Earth Sciences for Civil Engineering Part-2
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Flood and related hazard (Part-1)
Module 04
Lecture No 18

Welcome back.

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Now this one of the the last topic and after this we will be having one more lecture on groundwater. Now floods okay. As we have been talking about that the hazard, natural hazard, this is one of the most important one which we experience every year and they are seasonal okay. This the photograph in the backdrop which you see is of Brahmaputra river in its flooding condition during monsoon season now floods if we take there is another photograph of the Bramhaputra river which shows that it was in flooding state during monsoon season.

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Now floods if we take in total then they are the most common type of geological hazards and can be predictable.

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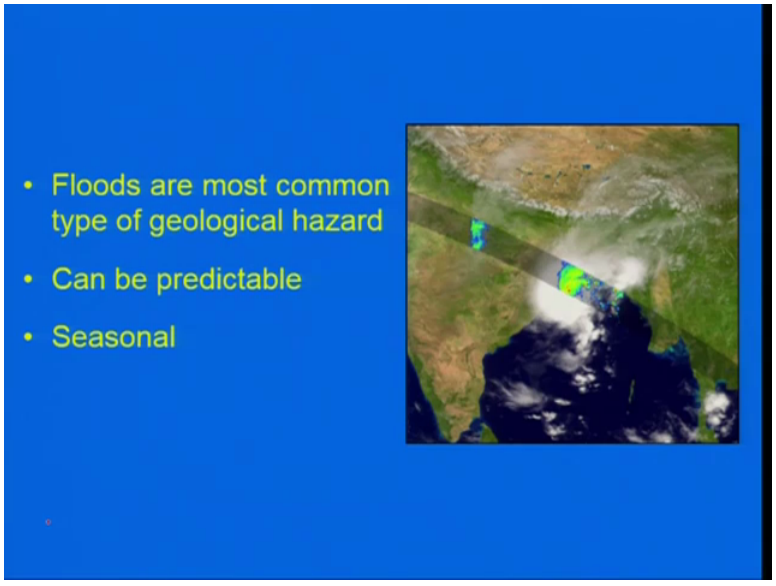

Now why this can be predictable because they are seasonal so we have more number of data points which we can use and try to understand that how much rainfall is expected every year and

how much area will be inundated or the people sitting close or settled close to the the river valleys or riverbanks will be affected.

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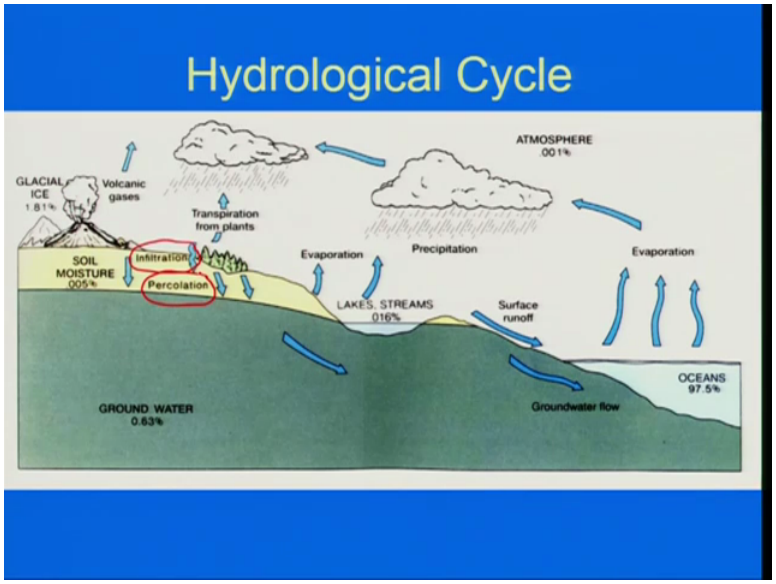

Now in total if we take the hydrological cycles, what all parameters which are important and because floods are created because of water, overflowing of water in river channels. So now the important part here is that not only the understanding the hydrological cycle but also having some understanding of the the landforms related to the river valleys or fluvial landforms we will say and of course the area in which we are living, that is the geology also because the precipitation will not only when it it comes on the surface okay in form of rain then infiltration is one of the important parameter to talk about the run off of the water okay and this will absolutely depend upon the subsurface geology. So this is again an important parameter to to be understood okay.

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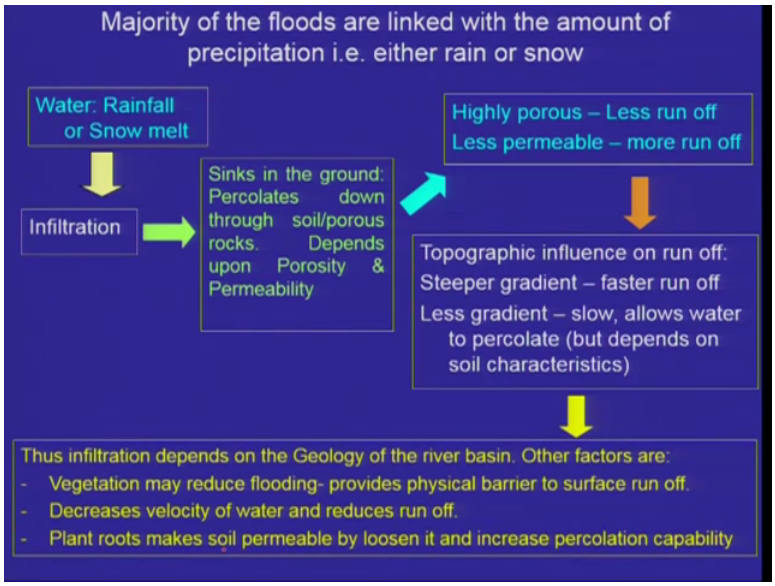

Now looking to the majority of the floods, they are linked with the amount of precipitation that is either in through rain or we are having the snowmelt and all that okay so water we can have either from the rain or from the snowmelt then further infiltration is extremely important because if you are not allowing the water to infiltrate, you are allowing the water to flow over the surface and that can lead into the overflow of the banks of along the river.

So sink in the ground okay so percolates down the water percolate downs through soil porous rocks. It depends upon the porosity and permeability of the material so this is extremely important in the area okay and highly porous rocks if you are having or the material you are having you will have less run off leading to less amount of water available for the run off okay and less permeable will allow more run off.

So in hard rock terrains, we will have more run off of the water so water we don't allow the water to percolate down okay. Then of course along with that, the topographic influence on runoff is extremely important okay so steeper gradients, we will allow the water to move as fast as possible. Less gradient, we allow the water to slow down, that allow the time allows the water to percolate but again it depends on the material characteristics okay.

Then further the infiltration depends on the geology of the river basin so we have the catchment area, water shed and further we are looking at the downstream regions okay. So an other factors which are responsible for the infiltration other than the geology is the vegetation where the vegetation may reduce flooding, provides physical barrier to surface run off, decrease velocity of water and reduce run off, plant roots make soil permeable by (loosen) loosening it and increase percolation capabilities. So these are few points which are extremely important which eventually leads to the flooding conditions okay.

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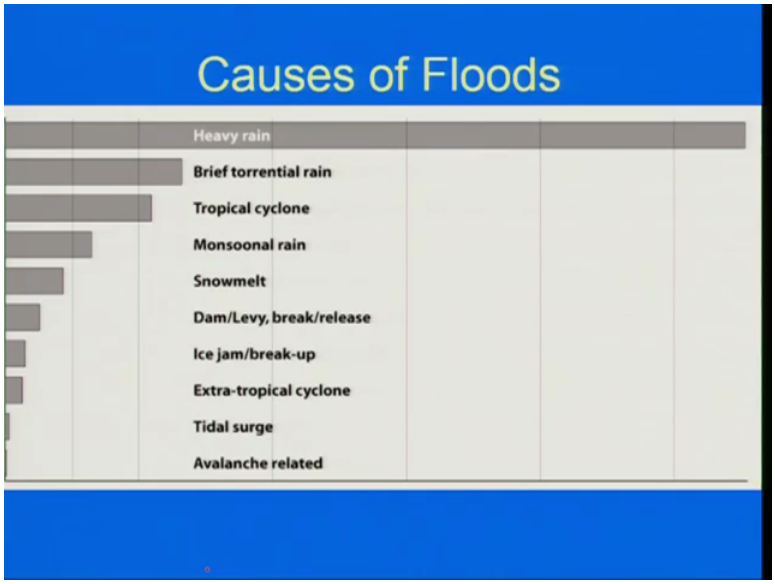

Now causes of floods, if we look at then the most of the floods are through heavy rains okay in any area then we have some torrential rains okay or even we can say that the cloud burst can result into the flooding. Tropical cyclones as we have seen one of the example of Vardah in the beginning of this course which can lead flooding in the coastal areas and even in the inland side where the the landfall is is expected.

