams and like this features, like these,

these are the roads, these black lines, okay.

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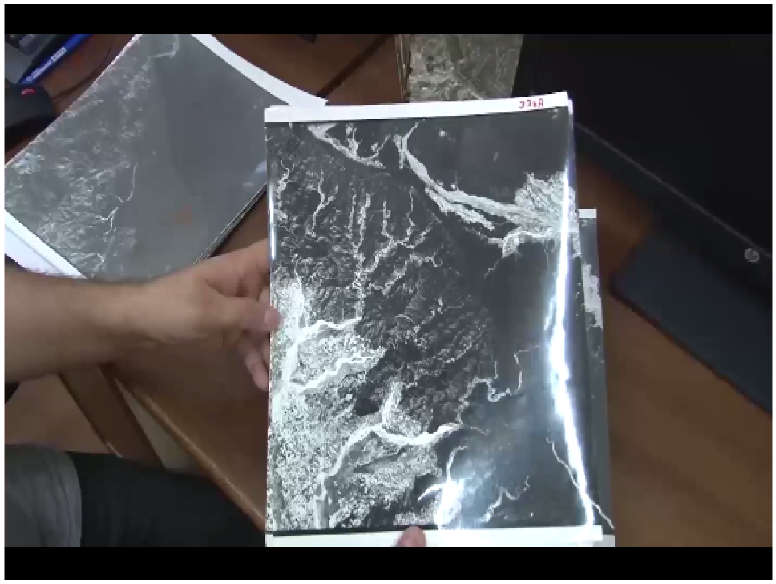

Very obvious topography, okay where you can classify slope and different kinds of morphological parameters, okay.

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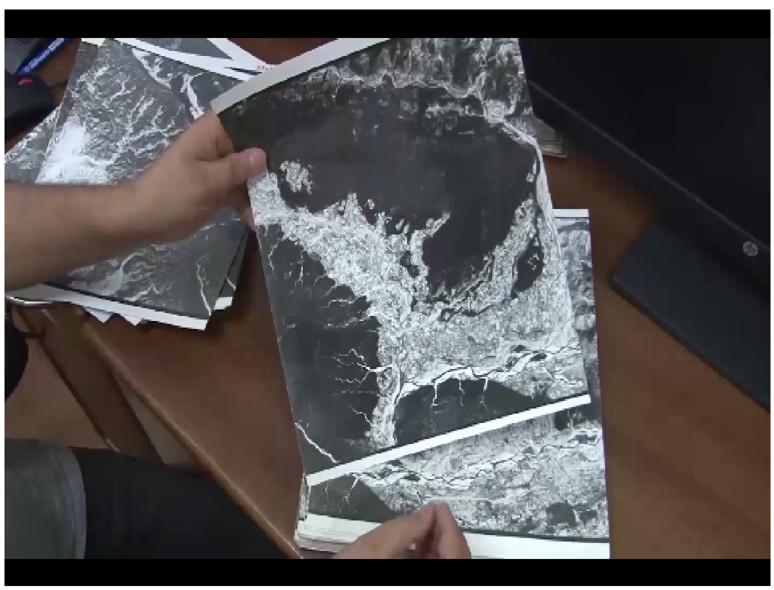

River and active flood plain as well as older flood plain. So this active flood plain means where river can spill in normal periods whenever there is high recharge in the river wherever there is high discharge in a river and the older flood plain is surrounding the active flood plain. So these are the abundant or older flood plain where river migrated in the past.

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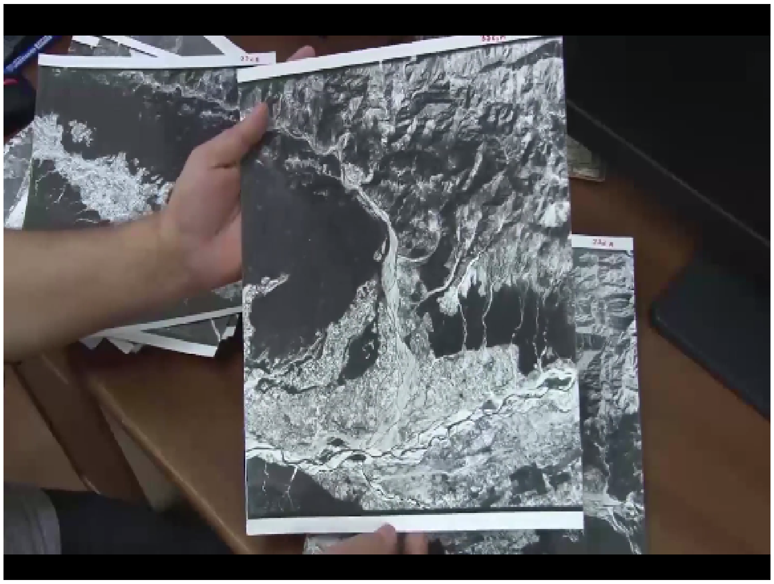

Here you can identify number of features on these photographs showing very prominent landforms related to fluvial topography.

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Similarly, here, a meandering channel having sinuous curves.

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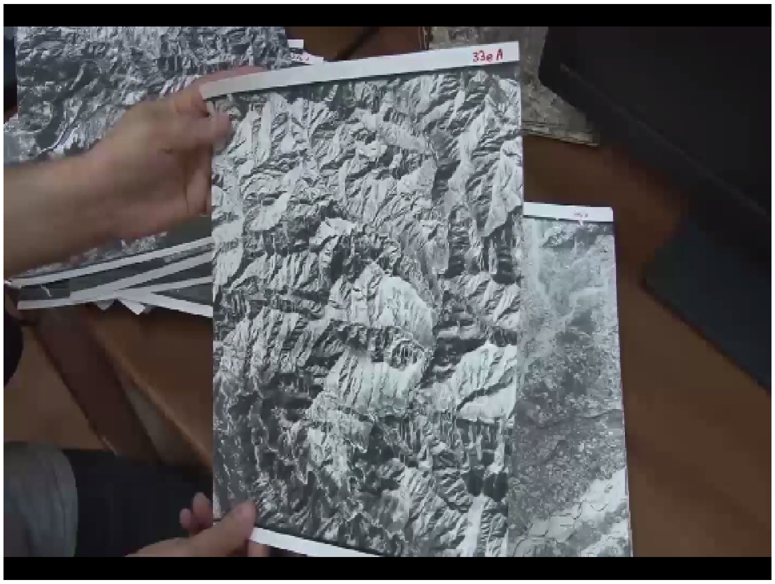

Dissected topography. How this topography looks in the colour images of the Google Earth, okay. When you see the same topography, the same landscape on the Google Earth images, you will have the idea of what colour exaggeration, okay. It means you will be able to see the third parameter of elevation also. Here you are only looking on to a single image.

So it is not possible to see this image in 3D until unless you are having the second part of this image which is overlapping, that is the stereo pair on this image, okay. So but in the, on the Google Earth, we actually have the, there is an option of vertical exaggeration where we can look the same area in 3D, okay without having any aid like stereoscope or stereo pairs.

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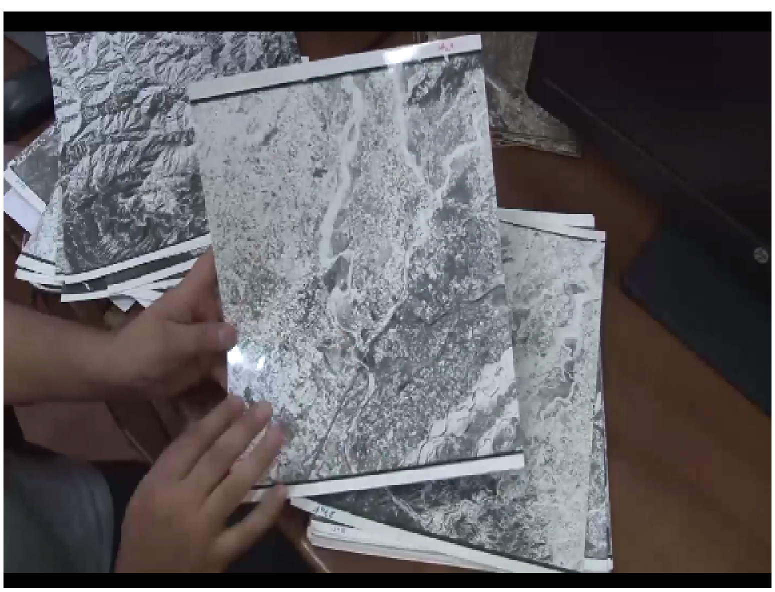

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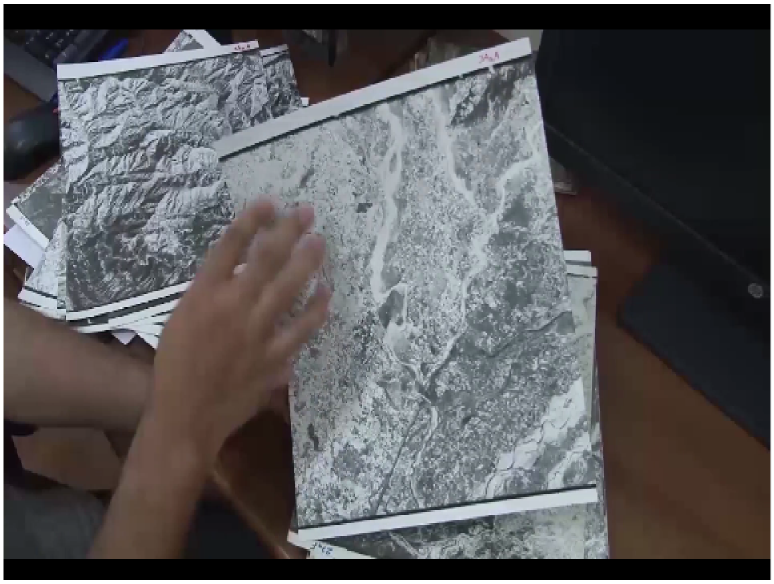

Similarly, this showing some agricultural fields. This particular rectangular texture shows the agricultural fields. You can identify number of features like settlements, the canals, the roads and all these things are very clearly shown on these images.

