REMOTE SENSING FOR NATURAL HAZARD STUDIES

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Lec 15a: Remote Sensing for River Planform Studies- Part A

Hello everyone, today we will start Lecture 15 of Module 5, which is on flood studies. So, this is the first part of Lecture 15. So, you might have heard about the Planform; it is not "Platform"; it is "Planform". So, the planform of a river channel signifies the top view, integrating plan features like straight, meandering, or braided channels and fluvial reliefs, such as floodplains, flood channels, and low water channels. So, basically, we are looking at the river system from the top right, then we try to see the area, and then we try to quantify it. So, that is known as planform evaluation of the river systems.

When we talk about the platform studies. We have potential applications of remote sensing datasets because, from remote sensing, we can see the entire area captured at the same time. So, here we will see some examples, such as whether the system or the river is sinusoidal, whether it is a meandering river, or whether it is a braided river. So, one example of a sinuous river is the Mahanadi, the meandering river is the Ganga, and the braided or highly braided river is the Kaming, which is part of the Brahmaputra and we all know that flood-affected areas can be easily identified using remote sensing data if we have pre- and post-flood event data sets. Here, you can also see that flood-affected areas can be easily demarcated, So, this is what we can do and why we are trying to learn what the potential application of remote sensing is in platform studies. So here, visually, it is very clear that all these boundaries are for the river. This may be the flood-affected areas. Here, you can also see that this is the main channel.

And this is the floodplain, this white color. So, visually it is very clear, but how do we actually extract this information? We need to quantify it in some numbers. So, we will learn today how remote sensing data sets are being utilized to derive information for any given river system. So, before we continue with this, we need to learn the data type. So, if you remember, I have already discussed this data type at the beginning when I was covering remote sensing.

So, here you can see that we have two major types of data sets. The first one is the raster where the images are generated, and it is divided into pixels. So, the grid cells, pixels, or elements are present, and they divide the area. When we talk about the vector, we have points, lines, and polygons. So, here you can see that this is one type of polygon. This is another type of polygon. But if I draw a line here, it will become a line feature. This is one point. This is another polygon; this is another polygon. When we want to precisely define the boundary of a particular object, we use a polygon.

If we want to delineate the roads, we will prefer to use the lines. If we want to demarcate the centerline of a river, we will use the lines. If we want to demarcate the boundary of a river, we will use polygons or prefer to use them. So, we have also learned about raster data. So, the area is divided into pixels; it stores images as rows and columns of digital numbers for each pixel; then the digital output of any camera or sensor is raster data. So, all the satellite images are raster data. Based on the map scale or spatial resolution, each pixel represents the area on the ground. So, if you remember, I talked about one detector of a particular sensor looking at the ground and covering a particular area. So, this area will determine the spatial resolution of this particular sensor. So, if it is 30-meter by 30-meter.

Then that means this particular detector looks at the ground, and that area is basically 30 by 30 meters. It is very useful in representing continuous variation, thematic, or dense data sets. So, if you have continuous variation, I gave you one example that if you take the boundary of the lake, this raster data is not a good option. Why? Because if the pixel is like this, then half of the pixel will be land and half of the pixel will be water. So, depending on the spatial resolution, we decide whether the lake can be represented by our raster data or not.

Because the area will not match the actual area. It is a very simple data structure, but it requires a large storage space to store this data set. Commonly used data formats are JPEG, TIFF, and GeoTIFF. So, these are what we have already learned in the beginning of this course. So, why am I referring to it again? Because now we will actually be using it to derive or extract information for our river or fluvial system. So, the simplest element of vector data is the point, as you can see here. So, this point can be the confluence point of a river where tributaries meet. So, if you want to highlight that particular thing, then you can use this point. Then line a set of connected points because these will be connected, and these lines are used to demarcate the boundary. Then comes the polygon; if a river is wide, then one single line is not enough to demarcate or represent this river.

So, what we will do is use the lines on both sides, and then it will become a polygon. So, this whole river system will be represented like this. When we talk about vector data, the area is separated by different polygons; here is an example. Statistics can be estimated for the individual lines or polygons because each line and polygon has different characteristics. So, the length, area, and perimeter can be easily estimated for each of these features.