Monsoonal rains, again snowmelt can result into the floods. Then in some cases, we have the release of excess water from the dam which we can say that it could be an manmade flood okay or human induced flood we can say and then breaking of levees and all that and then we have like for example ice chunk or the the rivers which are blocked of the landslide the upstream.

In the last lecture, when we are talking about the landslide, we talked about that if there is a blocking of a river channel in the upstream side, it will result into the formation of natural dam and if that breaks, you will experience floods even though you are not having enough of rainfall or heavy rainfall in that region okay. Then we have tropical cyclones, tidal surge okay avalanche related and all that okay. So these are few of the cases which can result into the flooding events.

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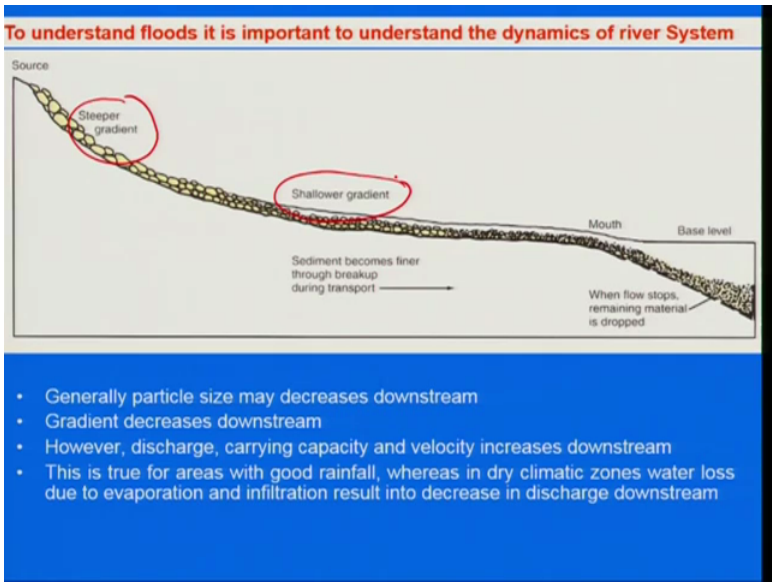

Now to understand the flood, it is important to understand the dynamic of river system. That is right from the upstream to downstream okay. Now if you take river or drainage basin then what you expect is that from the source to the mouth okay how it travels, what are the different landforms and how those landforms will be affected and where we can experience the flooding events okay.

So in if you take the river profile or the longitudinal profile then you will find that okay in the steeper gradient in the upper ridges where the river will always have coarser bed loads but in the downstream side, it becomes finer okay. So in general the particle size may decrease downward that is in the downstream site, gradient decreases again so we are having steeper gradients in the upstream and we have gentle gradient as we move towards the downstream side okay so gradient decreased downstream however discharge carrying capacity and velocity increases downstream.

This is true for areas with good rainfall whereas in dry climatic zone, water looses, that water is lost because of evaporation and filtration which result into decrease in this charge downstream.

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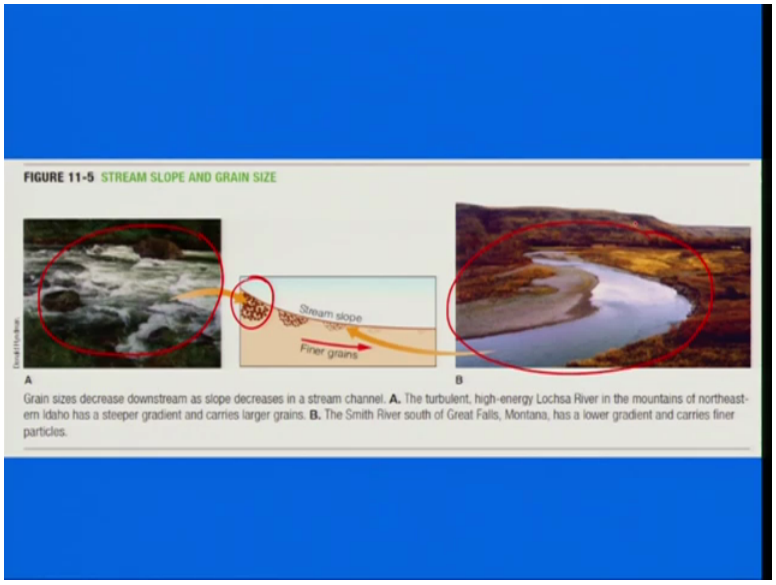

So this is what you will expect un the upstream side that you will have very turbulent flows and coarser bed loads okay but as you move towards the downstream side, you will have very the the discharge will be definitely will be okay in the sense but the conditions in the in terms of the flow will be much less and it will carry final deposits. So from the upstream to downstream the the grain size reduces okay and also the landforms changes from place to place so steeper gradients will carry larger grains and the shallower gradients will carry the finer grains.

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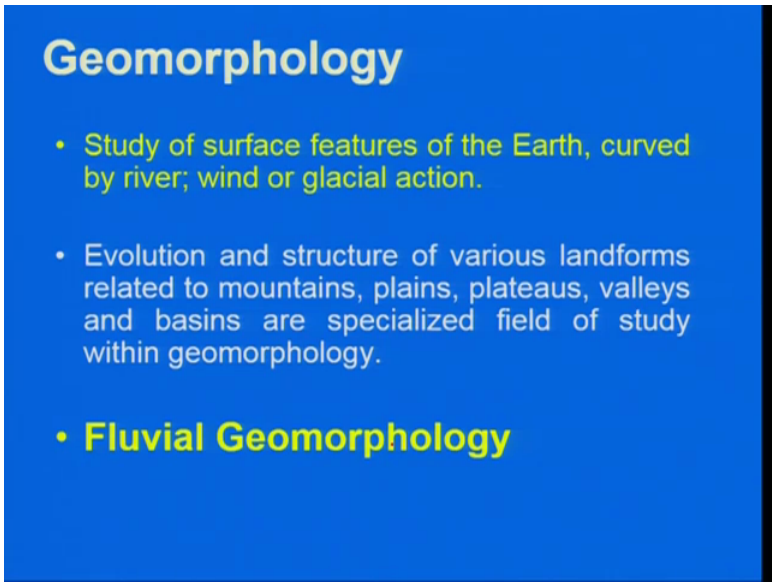

Now if we take the the one of the branch of earth sciences that is geomorphology where we deals with the the study of landforms mainly. Now in terms of the study of (surf), this is what is definition in short we can say what is geomorphology, the study of surface feature of the earth which are sculptured or curved by rivers, winds and glacial actions okay so these are the agents which will calve the the landforms on the earth's surface.

Evolution and structure of various landforms related to mountains, plains, plateaus, valleys and basins are specialized fields to study within geomorphology and for a river, particularly, what we say is fluvial geomorphology.

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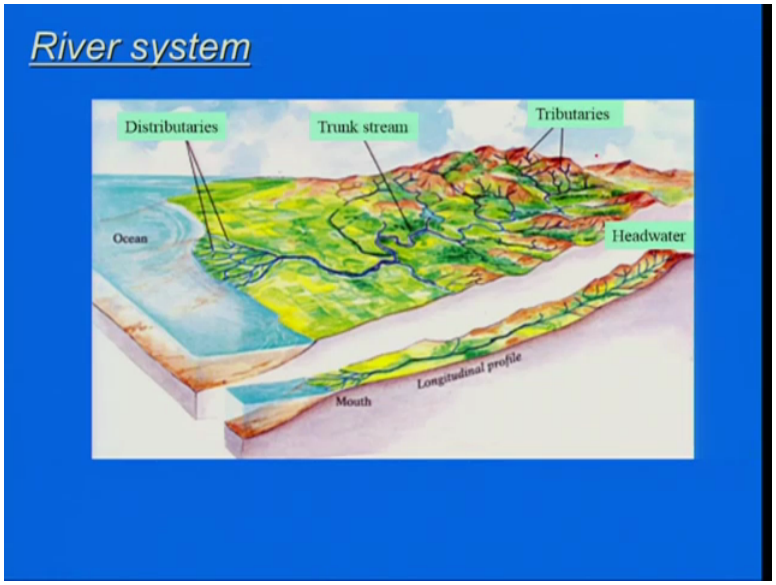

So we will see couple of example of a of a river landforms so in total if you take the river system, what we have is, we have the tributaries in in the upstream areas so this is the watershed okay in the upstream area or we can say the headwater area and then we have the trunk stream and distributaries okay so through this journey when it flows through right from its emergence, it has different landforms okay. So if you take the longitudinal profile here, you are having headword and you are having an mouth here okay so any water body, it can meet tributaries will meet the trunk streams okay.