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The high altitude data, you will get less information because they will cover a large area. If this is in case of low altitude images, so in that case you will cover a lesser area but in greater detail, okay.

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River, its active flood plain and older flood plain.

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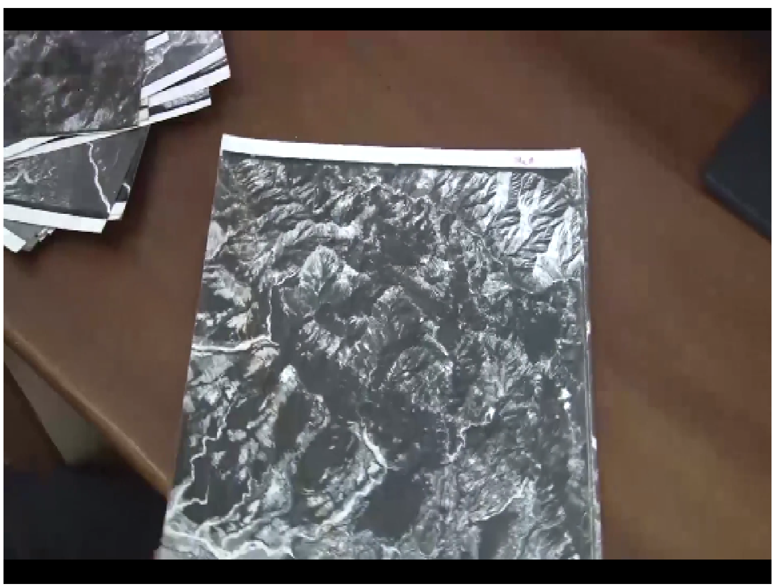

Similarly, we have number of photographs. We can, we can have this data from NRC and other agencies which collect and process the satellite data and they distribute data on the procurement basis. So these are the grey scale images.

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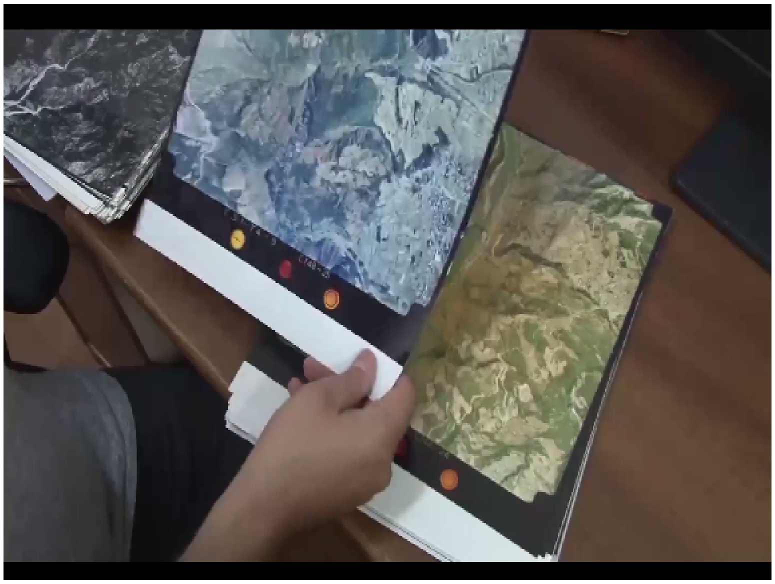

Now I will show you the colour photographs. These photographs I also showed in the first part for characterizing this landscape, okay. These are some colour photographs where you are able to see the, the features and everything but not in 3D.

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Of course, you have a perception of depth here but you are not looking at this ground in 3D, okay. You can perceive the depth, however, by looking at this plain that this is a plainer area and this, this is somewhat at a higher elevation, okay. But you cannot have the exact perception everywhere on this image, okay.

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So it is only possible with the help of the stereo pair.

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Similarly, yes, this is a very good example of meandering channel where this whitish part, whitish islands, these are the sand islands which are also known as the point bars when they are inside. So inside the, at the inside of the meandering curve, a river deposit the sediments. At the outer beds, it erodes, okay and due to erosion, there is a shifting of the river channel.

So river migrate continuously. For this purpose, sometimes people have to channelize the river so that they cannot do hazards to the surrounding regions, okay like flooding and the, destroying the farming and agricultural patterns. So in order to that, in the foreign countries also, they use to channelize the river, okay.

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Similarly, here, a very good meandering channel. So these are some colour photographs.

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Now let us move to, so suppose this image is given to you in your exam and it is asked to you identify the landforms or geomorphic features related to a river. So then how will you identify it? You will first say I am looking a meandering channel, okay. The second thing you will say that I am looking at the sand bars or the sand islands in between the river which form generally due to, when there is low discharge in the river.

So in that case there, the sand island becomes exposed in between or on the sides of the river. So this is the formation strategy of such kind of sand bars or islands. Another thing you will identify that is you can say that okay this is the flood plain. This is the active flood plain region of this river where river can flood whenever there is a high discharge during, such as during precipitation or during some supply of water from a higher barrage located somewhere, okay, or in any upland region if there is some release of water from any source such as dams or anything.

So in that case, it will be, this region will be flooded, okay. So the active flood plain is the region which is generally flooded during a, river spill course. But there is a part which is also called the older flood plain like there are settlements, okay. So the settlements are basically present on the older flood plain of the river. So when you look at these images in 3D, you will see that there is a depth where this part is the lowest and these are the terraces of river.

So we can also say that I am also looking at the cliff. Cliff is basically the Levies, the channel, okay. They are the sides of a channel. So these are the natural Levies. So the Levies are standing upside so that a river cannot spill its water and it, the water remains throughout its channel, okay. Another thing you can identify that there is terrace, a higher ground, terrace 0, terrace 2, 1 2 3 4. Similarly, there may be some terraces or some kinds of platforms which is a representation of the base level of erosion of a river, okay.

So similarly you can identify various features in this, on these images. Now we will move to Google Earth images, okay.

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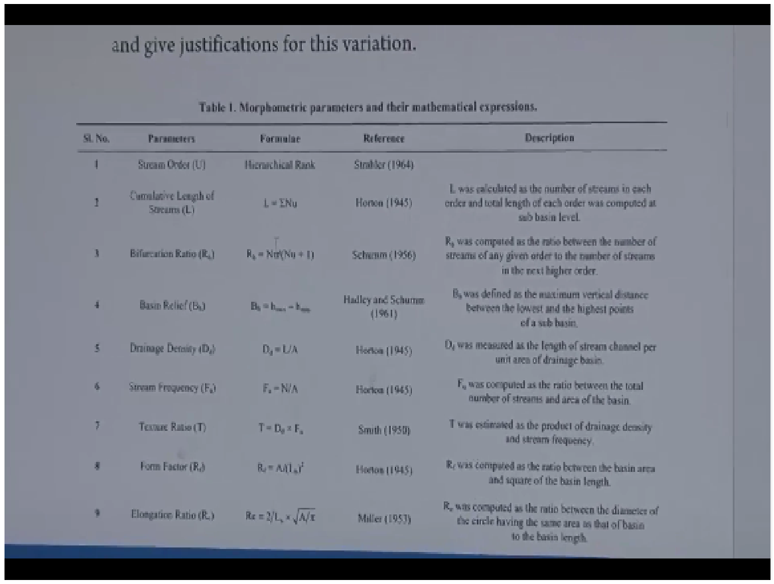

and give justifications for this variation.

Table 1. Morphometric parameters and their mathematical expressions.

Sl. No.	Parameters	Formulae	Reference	Description
1	Stream Order (U)	Hierarchical Rank	Strahler (1964)	
2	Cumulative Length of Streams (L)	$L = \Sigma Nu$	Horton (1945)	L was calculated as the number of streams in each order and total length of each order was computed at sub basin level.
3	Bifurcation Ratio (R_b)	$R_b = Nu/(Nu + 1)$	Schumm (1956)	R_b was computed as the ratio between the number of streams of any given order to the number of streams in the next higher order.
4	Basin Relief (B_h)	$B_h = h_{max} - h_{min}$	Hadley and Schumm (1961)	B_h was defined as the maximum vertical distance between the lowest and the highest points of a sub basin.
5	Drainage Density (D_d)	$D_d = L/A$	Horton (1945)	D_d was measured as the length of stream channel per unit area of drainage basin.
6	Stream Frequency (F_s)	$F_s = N/A$	Horton (1945)	F_s was computed as the ratio between the total number of streams and area of the basin.
7	Texture Ratio (T)	$T = D_d \times F_s$	Smith (1950)	T was estimated as the product of drainage density and stream frequency.
8	Form Factor (R_f)	$R_f = A/(L_b)^2$	Horton (1945)	R_f was computed as the ratio between the basin area and square of the basin length.
9	Elongation Ratio (R_e)	$Re = 2/L_b \times \sqrt{A/\pi}$	Miller (1953)	R_e was computed as the ratio between the diameter of the circle having the same area as that of basin to the basin length.

So before moving to Google Earth images, first I am going to show you an exercise, a very short exercise on calculating morphometric parameters related to geomorphic landforms of fluvial terrain. So in this exercise, you have to first calculate the morphometric parameters as listed in this table, okay. Now whatever parameters are here, shown in this table, you can calculate some of them.

Because based on the information or based on the map, you are only given an image or a photograph and you are going to first draw the drainage, okay, drainage basin out of that. Then with the help of streams, on a number of streams, you are going to identify different types of drainage pattern and then you have to calculate the lengths of these streams and the area of the drainage basin. So in this exercise, basically you are given an image, okay.