Very useful in representing discrete data, it is data that has a defined boundary, which we can easily identify as the ending of this particular feature. Many attributes can be associated with each polygon, as we have discussed, for the same point, line, or polygon. We can have multiple pieces of information collected in the field or from various sources that can be stored together. And because of that, it has a complex data structure, but it requires very little space to store because everything will be stored in the form of ASCII, and using this data type, we can represent our object very nicely. Now, when we have satellite images, how exactly are we trying to extract this information that we will see now? So, let us say this is one satellite image, this one.

Now, you open this in ArcGIS, QGIS, or any other GIS software, and all the GIS software has the option of digitization. So, once you open this, on top of that, you can create a layer of vector, and then you can start digitizing. So, once you start digitizing, this kind of map can be prepared. So, let us say that this is the channel; I am going to digitize. So, depending on my accuracy, this data will be generated because this is the manual delineation we are talking about. So, it depends on my accuracy how accurately I am digitizing this one. So, if you see, I have missed many points. So, here we are generating this vector layer using the polygon. So, like this, you will digitize, and then you will generate the vector data for your river channel. Then I have to close this one, close this one, and then close this one because it will become the polygon.

Now, if you see, this represents the water channel of this particular river. Now, if I have to demarcate the boundary of the floodplain, then I have to use this right. I have to demarcate this boundary, not only the water one. So, this will become the floodplain. So, this floodplain helps restrict the flow of water during the flood event. So, they also accommodate some amounts of water. So that will help reduce the discharge at the lower reaches. So, using this particular method of digitization, you can see here that this map has been generated, and once this map has been generated, you can easily calculate all the parameters, like area, perimeter, and distance; all these can be easily calculated. This is another example of vector data, which is generated using raster data. This one is another one where this has been overlaid on the satellite image.

So, information on streams, rivers, or fluvial systems is being generated using geospatial technology for further studies. Because now we are talking about platform studies. So, first we need to have the data; then only can we talk about the methods. So, I thought of giving you this brief introduction at the beginning so that you will be able to understand how remote sensing, satellite images, or UAV images are being used in the platform studies. So, once you have this data, you can calculate area, length, and perimeter.

Now that you have this, you are ready for the analysis. Because for each polygon, you can easily calculate the area. If this is, let us say, one river, then you can also digitize the centerline. Which is the main water channel for this particular river, and you can calculate the distance from here. So, the length will become the distance between this point and that point. Now, the aerial distance between these two points will be this. If this is the flow of water, then this will become the centerline or the waterline of this particular river. So, this length will be something like, let us say, 300 kilometer, but the aerial distance between this and this will be approximately, let us say, 250 kilometer. So, the 50 kilometer is more because of these undulations. So, this kind of information will be extracted even if we can calculate what the number of first-order channels and second-order channels is, which is very clear from these maps.

So, all this information will be extracted from this layer and then we will be using it. For platform studies. So, before we start the platform study, let us understand the geomorphology. So, geomorphology investigates the landforms and the processes that shape them. So, here we try to understand and study the landforms and the processes that are involved in shaping or developing them.

So, here are some examples. This is one landform, this is another landform, here you have another landform, and here you have another landform. So, this falls under geomorphology. So, since we are talking about the river or fluvial system, we will focus on hydrogeomorphology. So, hydrogeomorphology designates the study of landforms caused by the action of water. So, here we only consider water as an agent that is responsible for shaping the landforms we see today.

So, here you can see this particular river channel; it is eroding, and because of this, the shape is like this. So, everything here is because of the water. Here, you may consider this a floodplain. So, hydrogeomorphology is an inseparable part of geomorphology as water is one of the most important agents in forming and shaping landforms. So, here you can see that these landforms are shaped by the action of water, So, anthropogenic activities like manmade or human intervention, river regulation, and sand mining are gradually increasing.