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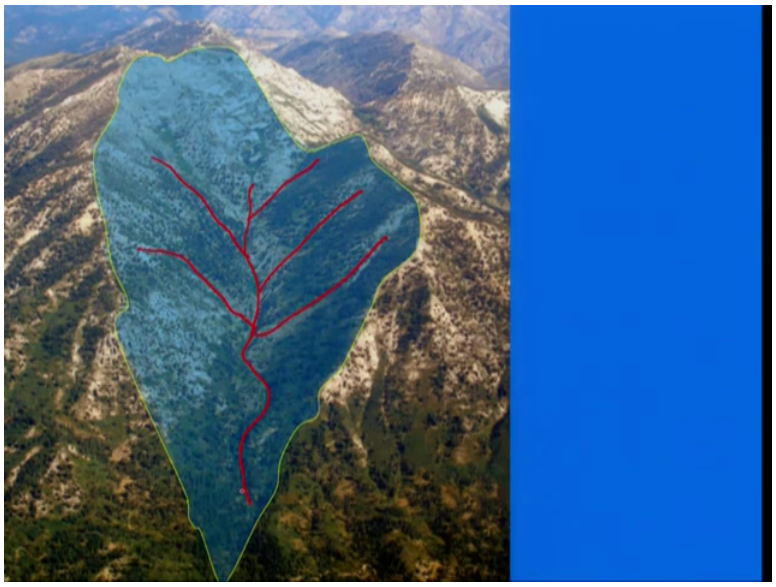

So if you take here this picture, what you see is that this your trunk stream flowing and then you are having smaller streams which are joining here these are the tributaries. So all are pouring water to the main trunk stream okay and this area is been termed the the (wash) the watershed area or drainage basin.

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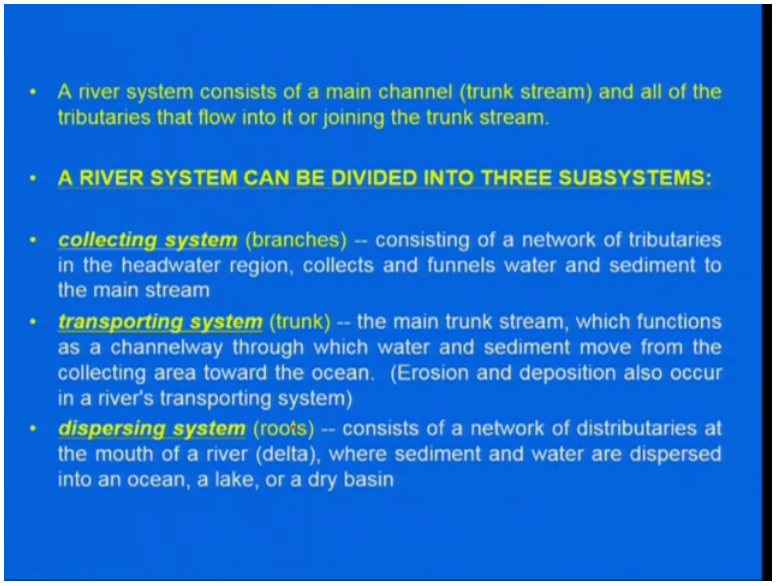

So a river system consists of a main channel that is what we termed as in trunk stream and all of the tributaries that flow into it or joining the trunk stream okay. So river system can be divided into 3 subsystems, one is the collecting system, that we are having the branches, the the network of tributaries in the headwater region, collect and the funnel the water and sediments into the mainstream and then we are having, we can say it's an transporting system that is the trunk, okay trunk stream will be the transporting system.

So whatever the material is been collected the water is been poured into the main channel. It will be further transported by the trunks stream okay which functions as a channel way through which water and sediments move from collecting areas towards the ocean okay. Now erosion and the pollution also occurs in the rivers transporting system and then we say dispersing system okay so this we say roots okay so consists of the network of distributaries at the mouth which result into the formation of deltas where the sediments in water are dispersed into the ocean or it can be a lake also or a dry basin were river finally ends its journey.

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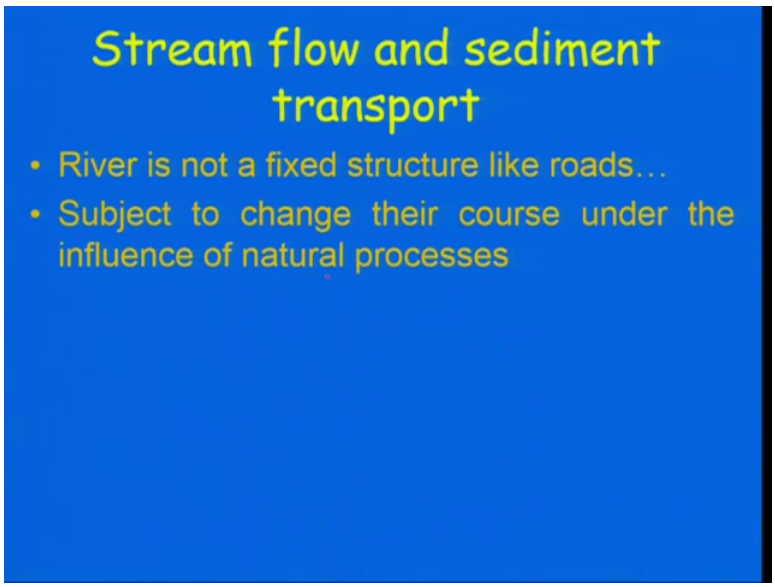

So stream flow and sediment transport, if you take, river is not a fixed structure like roads, subject to change their course under the influence of natural processes and these natural processes is not only the internal one but the external one also okay. So internal as well as external can result into change in of the course of many rivers okay. So in in like for example, in

the mighty Himalayan rivers okay or one of the the name I would I would give here is the lost Saraswati.

People are still trying to find out what were the causes for that shift of the Saraswati in the Indo Gangetic plain or why we lost the Saraswati which used to debouch into then existing Arabian sea in Great Rann of Kachchh okay. Right now that area is marked by Great Rann of Kutch and all settlements okay like Indus valley civilization was flourishing or flourished along the the Indus valley and the Saraswati probably that was one of the the main river which flowed during that period okay.

So whether the climate was responsible which again you can say that has external process or the tectonic activities that is internal processes were responsible for the changing the course okay. So it also influence the human transfer from one place to another place so rivers are complex network interconnected channels with tributaries okay. Respond to change, that is a regional climate change or local weather or amount of variability of flow and sediment supply and size also. So if you you disturb this, it may result into the the change of the river course also.