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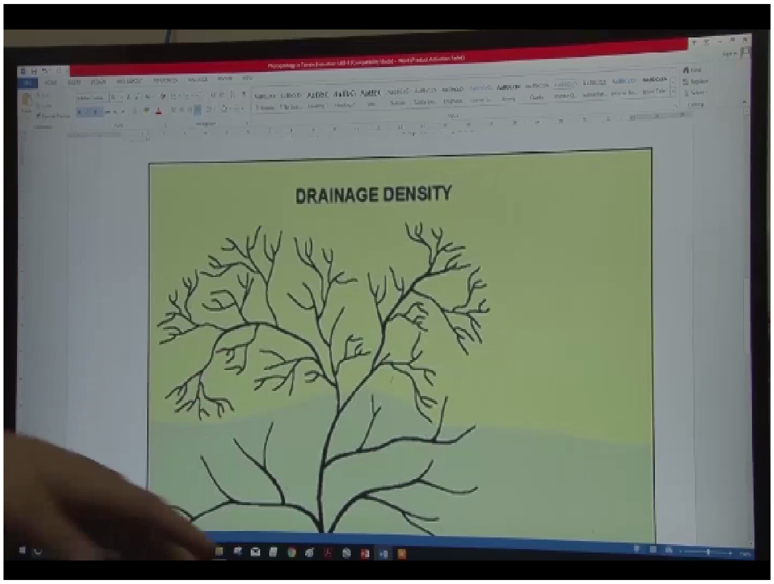

So from that image, you have to extract this detail, okay. Suppose, you are given with a photograph, a very simple photograph, like this.

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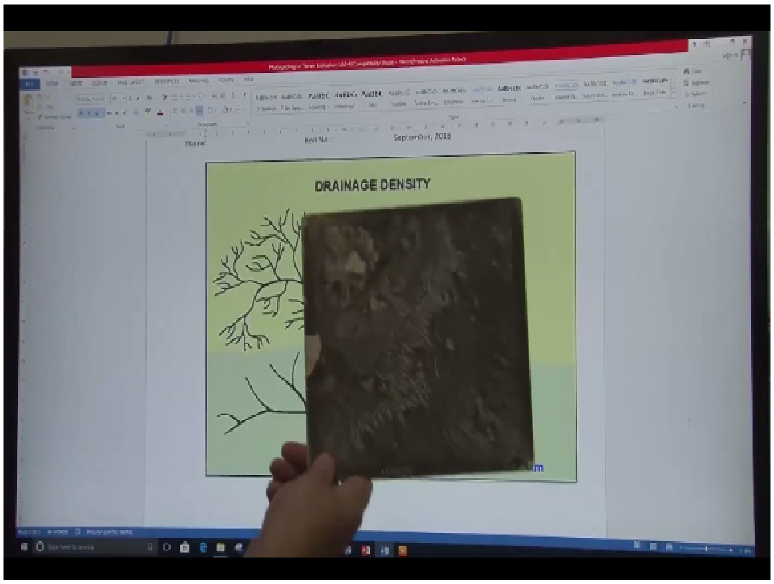

You are given with this photograph and there is some drainage basin, okay. So a drainage basin is where all the water from all these streams joins the main channel or the main stream which is in between, okay. This stream. So this is a drainage basin and it has a drainage divide with the other basin, okay, so suppose there is a drainage basin. So it must have some topographic divide so that the water from this basin cannot go to the other basin or the water from the other basin will not move into this basin.

So we mean to say is in total, this drainage basin represents the total discharge out of all the drainage system which is connecting through various streams or tributaries and joining a main channel or a trunk stream, okay. So it represents the total discharge and the area of the drainage basin is the drainage area, drainage basin area. So here suppose you are given a, a map.

So first you have to draw a drainage basin, okay. And then I will explain about these parameters, what are the morphometric parameters which you can calculate with the help of a given image. Suppose this is the image and you have extracted the drainage, okay, by simply drawing these streams from an image like this.

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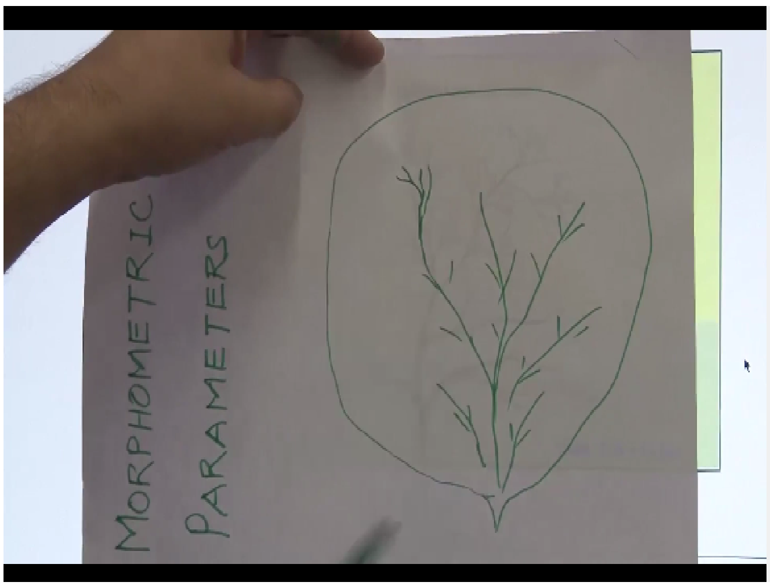

Suppose an image was given to you and you have just drawn all the streams and tributaries, okay. Which you can do very easily, okay. So now you have a drainage basin and from that image or a photograph, you can also bind this drainage basin. So it will be a shape of a balloon like. It may be elongated or it may be rounded and the area of this was explained earlier in the first part of the course, okay.

If you request to me, then I can again share the same slides with you in this part also so that you do not have any confusion regarding that.

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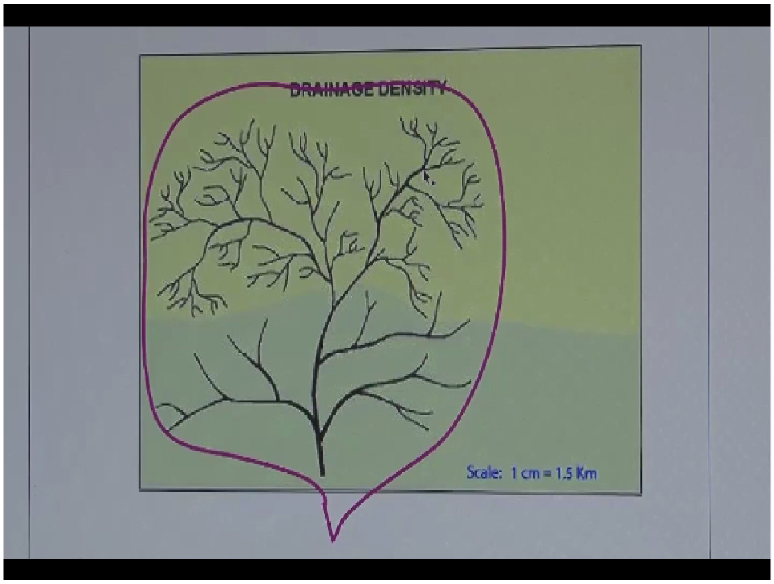

So you have drawn this drainage pattern which is prominently a dendritic drainage pattern, okay. So you are looking at that, this part actually, that have different shades. Why? Because I have marked it because this has a low density of drainage system while this part has the high drainage density, okay. So first I am going to draw a drainage basin, okay. My drainage basin should be like this, okay.

Let us take a balloon. Now this is our drainage basin. Now we have to first calculate the total length of the streams so that we can calculate other parameters, okay. So for basic requirement, we need to have the length of all these streams, means the total length of all these streams and the drainage basin area. So you can calculate the length of the streams by adding up all these streams, okay.

You can take measurements if you want to physically measure it, you can take some threads or any type of scaled feature. With the help of that, you can measure all the lengths of the first and second order and third order streams, okay. And then you can also do this task in a software known as River tool and other software you can, where you can measure the length of the stream.

So there is software for doing such tasks. This is only to explain so that you can have the better idea of how to calculate the drainage length of all these streams. So in the first order, second order and third order, okay. So what is the first order? So the streams which are originated in the initial stage, those are the first order stream. And when the 2 streams join to make another stream that will be of second order, okay.

So these all things are explained in a, in the part of this course, in the first part of this course. I will share the slide so that you can understand this concept. So suppose you were to first calculate the bifurcation ratio, so what is the bifurcation ratio? This is Nu/Nu+1 where Nu is the number of the streams in the first order, okay, of or of any given order to the number of streams in the next higher order.

So suppose Nu is the number of streams in the first order, so then Nu+1 is the number of streams in the second order, okay. Similarly, for the second and third order. Then third and fourth, okay. Then you can calculate some basin relief. So for this you have to have some height or elevation. So if you are having the elevation detail on an image, you can calculate it very easily.

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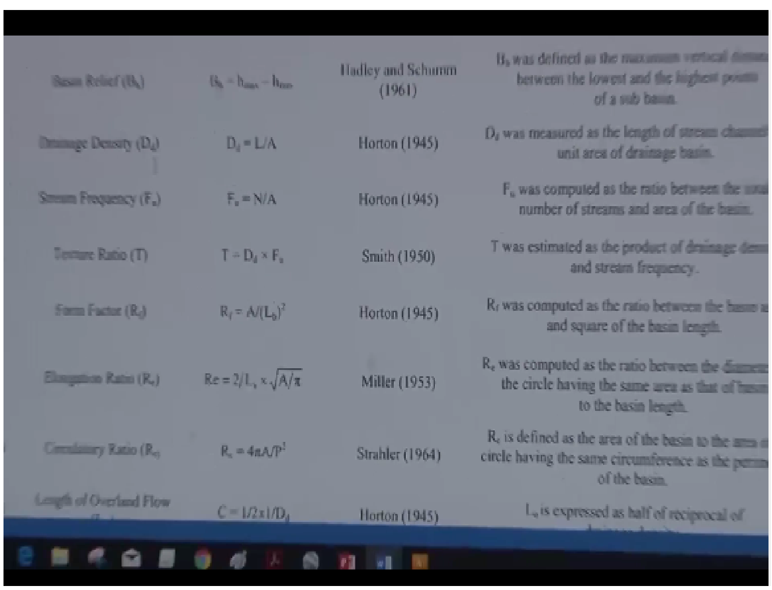

And the fifth parameter is very important, that is drainage density, okay. So that can be calculated by dividing the total, the length of streams, total length of streams by the drainage basin area, okay. A is the drainage basin area where L is length, total length of the streams. Then there are some other factors, other parameters. So these are called the morphometric parameters. So but here in our case, this first 3, 4 parameters are important to calculate in this exercise.