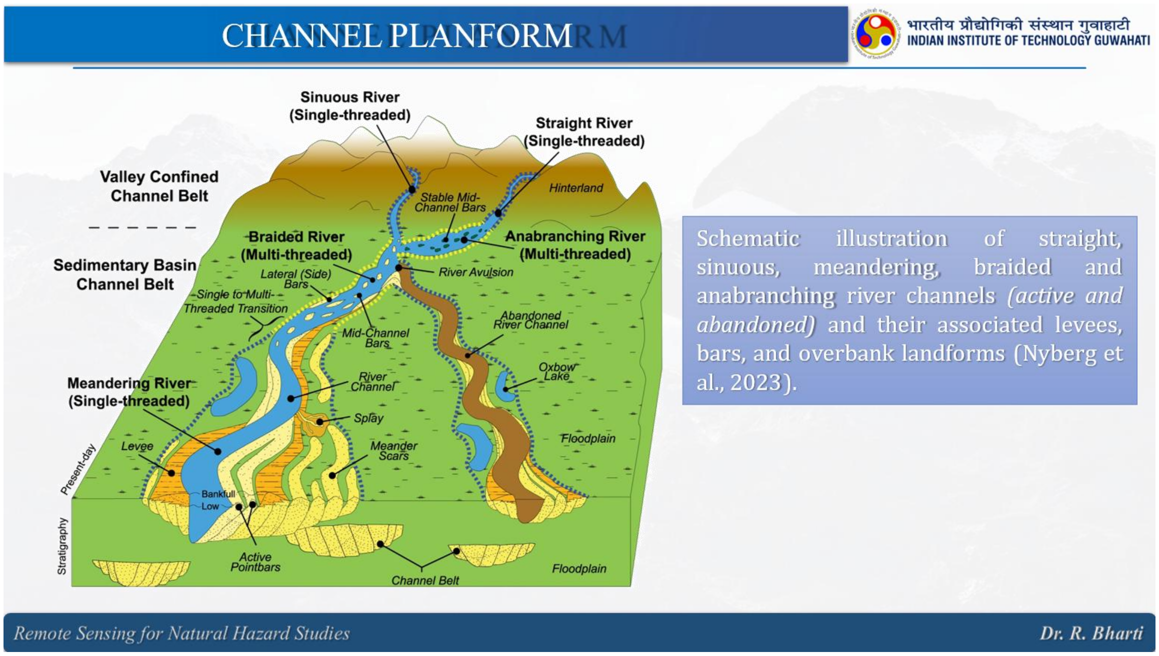
Because we are slowly having more requirements and extracting natural resources, that is disturbing the natural setting of a fluvial system. So, they are gradually disturbing the natural form and processes of the river. So, what we see today was supposed to be because of the hydrogeomorphology, because of the action of water, but since humans are very actively engaged in disturbing these natural resources, we also need resources to sustain ourselves on this particular planet. So, because of that, whatever we see is not only because of the natural water action, but it is also because of anthropogenic activities. So we need to understand this before we begin.

So, when we talk about the Himalayan River or any river system, you see the water originates at the snow or glacier level. So let us talk about the Himalayan Rivers. So here, this is the source of the water rights, and rivers and streams work together as a fluvial system, actively shaping the land by eroding, moving, and depositing sediments. Now, because of this erosion, transportation, and deposition, these landforms are being created. So, let us see some of the photographs that I have captured in the field.

So, this is at the glacier level from where the water is generated due to the melting of the snow glacier. Then slowly it is flowing towards the low-lying area, and with the slope, it is, because of the action of water, these valleys are slowly created, and you can see how the water is moving in this particular region, and then slowly it is reaching the plain land. So, here we can understand from our history that rivers are the lifeline for the sustenance and development of the human race. So, rivers are a lifeline for the sustainment and development of the human race because we need water to survive on this particular planet. So, the quantification of such fluvial alterations is essential for a sustainable river restoration and management program.

Because we need to quantify, only then will you be able to utilize this information in the river restoration and management program, if required for a particular area for a particular fluvial system. Until the 1980s, the flow and sediment quantification were based on hydrological data. It was purely based on the in-situ data. The geomorphological studies were carried out using maps and topographic sheets.

It was very basic. So, it started because geomorphology was evolving. So, subsequently, it became quantitative geomorphology. So, now, if we look at the 1980s era, maps and toposheets were the main sources of information. After the 80s, remote sensing was introduced; we had a few satellites, and the remote sensing datasets were used right away. Subsequently, new developments in data analysis and interpretation were initiated, leading to new research on large rivers and supporting the integration of geomorphology and ecology.