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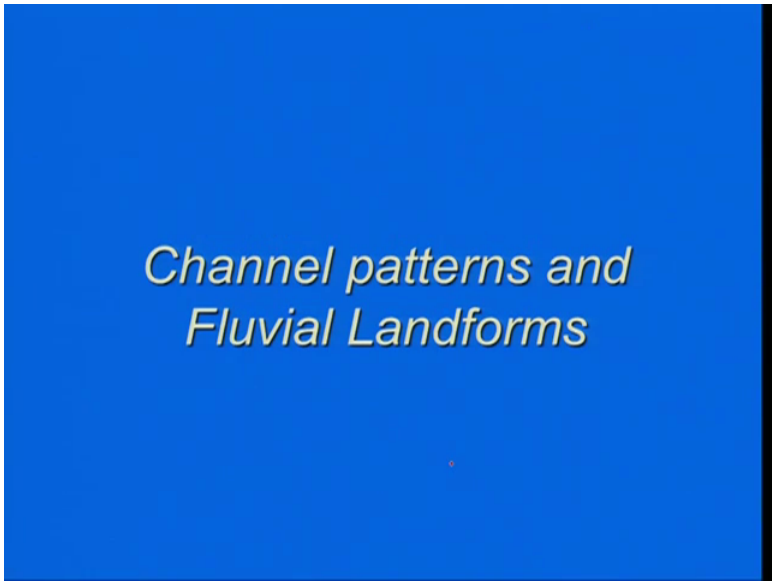

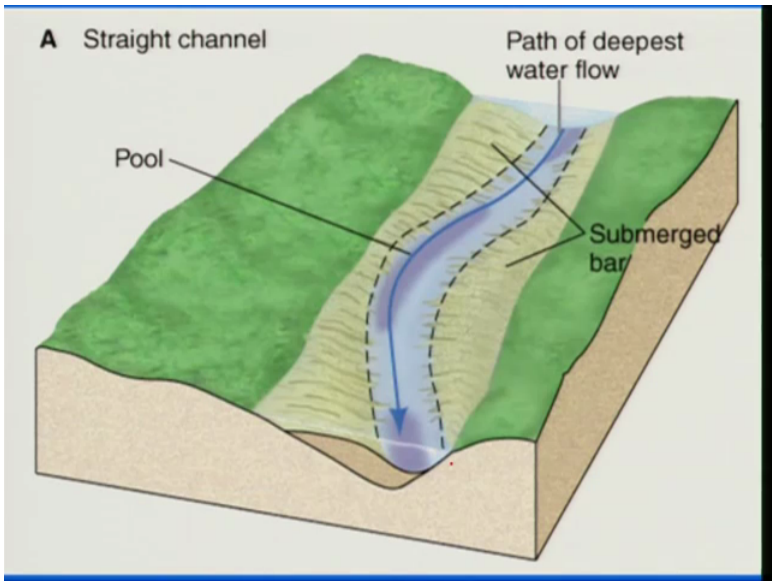

So channel patterns and fluvial landforms in total if we take okay, we have one is straight channels so in drainage basin, you will encounter this pattern of channels okay. So where if you are having straight channel then the maximum deepest part and the maximum energy will be in this central portion of the channel.

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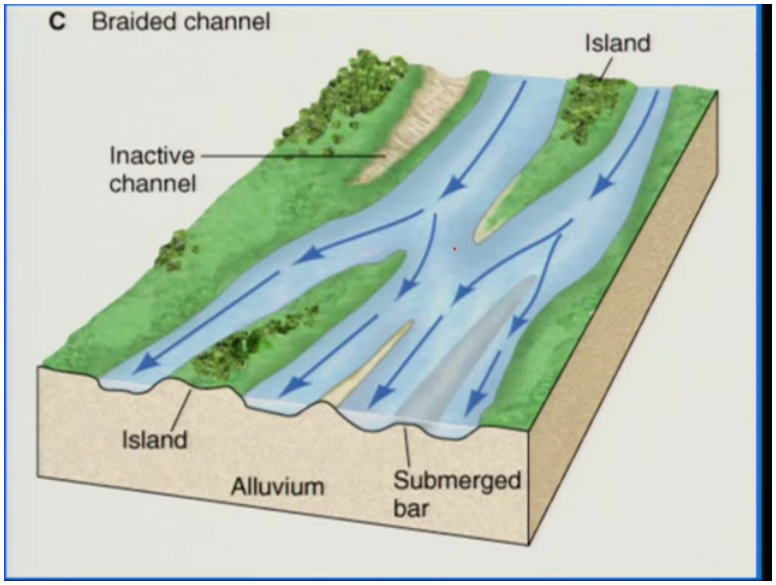

Then we have braided channel where again in is in combination of several straight channels or it may be in combination of meandering channels okay. So it joints and flow through the river valleys okay.

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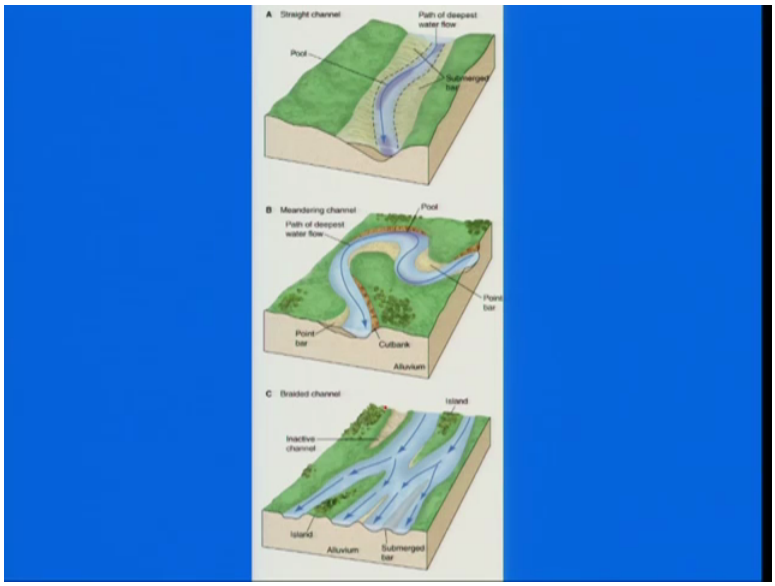

So we have like meandering also, I I will come to this in coming slides okay, meandering rivers but in meandering rivers are like a curved, it takes curved path or we say sinuous path okay and mostly you will find this in the in the lower ridges or the downstream side.

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So braided river system okay exhibits numerous channels that split off and rejoins each other to give a braided appearance okay. The typically carry coarser grain sediments down the steeper gradients okay.

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These are the examples of the braided river so it may be straight or it may be multiple meandering channels okay.

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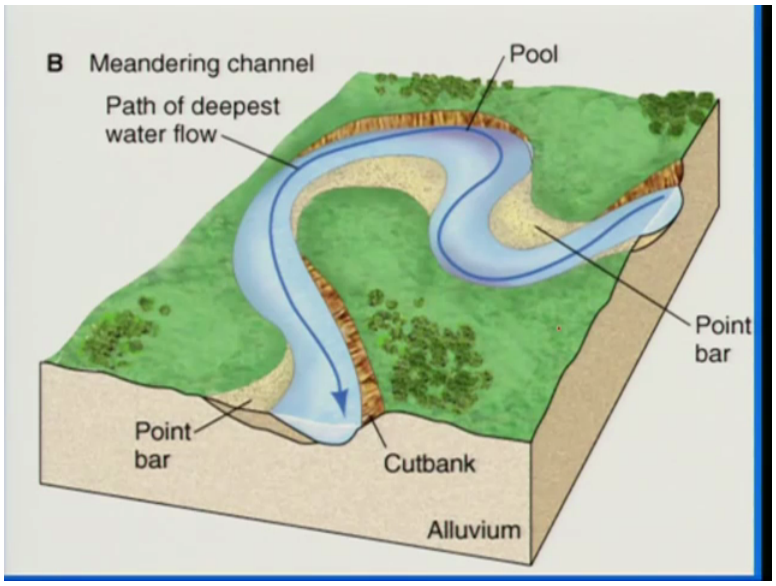

Now meandering channels, usually what we will find so I will just talk about this one before we go to the meandering channels.

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The landforms which we see here are the braid bars okay so these are the the braid bars which are sitting between the 2 adjoining channels okay. These are all braid bars or we can say the island because it has been covered from all sides by water.