So suppose for calculating the total number of streams, you have to count the total number of streams in the first order, okay. So the streams which originated at the first stage are of the first order, first, first, first. So these are all the first order streams. You can count these streams and suppose, so this is also first, first, first, first, first, first. So first, first when join, where it will be forming the second order stream, okay.

When 2 second order stream will join, they will form the third order stream. So here you can say first order, first order will join to form a second order stream and here also 2 first order streams are forming the second order stream. Then again the second order and second order streams are joining here forming the third order stream. When 2 third order streams join, will form the fourth order stream.

So this trunk stream is of the fourth order, the highest order of this drainage basin is fourth order, okay. So calculate, first count the stream, total number of streams in the first order. Then calculate the total number of streams in the second order. Then divide Nu/N1, Nu/Nu+1. So you will get the bifurcation ratio, okay. And what it indicates, it has been explained earlier in the first part. Then comes to drainage density. How you can calculate it? First measure, take measurements of all the streams, okay.

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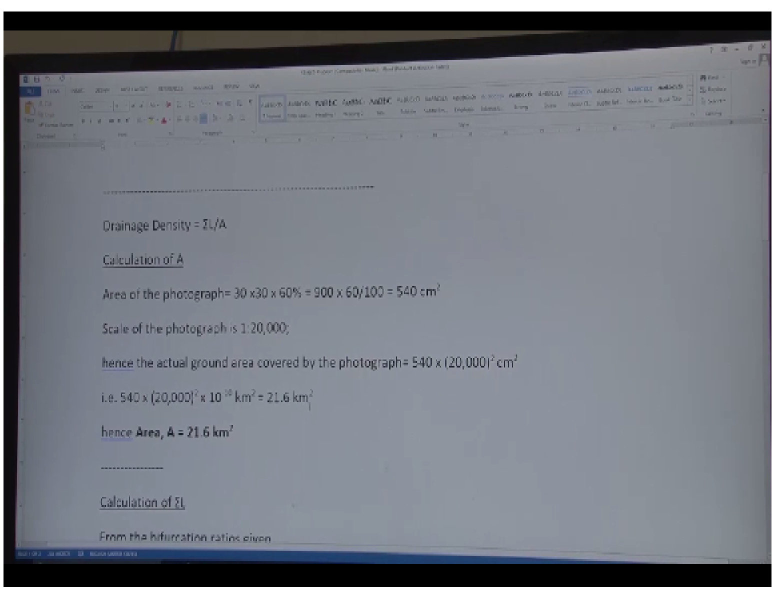

Suppose total stream length sigma L is coming out like this, sigma L, okay.

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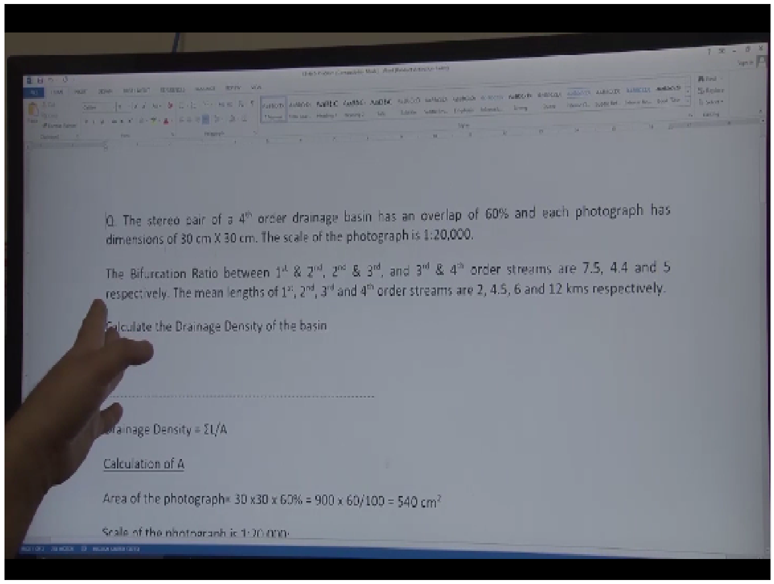

Here it is explained. So suppose in this basin, first see, look at this problem, okay. You are given a stereo pair of a fourth order drainage basin as I explained, okay, the highest order is fourth order. It has overlap of 60% which is understood, okay. So these are the dimensions for calculating the scales and drainage basin area, these parameters are given and this is the photographic scale where you can calculate by using all these parameters.

The drainage basin area, okay. Then bifurcation ratio of first-second, second-third, third-fourth order, you have to calculate, okay. And here it is given, okay, the mean length is of the first order stream is 2, okay. So with the help of this scale, by using scale and taking a graph paper or marking a grid over this, show grid.

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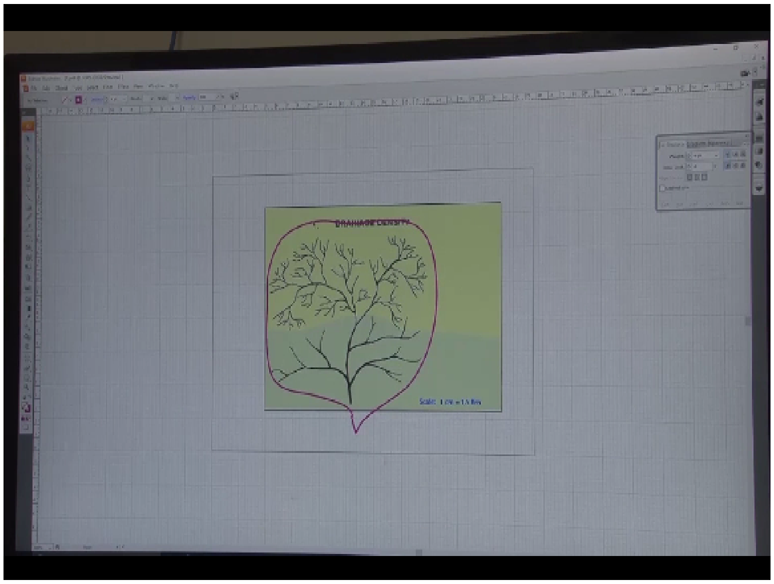

So suppose this grid is of 10 cm x 10 cm, okay. So this 1 square is of 10 x 10 cm. So then you can appropriately demarcate the boundaries of the drainage basin and then you can calculate the drainage basin area by considering the scale and area of the one little square. If you zoom it here, so area of the one little square you will show. So suppose this one little square is equal to 1 cm square, 1*1 cm, okay.

So then you are going to calculate the drainage basin area. Then you can multiply it by the scale as it is done here. Calculation of A for calculating drainage density, okay. Area of the photograph is this because 60% is overlap and this is the area of the whole photograph if the photograph area is asked to you. Then scale of the photograph is this suppose and actual ground area covered by the photograph is this. Hence area=21.6 km square.

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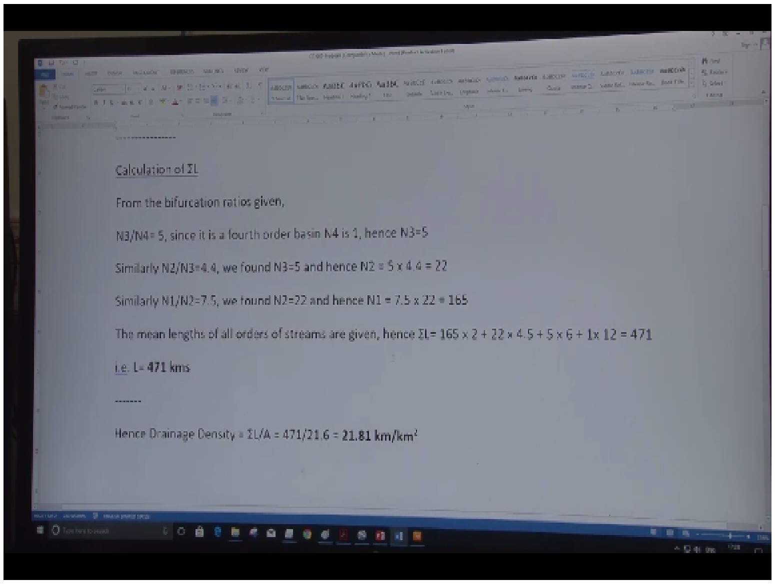

And suppose for bifurcation ratio, you are calculating the total number of streams in the first, third order and the next higher order means the fourth order, is equal to 5. So then you can calculate the total length of these streams, okay. So you have considered that the mean length of these streams in the first order is 2 cm, okay. So then you can multiply it by total number of stream in the first order.

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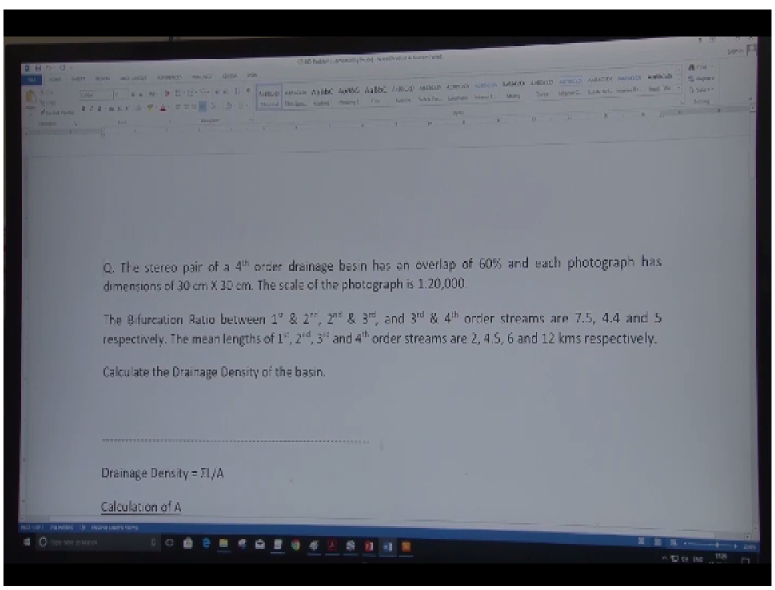

Similarly, the mean length of the stream in the second order is 4.5. You can suppose it, okay, if you, it is just for exercise. This is the mean length. So what you can do? You can first count the total number of streams in the second order. Then you can multiply it by the mean length. Similarly, for the third order and the fourth order. Then by adding up all these things, you will get the total length of the streams that is 471 km, okay. It is after considering the scale.