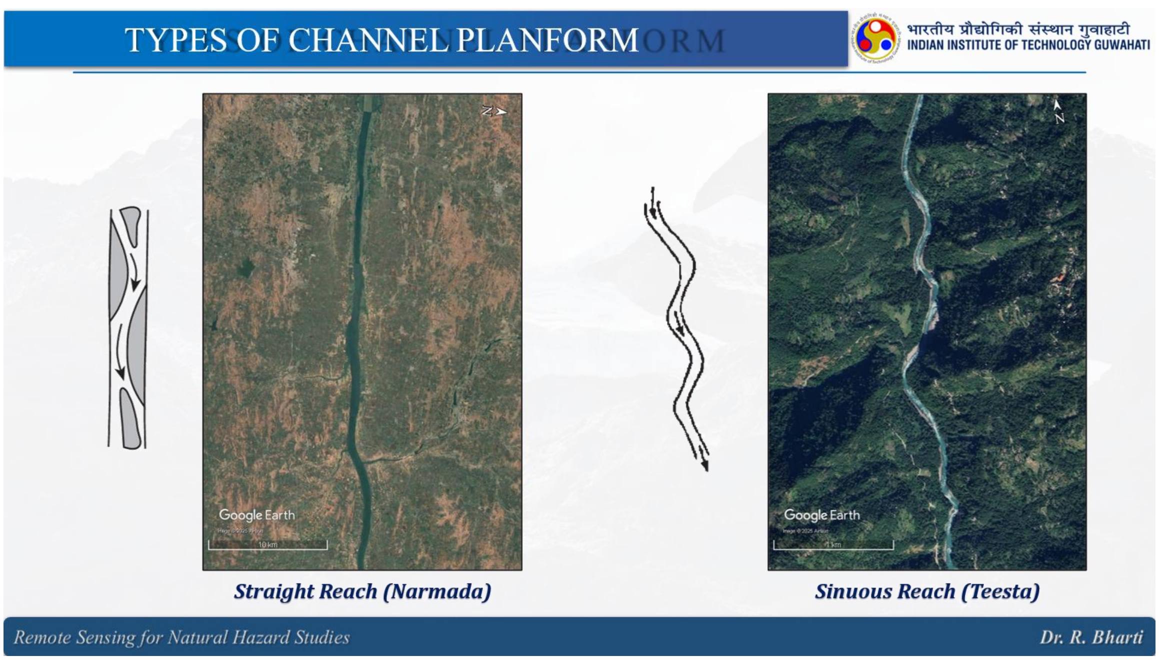


So, this is what I wanted to convey: in the beginning, we were only using the maps and toposheet for the geomorphological studies. Now, because of the advancements in technology in terms of remote sensing sensors and analysis techniques, we are moving ahead and doing more quantitative geomorphology, and in this case, it will be more quantitative hydrogeomorphology. So, this particular figure shows major Indian cities on the banks of the Ganga and Brahmaputra rivers and their tributaries. So, it shows or proves that for our sustainment we need water, and we only started our civilization along these river channels, now comes the Channel Platform. The planform of a river or channel signifies the top view, integrating plan features like straight, meandering, and braided features, as well as fluvial reliefs such as floodplains, flood channels, and low water channels.

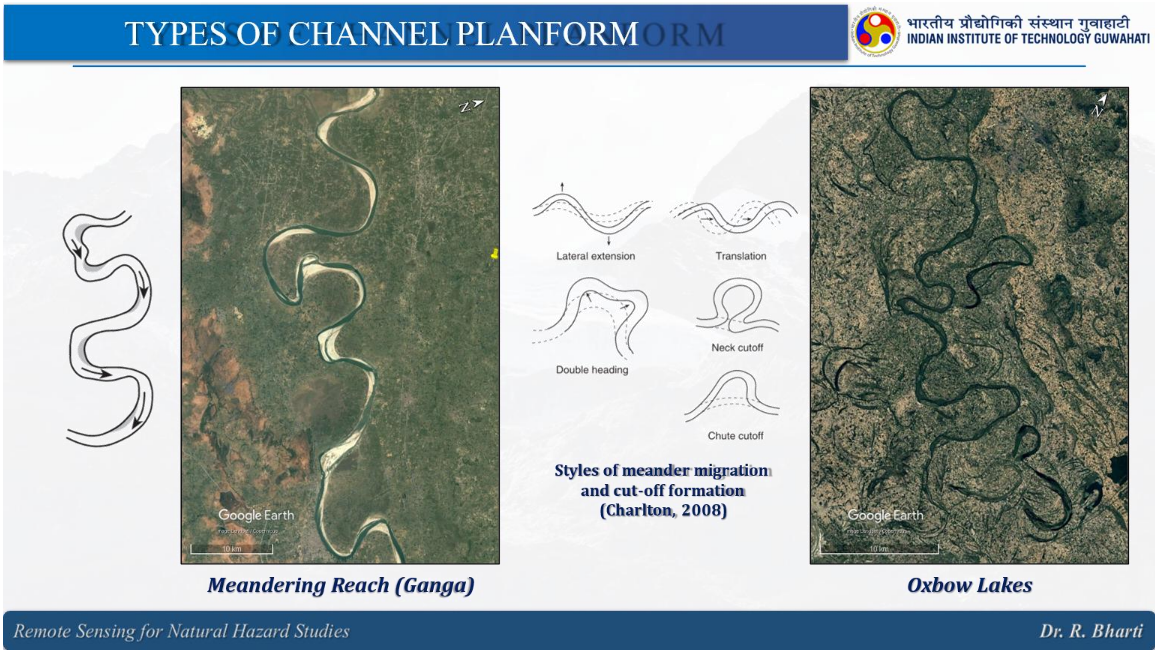
Combinations of these categories define the diversity of patterns because we don't see the same type of feature in all river systems; all river systems have their different patterns. Stream power signifies the kinetic energy associated with flowing water. This integrates channel bed slope and discharge. So, now the bed slope and the discharge are integrated into this analysis. The critical stream power and the hydrological regime together define the channel patterns.