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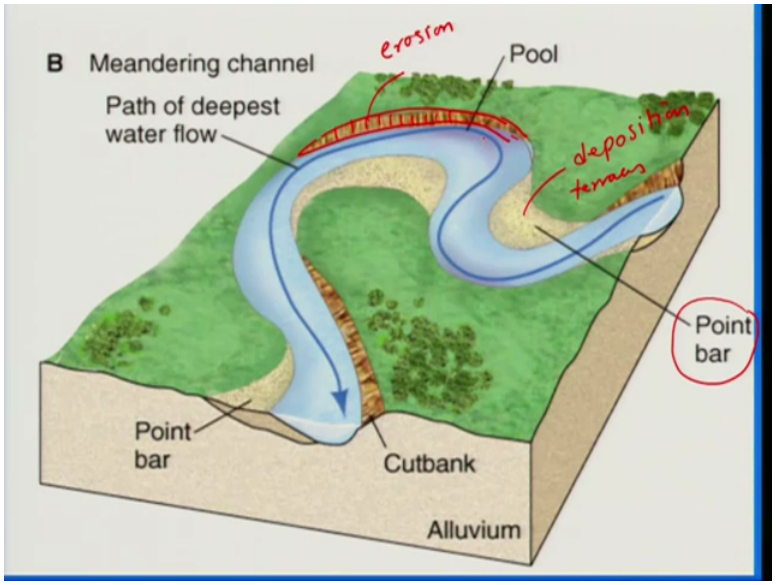

And meandering channels, it has an capability of deposit and erode okay so on the inner side of the the curve, it will deposit and the landform which is generated by such activity is been termed as point bars. And this portion that is the outer side of the curve, it will erode okay so this is an erosional part okay so you have erosion here, you have deposition here. So you you generate landforms, erode the the areas okay and the erosional sides will have particularly higher cliffs okay so it will have cliffy banks whereas on the on the depositional side, we will have the formation of terraces.

Let's see some examples of this. The another important part which I would like to mention here is that the the part which is the outside side okay will be deeper and will be having higher energy conditions as compared to this one.

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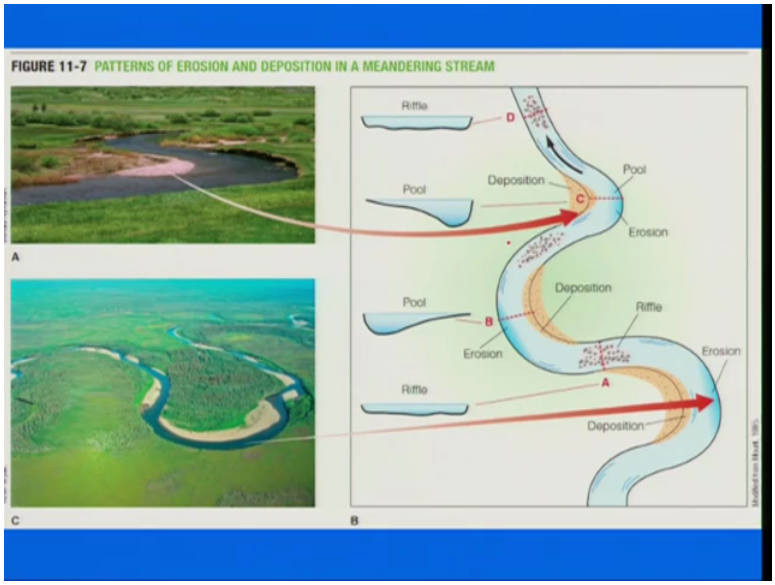

So what you see here is that if you take channel okay which is flowing here like here like this and you have some portions, you have straight channels so if you take the cross section, you will find something like this but if you are having the meandering and if you take this so this portion will be the deeper part okay and will have the high energy conditions. Similarly on this side, you are having this side is an erosional one and deeper part again, you are having straight channel here okay.

So this will result into the formation of point bars, these are what are being shown as a point bars and these are outer sides on which you can see the cliffy banks over here and we will see, we will talk about the formation of different landforms here. Now this is very typical we will see or observe in in the plain areas. For example like an Indo Gangetic plains okay. What are these landforms and how they are created? We will talk about that.

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So we have the different landforms which are associated with that and important one close to the river channel is the levee. Levee's are basically, if you look at the cross section here then you will find that then and these are like slightly elevated and then this is your river valley and then you are having this is going so slightly elevated portion closed to the river banks are termed as.

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There is another example of the Sinuous river or meandering river so meandering rivers have capability of shifting and leaving behind some of the landforms which eventually will get in will get converted into the backswamp or the wetland okay so you will you will also find in the Indo Gangetic plains, lot of wetlands and backswamp areas which are the result of the migration of shifting of the meandering rivers.

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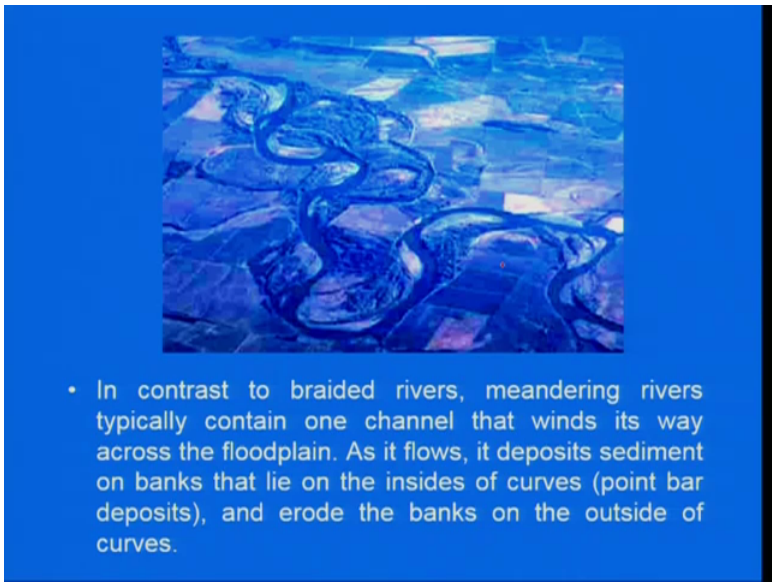

So in contrast to the braided rivers, meandering rivers typically contain one channel that winds its way across the flood plain, as it flows, it deposits sediments on the banks that lie on the inside curve and result into the point bar deposition and erode the banks on the outside curves okay which will result into the formation of cliffy banks.

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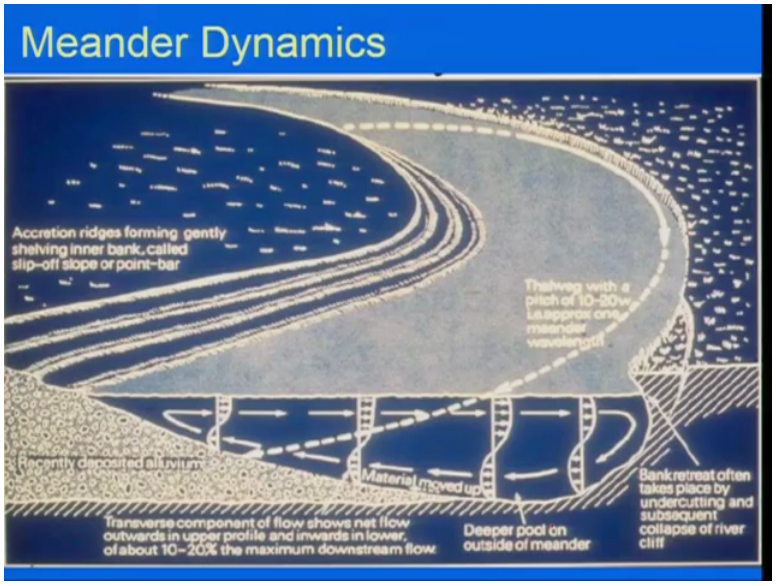

So this is what I was talking about now if you take the the total view of the meandering dynamic okay then you will find this part that is the outer side which is eroding will be deeper and will have higher velocities okay whereas this will act as accretion ridges okay forming gently and moving towards this side okay. So we will have the migration of the point bars here and this channel will keep on eroding this side.

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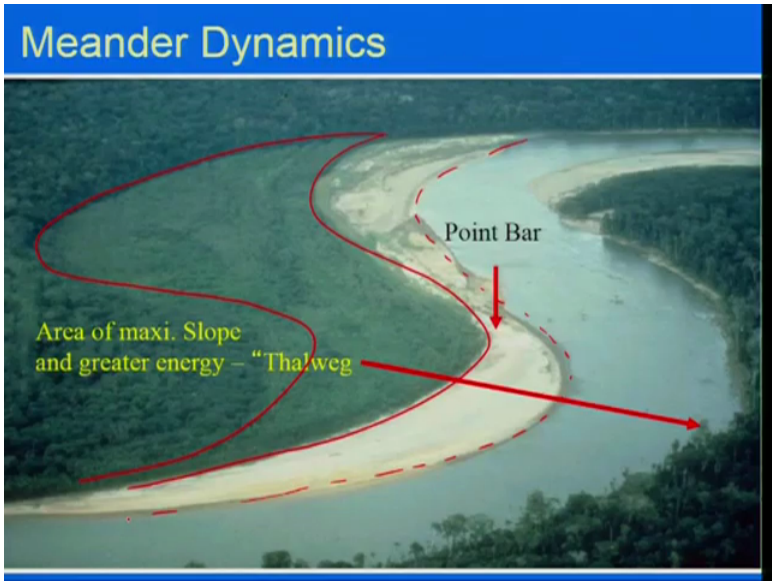

There is an example of that so you have the older channel over here which flowed earlier and this is the boundary of that and now it has migrated over here okay. These are termed as point bars and the deepest and the steepest potion okay with the greater energy is been termed as Thalwag. So this portion which you see here okay will be the deepest part which is termed as tawage.