So now the drainage basin area is 21.6 and the total length of stream 471, it has come out like 21.81 km/km square or you can say 21.81 per km, okay. So this is the drainage density of this region. Similarly, if you want then you can calculate some other morphometric parameters from these formulas, okay. So now we will move towards the Google Earth images, okay.

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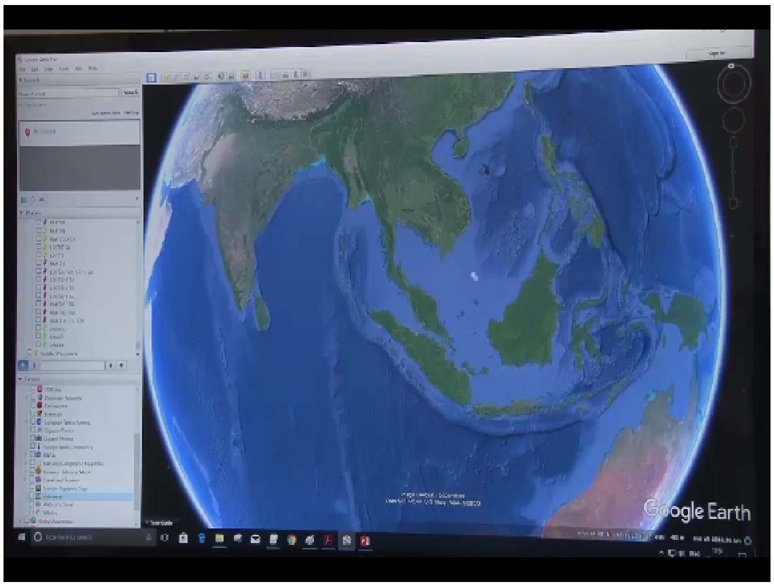

So Google Earth is a very well known software and it has been used for different purposes in the whole world and here I am going to show you the geomorphic landforms and some geological features that you can easily identify by going through, by browsing through the Google Earth images.

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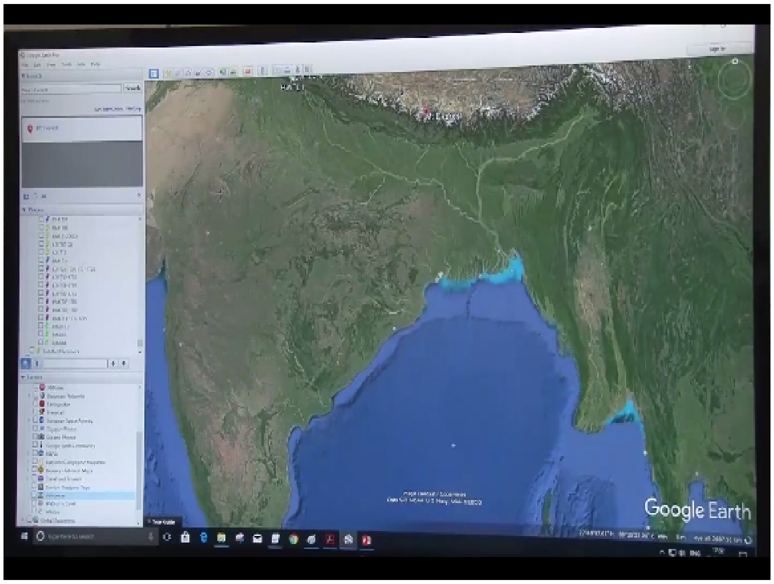

First to see, suppose in case of our Indian continent. As you know this is the Indian continental landmass, okay. Where this part shows the Bay of Bengal where it meets the Indian Ocean. This is the Indian Ocean, okay.

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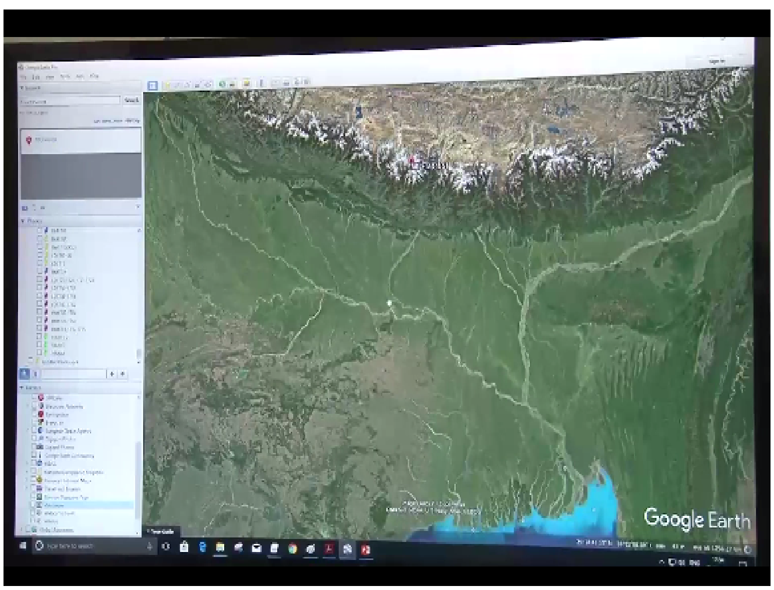

So Bay of Bengal, all the rivers coming out from the northern eastern and western part are debouching into the Bay of Bengal and here you can see very sky blue, sky blue colour which shows the fresh sedimentation, okay, fresh water and fresh sedimentation due to which here you can mark this area very easily. We can see that this river is coming and debouching its sediments into this region.

This is the major river Ganga. This is Brahmaputra and this is Kosi and there are different rivers, Kosi, Gandhak, Ganga and all are joining the Ganga and these, Yamuna and all are the tributaries of Ganga river. And Ganga is the main river or trunk river, okay. So the major river in India in the northern side are Ganga and Brahmaputra and all these 2 are joining here and debouching into the Bay of Bengal.

So Bay of Bengal in the Indian landmass is the part of lowest elevation, okay. Because here most of the rivers you can see that they are debouching into the seawater, they are at the sea level okay. So that is why they are forming a delta, deltaic region and they are depositing their sediments and supplying water to Indian Ocean. They are almost at the mean sea level.

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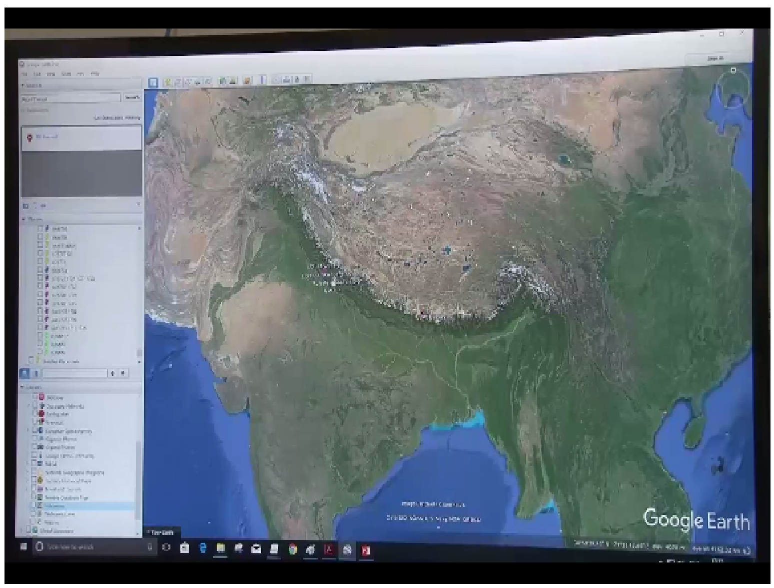

Now let us talk about the highest point in our Indian continental landmass. This is the region. This is the Himalayan belt, okay. It is shown as whitish colour. Why? Because it forms the highest region in the world and the Mount Everest is the highest part as you know well.

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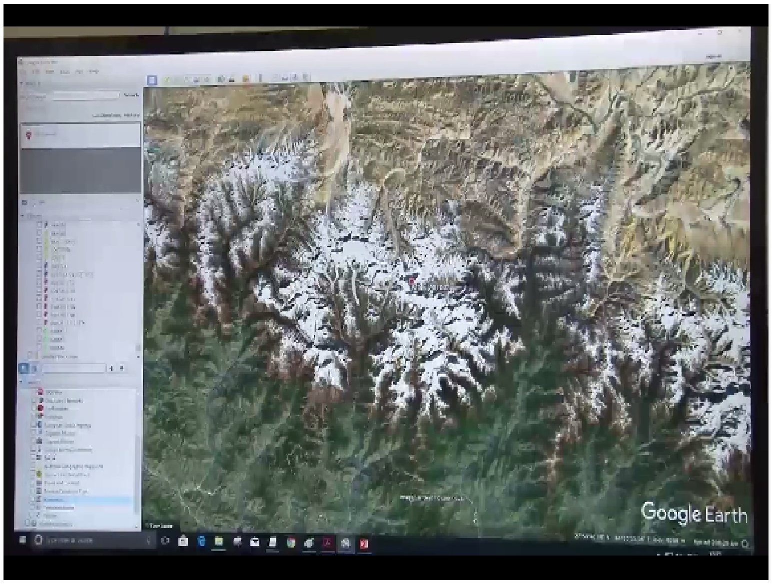

And we can see here, this part is showing the Mount Everest and this whitish patch are nothing but the snow and ice. The mountains are covered by…