So, now, whether the channel pattern will be like this or whether it will be like this, it all depends on the stream power, what the energy in your water is, and the hydrological regime. So, together they will be responsible for shaping this river system, So, that is why we have started with geomorphology; then hydrogeomorphology; now comes the channel planform. When we see a particular catchment here, we can see that different features are mentioned. So, here you have a straight river, here you have a sinus river, here you have a braided river, and here you can see the meandering river. So, this figure explains all the different types of features of a particular channel.

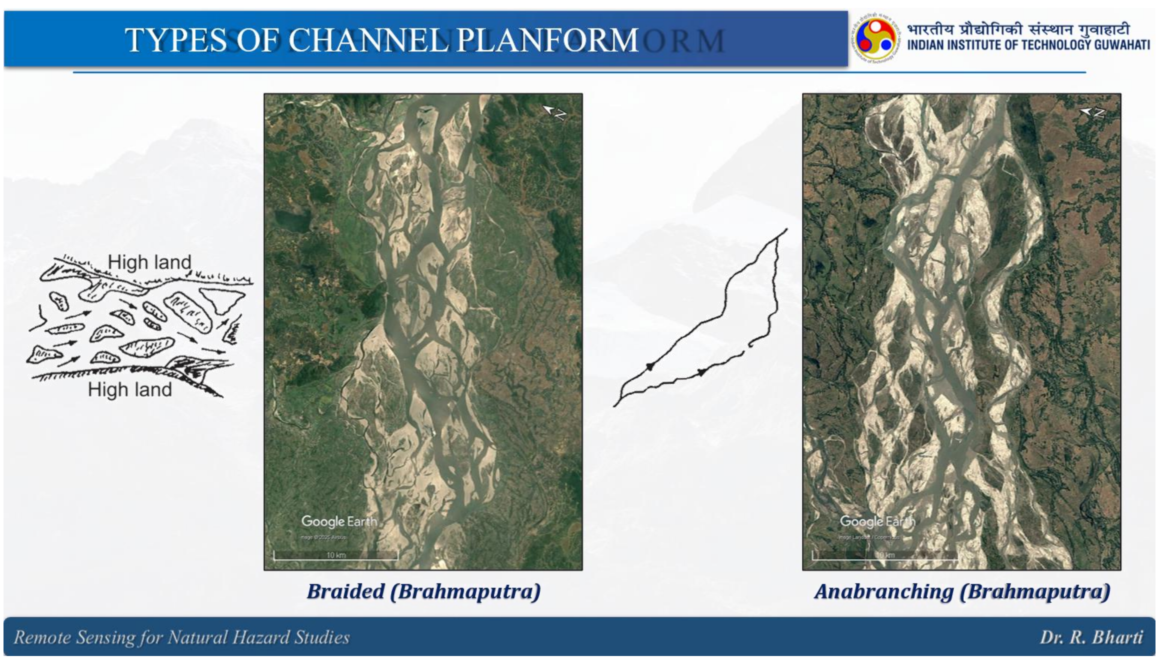
It is a semantic illustration of straight, sinus, main ring, braided, and anabranching river channels, some of which are active, some of which are abundant, and their associated levees, bars, and overbank landforms. So, it is a very nice representation of all the different types of channel patterns, Now, let us see the types of channel platforms. So, when we see this platform of streaming, it has two types: single-channel streams and multichannel streams. Then, for the single channel, we have straight and meandering; with the multichannel, we have braided, anabranching, reticulate, and deltatic. Then with the meandering, we have two different types, So, all these are the different types of planforms that you will be seeing in different river systems, So, let us see this particular platform.