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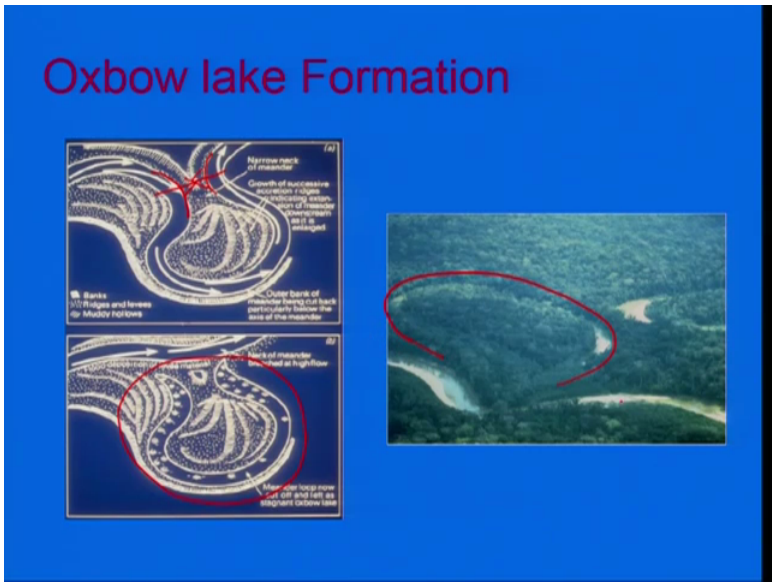

Now this what I was trying to explain you that you are having the, how the oxbow lakes are formed so so you are having the meandering channel here which is flowing through this like that okay and then we have the the outer side, on this side so this will keep on eroding like this, this will keep on eroding towards like this okay and finally it will result in and cut off channel okay and leave behind a landform which is very similar to the foot of the ox okay hence it is termed as the oxbow lake.

These are the example of that so this this is an oxbow lake which are been termed okay so earlier the channel flowed through this over like this and might be going like that but now it is flowing through and through. So this is termed as the oxbow lake.

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Example of that. Now this is already the oxbow lake is formed. The next oxbow lake will form here okay. The river will be connected like this okay. It will flow through and through like this and this will be in another formation of the oxbow lake so in the plain areas you can see the the remnants of oxbow lake. This is one here and this is another one here.

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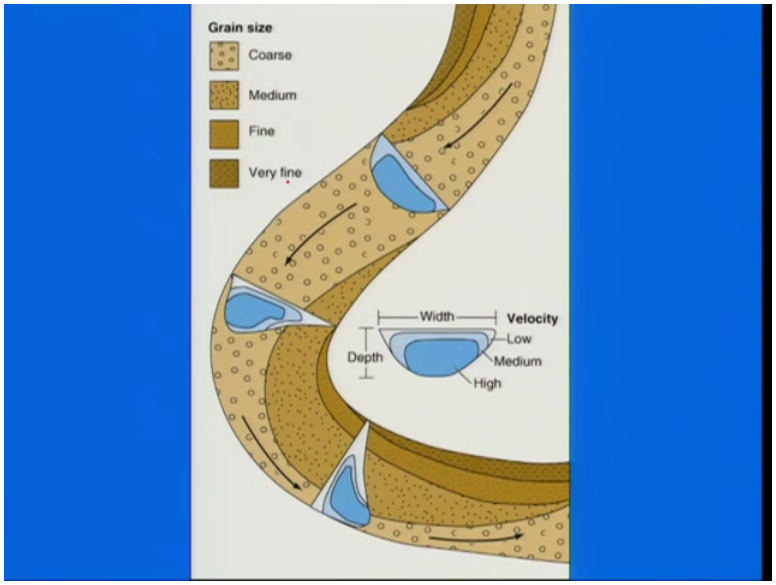

So you look at again the cross sectional view of a meandering channel and the straight channel what you find is that you are having here okay the courser bed loads okay and and in the point bar areas you are having medium to fine and very fine deposits. So this portion is having higher velocities okay and of course having the deeper portion here, shallower on this side so you can compare that the deeper portion, high energy, coarser bed load and the shallower one, you are having final deposits along that okay.

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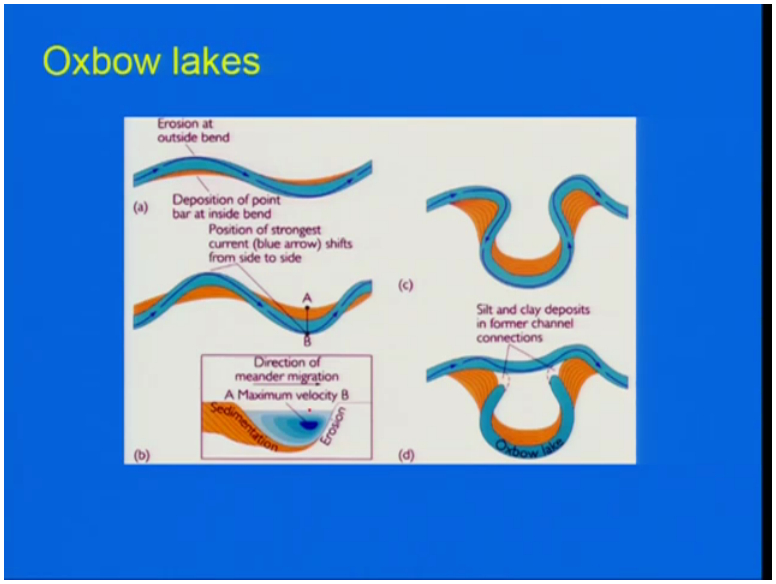

Again this explains the same what we have discussed that slowly this will join and will leave behind the formation of ox shaped okay the foot shaped feature which is termed as the oxbow lake.

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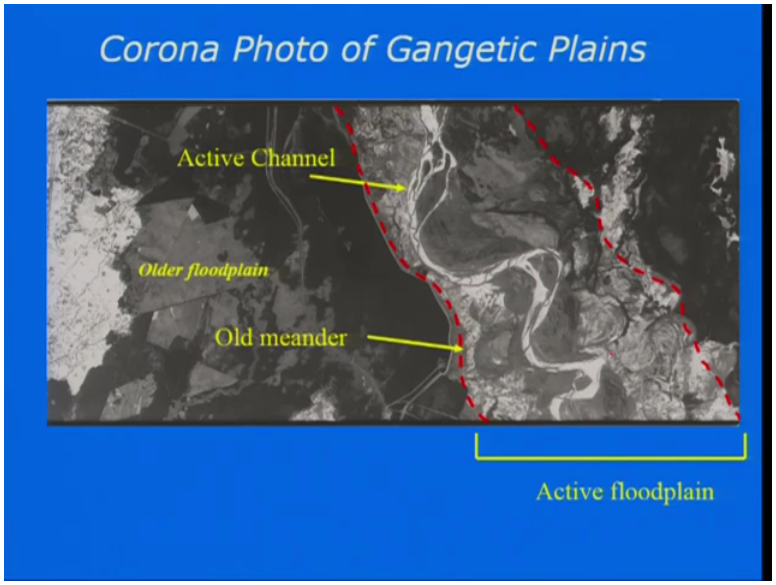

So let's look one of the the photo, satellite photo of the Gangetic plain. Now this is the photograph which shows the meandering channel and along with that, what we see this is an active channel which is presently carrying the water and sediments whereas other than that, we have few older meanders which are which can be seen on the on the bank of the the river and then we have some portion which are little bit with darker shades and this marks the older flood plains and in between those 2 are marked by the active flood plains okay.