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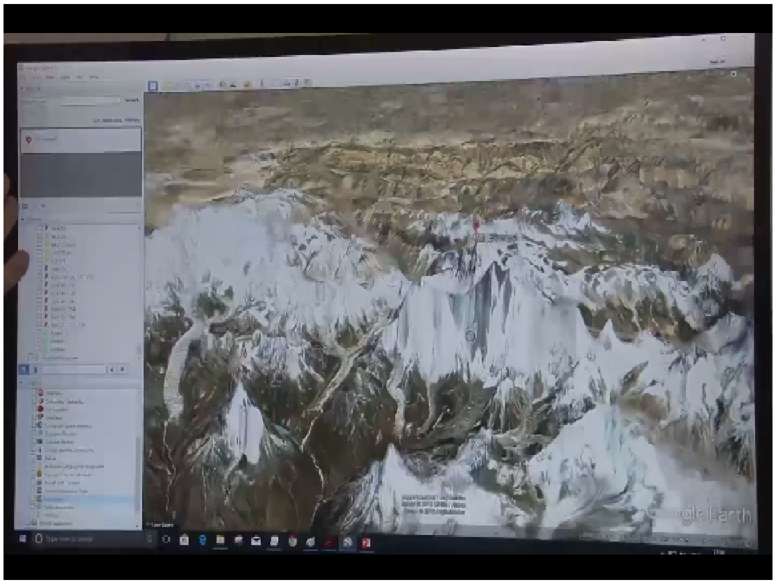

So what you can see here, you can have a depth perception on this image. How? If you put the midpoint of your browser scrolling down and take it in a landscape view, then you will be able to look at the Himalayas and the elevation difference of the Himalaya with respect to Indo-Gangetic plain which is showing at this place.

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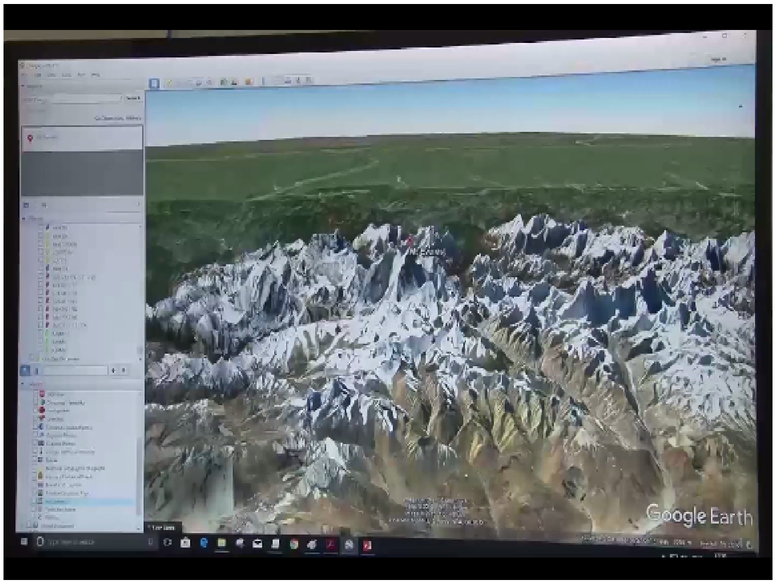

So now you can see here, we are looking towards Indian landmass by standing here at Mount Everest.

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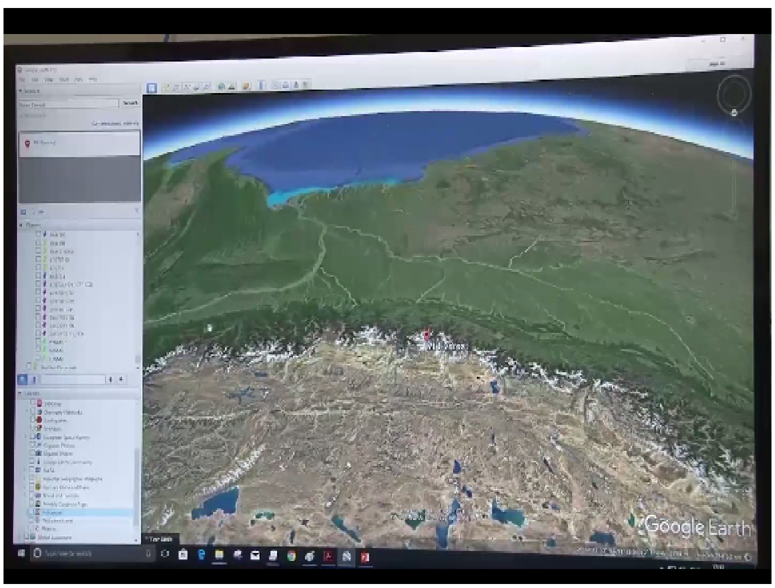

And we can see different rivers like this is the Kosi river, okay which cross the lands of Bihar and then join the Ganga, the major stream here, over here. So mean to say that this is the India-Nepal border, okay. And this whole range of mountain is representing Himalayas, okay. Snow covered Himalayas are the highest part of, highest ranges of the Himalayas.

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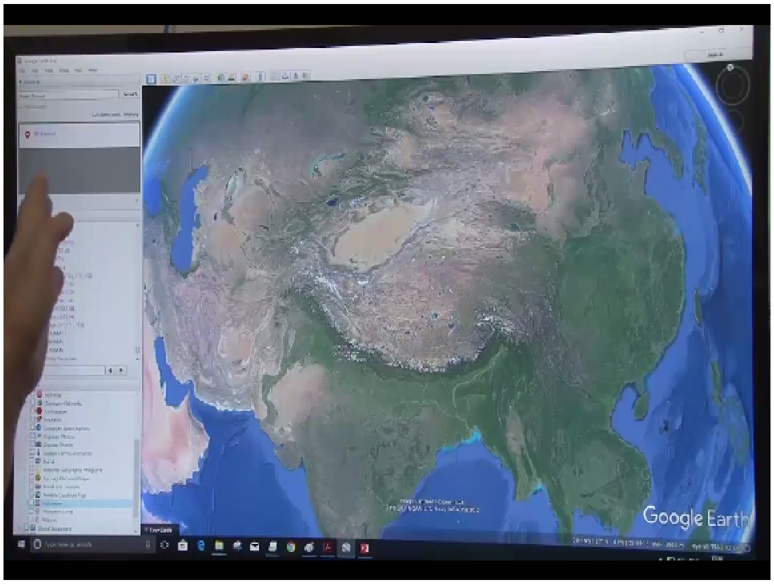

Now you can also identify like this is the plate boundary here where Indian plate is in collision with the Eurasian plate, okay. So this is the collision zone.

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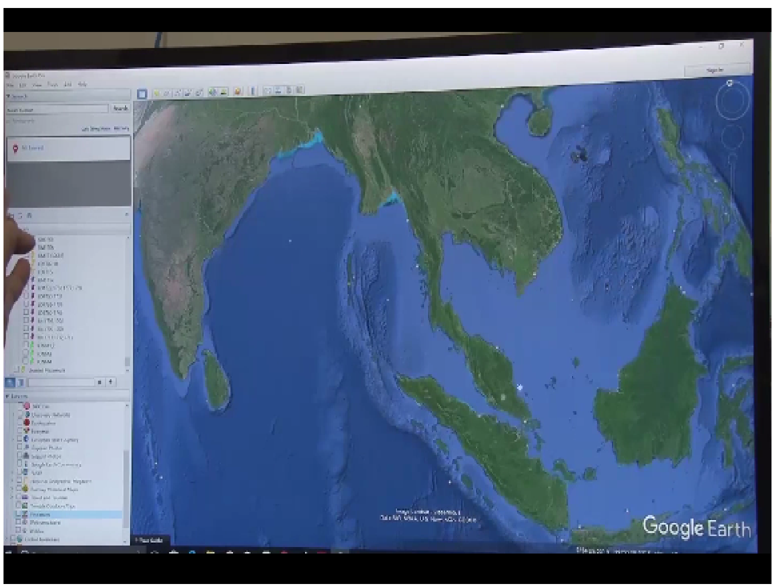

It continues like this and here, this is a subduction zone between the Indian Oceanic plate and the Sunda plate, okay. So what happened at the plate margins or plate boundaries, you can see there are number of earth plates and volcanic activities in case of a subduction zone when, where a plate is subducting beneath the other plate, okay. So suppose this is the continental plate at the higher elevation and this is the oceanic plate which is subducting beneath this, okay.

So it reaches at a part in the, where there is high temperature and pressure where all the, the rocks and the solid material of the crust is melted over, okay.

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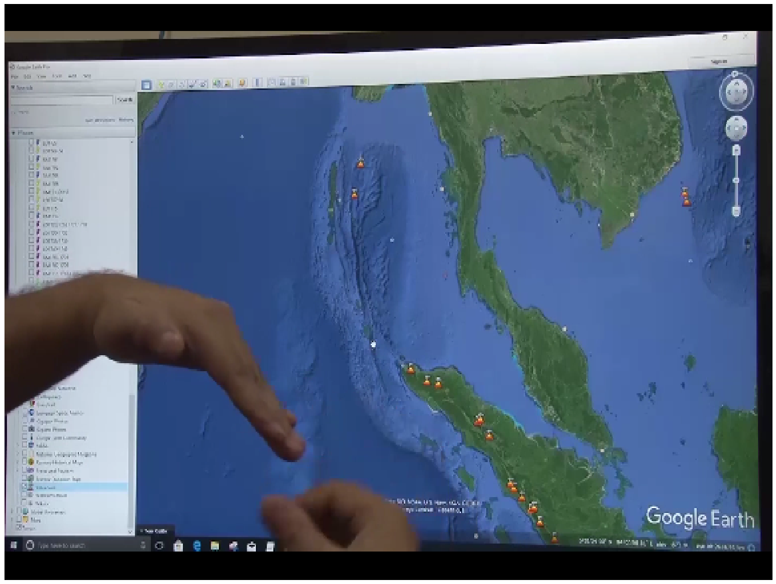

So to show the volcanism here all along this subduction zone, I will zoom it, this part and will click on the volcanoes option. So you can see here, there is a chain of volcano all along the subduction zone. Why it is so? I have explained earlier, okay. Due to subduction of the oceanic plate where it melts in the deeper part of in the mantle or the, the submantle part where it melts and the molten material under huge pressure and temperature, rises at plume, as a plume.