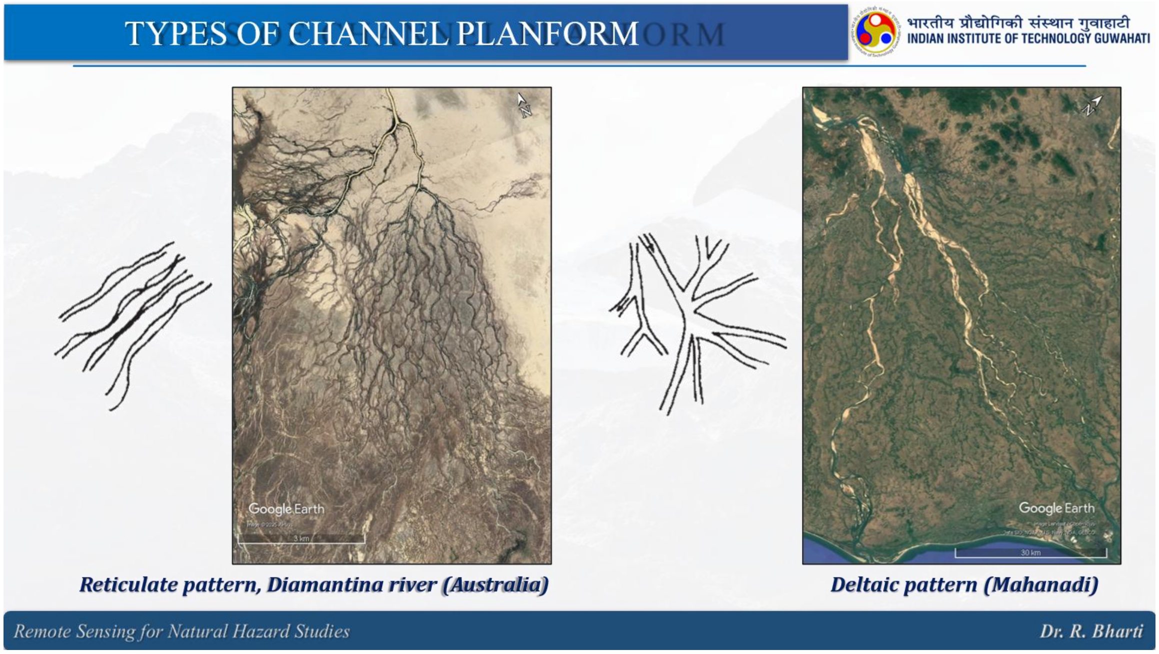
So, this basically shows the straight channel. So, this is from the Narmada; you can see how straight it is. So, we can easily extract this information, and then visually we can confirm this is a straight channel; but to prove it, we need some quantification, and that we will be discussing in the next few slides. Now here you can see this is an example of the Sinus River; this is the Teesta.



So here you can see how it is flowing, now comes the meandering one, so here the best example of meandering is the Ganga; here you can see some of the places where you can easily see the flood plains. Styles of meander mitigation and cut-off formation are from this particular book, so here you can see the Oxbow Lake feature.



I hope you know about it. Then, in the highland here, you can see the braided example; this is from the Brahmaputra. This is again anabranching that you can easily see in the Brahmaputra. So, this kind of flow will have two main channels divided, and then subsequently they will meet. Then, from Australia, we have a reticulate pattern.



So, here you can see this is from the Mahanadi deltaic pattern. So, you can see that this kind of feature will be present here, and the delta formations are very common, as it has been reported in many studies. So, let us start with the basic one: the meandering river. A meander is one of a series of regular sinusoidal curves, bends, loops, turns, or windings in the channel of a river, stream, or other watercourse. It is produced by a stream or river swinging from side to side as it flows across its floodplain.

So, with this, I will stop Part 1, and we will continue this lecture in Part 2 of Lecture 15. Thank you.