So here the important part is that we also need to know that which areas are the active floodplains even though the river is not flowing at that particular point okay at present but can reoccupy those regions in future also okay. So river have capability to migrate so for example, this area is right now is in is within where no water is flowing because the active channel is over here but it can reoccupy this okay because these are all the low laying areas close to the river channel so these are the older flood plains okay.

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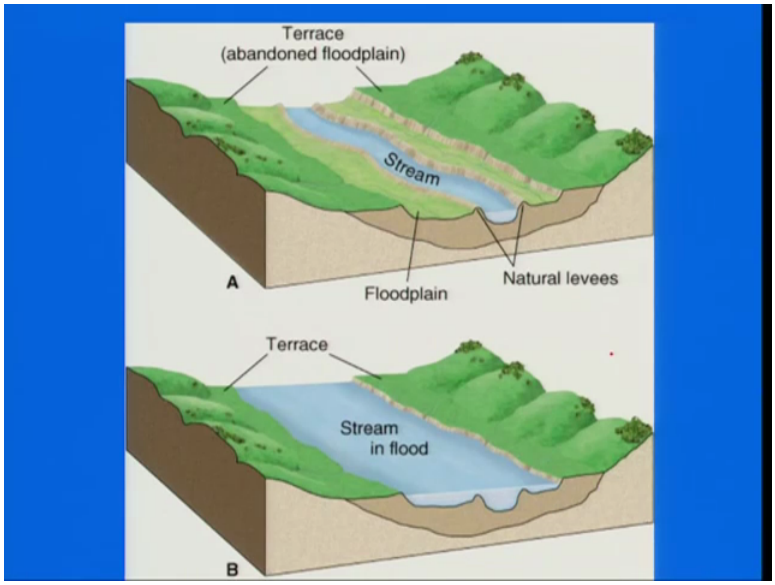

Moving further, again what we see is along with the the meandering channels and the straight channels or braided channel. We see these these landforms which we call the terraces are nothing but the abundant floodplains of the river valley, along the river valle. So active stream is flowing here and earlier this stream flowed along this one okay and then slowly it has eroded and resulted into the formation of terraces okay and close to the banks, we have slightly elevated portion which are termed as levees okay, natural levees but in field, it is most of the time difficult to mark it but you can this type of things okay.

Now when the river is in the flooding condition, as I was talking that it can occupy the or the older flood plains also which we were talking about like for example the abundant floodplains so during the bank full flows, it can reach and inundate the the areas like this okay so what you see in in the the figure B, we are having that it has left out the older terrace but the younger terrace over here, these are the younger terrace, they have been submerged okay so if you are having the settlements without having the much of understanding here okay. Here you are constructing your houses here then you will face problems okay during the the flood events so you need to understand that how big floods were been in the past by along this channel and so accordingly you can have the town planning.

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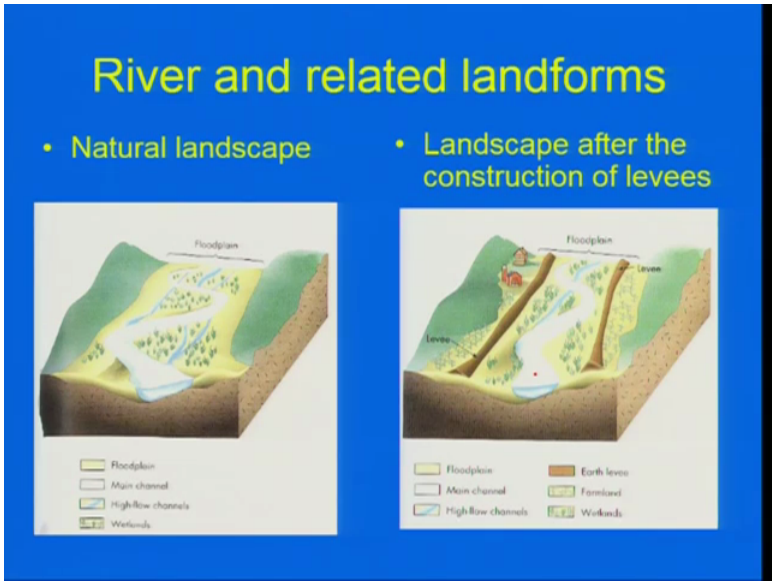

Not river in related landforms, we will quickly look at the landscape again, what we are looking at here is the floodplain and this is natural landscape but if you try to channelize the flow okay to avoid the flooding in the low laying areas where you have allowed people to settle down then you can have this one okay. This is what we call the the construction of artificial levees okay and then you can allow the people to stay in the in the neighboring lower terraces okay. So the you (aa) you you have channelized the flow by constructing the levees okay. I will just show some examples where there are big cities we are sitting (clo) which are sitting close to the the major rivers okay.

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Now alluvial fans and deltas are another landforms which are related to the the fluvial activities okay.

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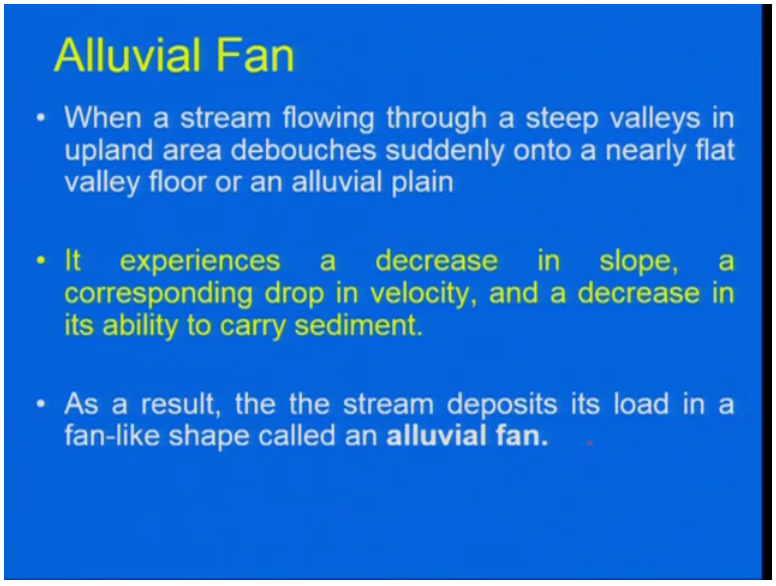

So alluvial fans are usually seen when a stream flowing through a steep valley in uplinks debouches suddenly onto a newly or nearly flat valley floor or we can say the alluvial plains likewise we are having Indo Gangetic Plain so close to the like we are having like this is there is

a mountain front here and then we are having so close to the front, we will have the the formation of alluvial fans.

So the it experiences a decrease why the alluvial fans are formed? Because it experience a decrease in a slope, a corresponding drop in the velocity and a decrease in its ability to carry sediments okay. So because river is coming from the steeper slope to the the gentler slope, it will it will drop the, there will be a drop in velocity okay and also it will have less capability of carrying the course of bed load so it will dump everything at the base of the the mountain front. So as a result, the stream deposits its load in a fan like shape so at the base, if you are having this is mountain front here so at the base you will find the lobe shaped feature which is very much similar to fan hence it has been termed as alluvial fan, alluvial is the all loose material okay.

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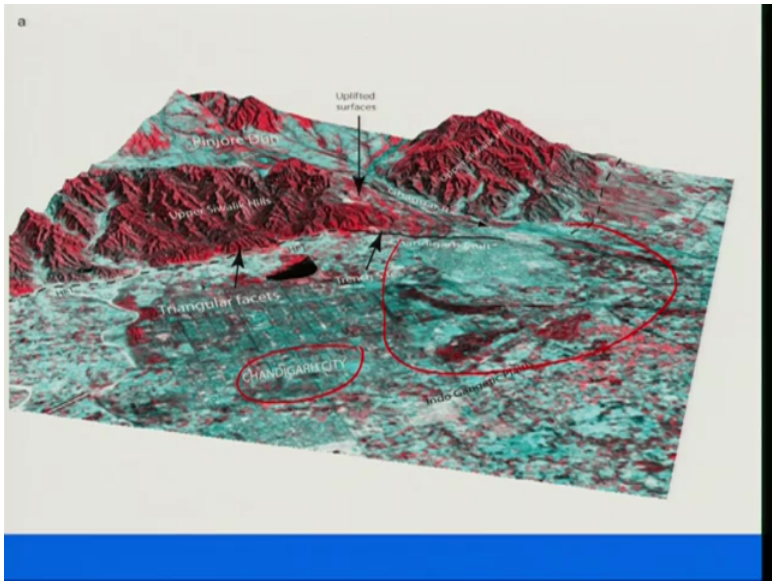

There is an example where you are having this is a very well known city Chandigarh and this is what you are having, the front, Himalayan front and at the base here, this is what we are having the alluvial fan okay.