And then they erupt in the form of lava on the surface. You can see this chain of volcano all along the plate boundaries or subduction zone boundaries, okay. They are very typical to subduction zone mountains, any subduction zone in the world. Let us say in case of (()) (42:10) subduction zone, okay.

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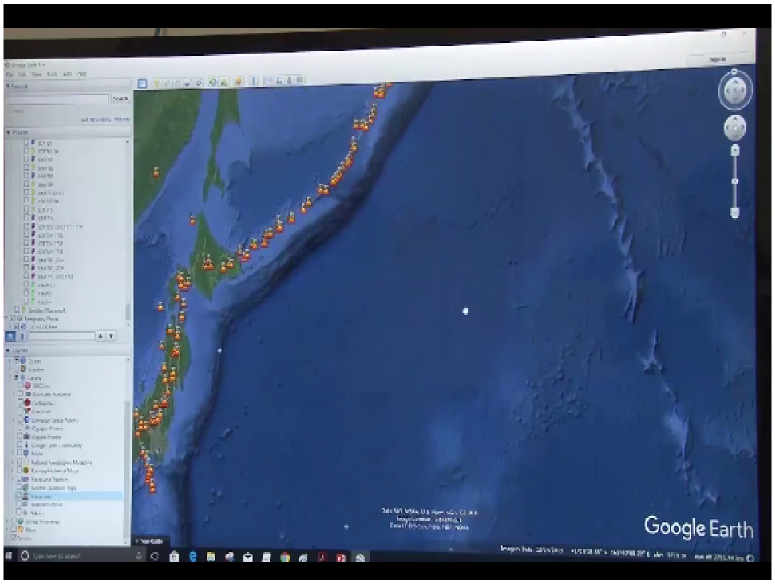

Here also you will see volcanism all along the plate margins, where 2 plates are in collision and 1 plate is subducting beneath the other plate. Any why only oceanic plates subducts beneath the continental plate? Because oceanic plate has higher density, okay. Why higher density? Because it mostly composed of the Basaltic and the, this, the lava solidified rocks, okay, of higher densities, the plates.

So this is the Pacific Ocean where the pacific-oceanic plate is subducting beneath the, this plate, okay. Where it is, it is having Japan, Taiwan and other countries along its belt, okay.

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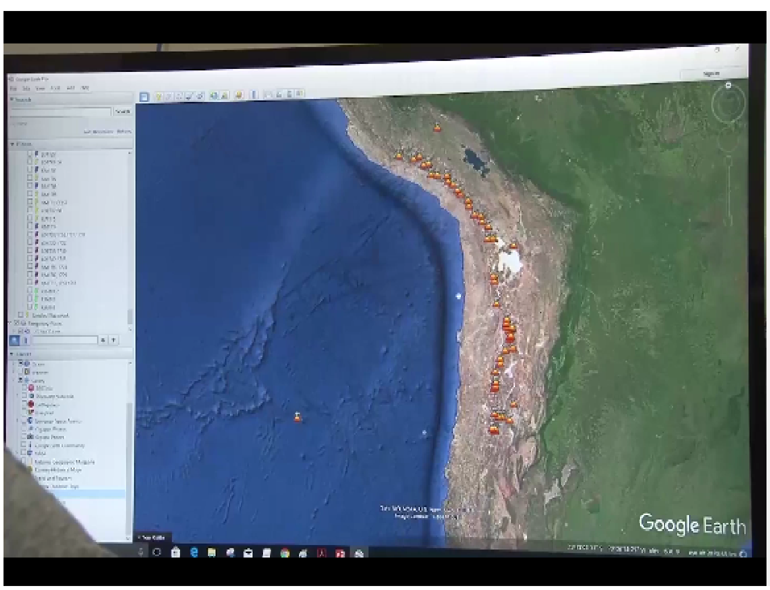

Similarly, in case of Chilean subduction zone. You will be able to look at some volcanism along this Cascadia subduction zone and Chilean subduction zone, okay. So this is a very typical feature you will find all along the subduction zone.

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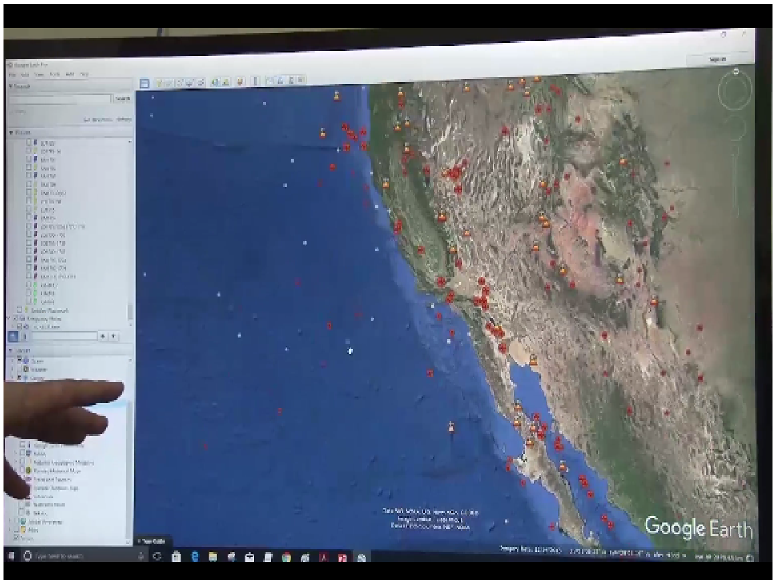

Another important feature is the number of large magnitude earthquakes. If I click the earthquake option here, so you will find these are all the, the red dots are showing the earthquakes all along the subduction zone boundaries. This is because of the subduction, the ongoing collision and subduction between these 2 plates and there is continuous release of strain energy in form of earthquakes.

And there are large magnitude earthquakes as well as volcanism all along the subduction zones. So these things are very interested and you can read these things in the text also. There was a course Earth Sciences for Civil Engineers in that course. There is explanations for the volcanism and earthquakes. If you want to know more about it, this course will a rerun in the next semester, okay. Yes.

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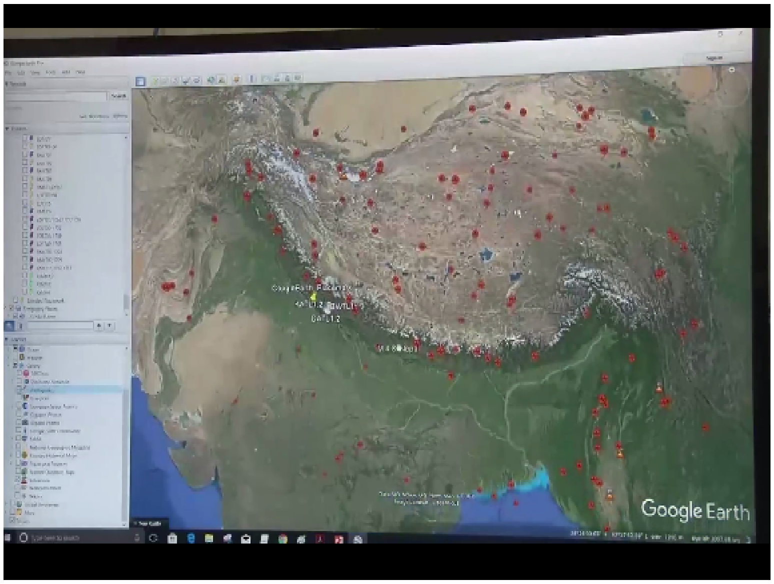

So this was about the; similarly, you will also find the earthquakes all along the Himalayan ranges.

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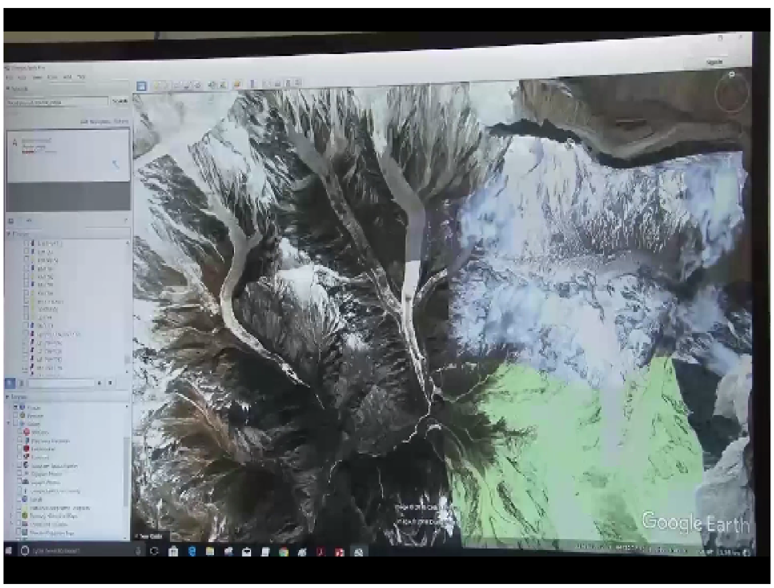

So if we see, if we talk about the drainage, so then let us first off it. We can very easily see here that there is initiation of the streams at the highest elevation. So suppose if you are looking at the Mount Everest, okay, you can see that first here glaciers are melting, the snow and ice are melting at this region, at the highest elevation, okay. The ranges where it is supplying huge amount of water or discharge to rivers and rivers are then flowing along a straight channel and then they are moving towards the low land under the effect of topographic relief or slope.

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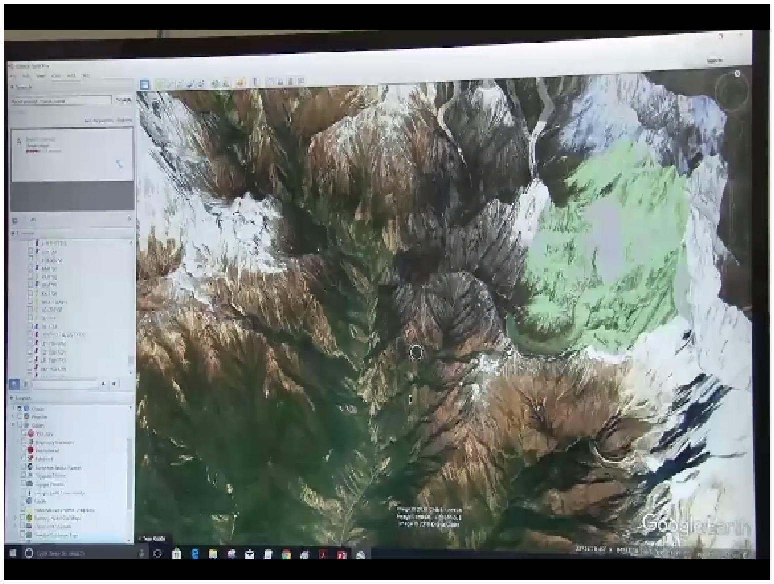

As slope increases, the river carries more water with high discharge and high sediment load and they are capable of eroding sediments from the uplands also.

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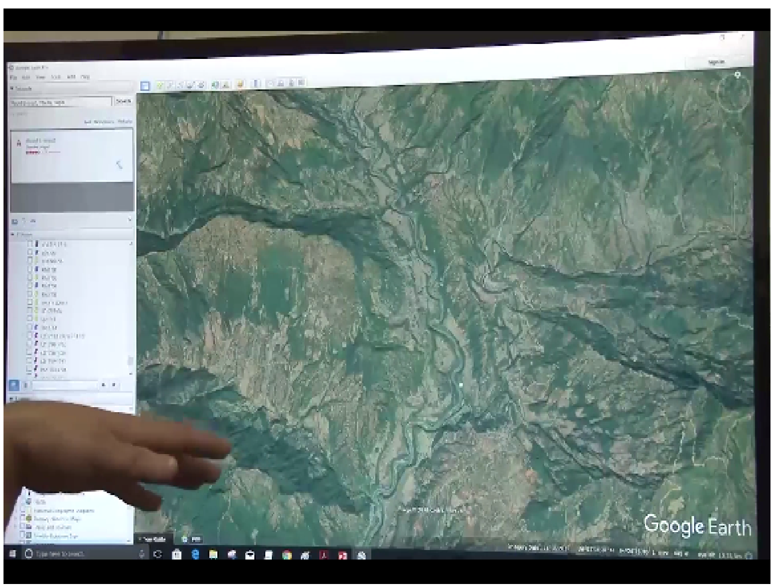

So here you can see, whenever in their course if some river is found, if some river finds some kind of low topographic relief, so in that case they started meander, meandering, okay. So these are very nice meandering patterns.

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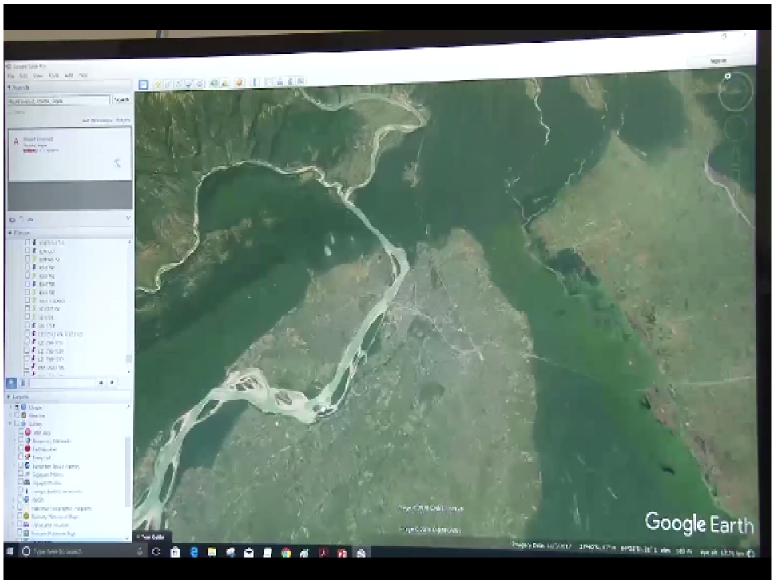

So when they are, so when they move from the upland regions to lowland regions, they will lose energy, okay and the channels become wider as shown here and river started meandering, okay. So now river has moved to lowland area or the alluvial plain area of India. So this part is basically known as Indo-Gangetic plain in the Indian landmass, okay. So where you can see here the river is changing its course.

And it is also showing some changes in the patterns, okay, very sharp meandering patterns and also there are changes in the drainage patterns, okay.

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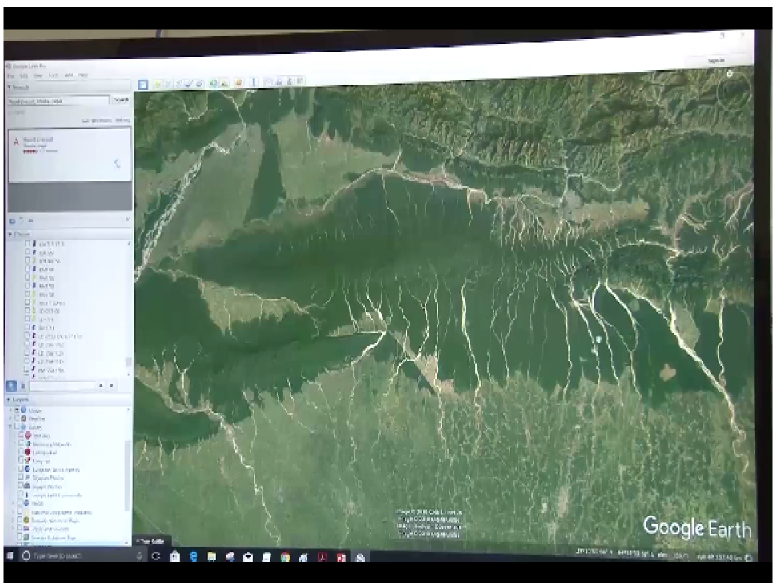

Like here, you are looking at the parallel drainage patterns and then as you move towards the

Indo-Gangetic plain, you will be able to see more meandering patterns, okay and wider channels and large and extensive flood plain areas, like these are the older stages of the river.

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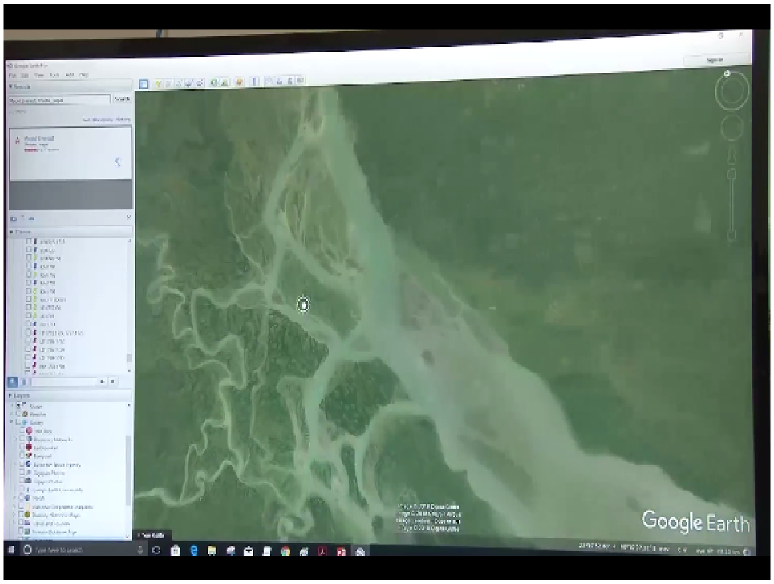

This is the oldest stage.

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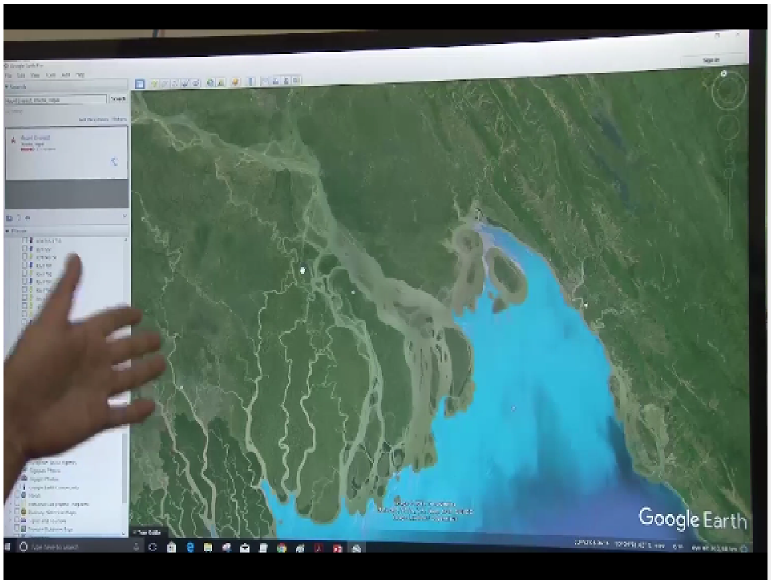

So here you can see that a river is basically divided into distributaries. So now in the upland regions, you were showing the tributaries and in the lowland region and the plainer areas, in the older stages, you will be able to see the distributaries. Means, suppose this is a river channel, and it is distributing into different tributaries or different streams, smaller streams. So this is called distributaries, okay.

So that is why they are forming here the deltaic pattern when they meet sea, then they form the deltaic environment and some deltaic deposits are there. So similarly you can identify a number of landforms and number of geomorphic features as well as structures, folding, folding and this I was showing the major features on the surface of the earth but you can also identify the small scale and the large scale features in a shorter area also, okay.

So possibly we are reaching at the end of the course and in a 4-week course, the thing, whatever things that can be explained in brief way, we have done it. Whatever doubts you are having about the topics of this course, you can write down to me over email or on the question forum. Then we will surely help you out in all your doubts and questions, okay. So most possibly we will be running a different course in the next semester. So till then, thank you so much.