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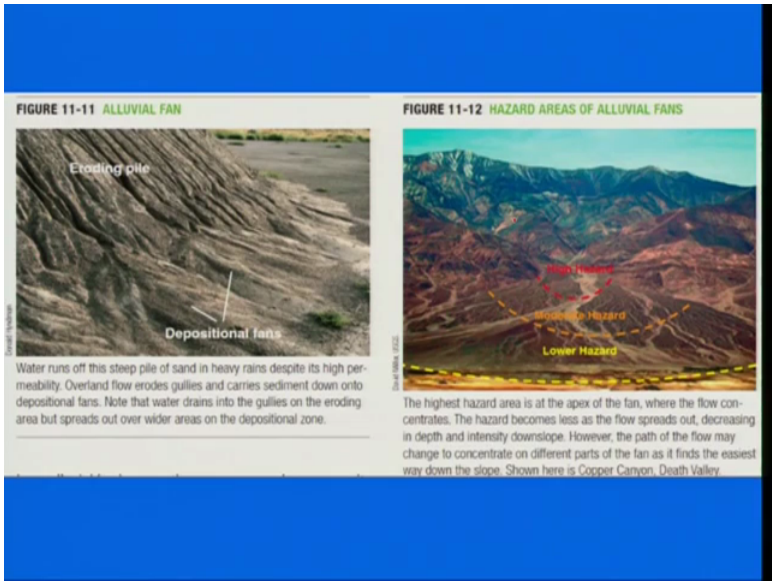

Now hazards related to these landforms are that close to the the front, that is what we call the the proximal part will be highly hazardous okay. In this area, the channel will have capability of depositing very courser bed load okay but as you move away in the fan region then you will have finer deposits okay so close to the proximal, you will have coarser bed load away from the the proximal part that is what we call the distal part of the fan, you will have finer deposits. So if you take in terms of hazards, the proximal part will have higher, high hazard. Then moderate hazard in the middle part and then you are lower hazard in the distal part.

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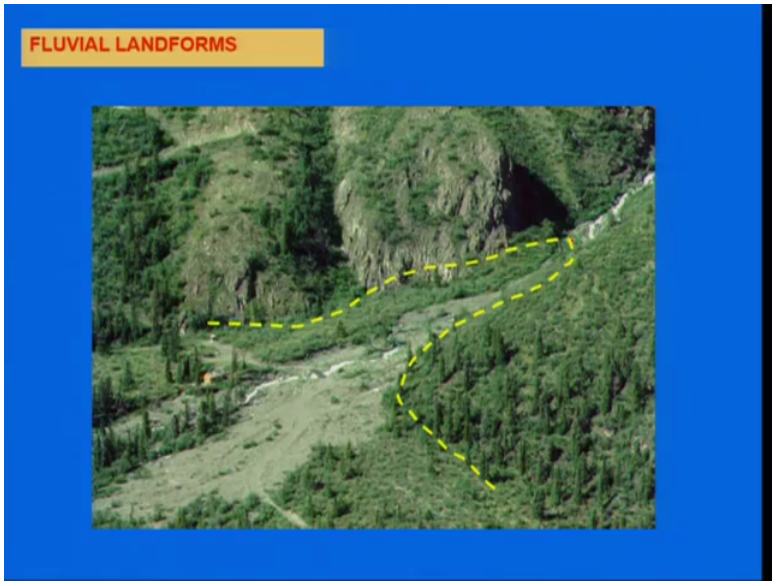

So again this is an example of that okay so you are having the mountain front here and you are having the deposit of the that is alluvial fan deposit okay.

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Further another example from the Himalayan front. You can see multiple formations of the fans here okay. These are all the (())(35:22) alluvial fans okay, so stream is coming from the confined

areas, getting confined on the on the gentler slope so this side the slope is deeper and resulting into the formation of alluvial fans.

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This is in desert area.

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And this what we see either you can call this is an delta okay or a fan area close to that okay.

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So alluvial fans are fan shape deposit of of water transported material that is what we call alluvium. The typically formed at the base of the topographic divide where there is a sudden break in the slope. Consequently alluvial fan tends to the coarser specially at their mouth, that is the distal, um the proximal part and at the edges, they will become finer okay and the piedmont zone, a slope surface at the base of the mountain formed due to erosion covered by thin wenner of alluvial so this portion will be termed as the piedmont zone okay we are having so here you will have coarser sediments. Here you will have moderate sediments in size okay. Here you are going to have the finer sediments okay.

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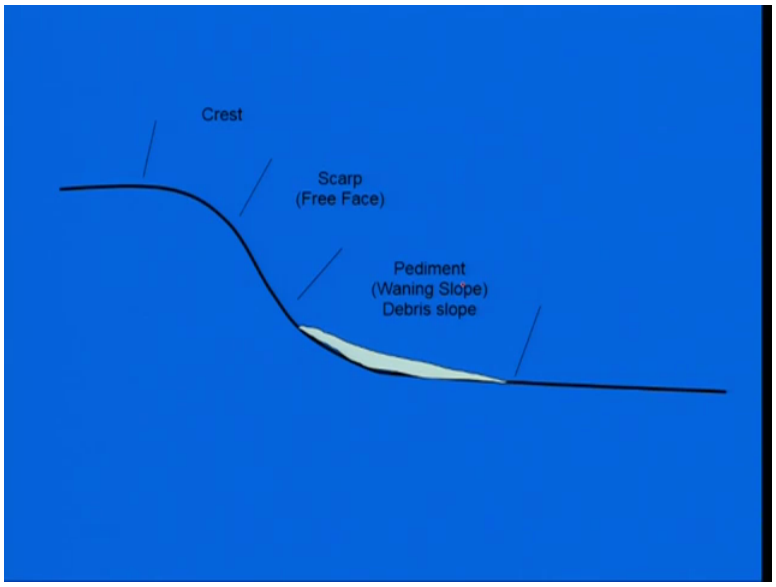

So this is what we have the confined areas then higher steeper areas and then river flowing down to the gentler part okay so you have free face here and this is the area where alluvial fan will be deposited and the region of this part that is at the base is termed as the piedmont.

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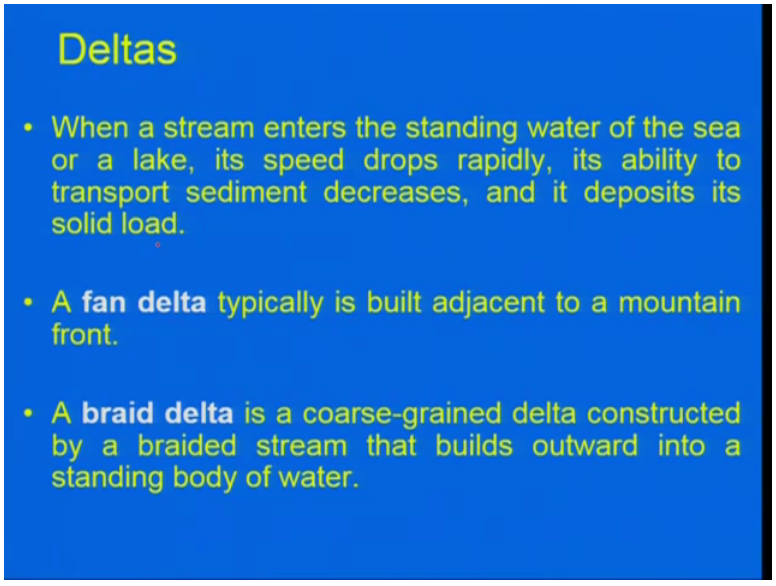

Now coming to another important landform which is delta and these usually are seen where the the stream enters the standing body, either it is lake or it is a basin or we can say it is an within,

in the ocean okay and here its speed drops rapidly. Its ability to transport sediment decreases and it deposits the solid loads okay and fan deltas typically is built adjacent to the mountain fronts okay and the braid deltas okay in are usually the coarser grain deltas constructed by the braded stream that build outward into the standing body of water.

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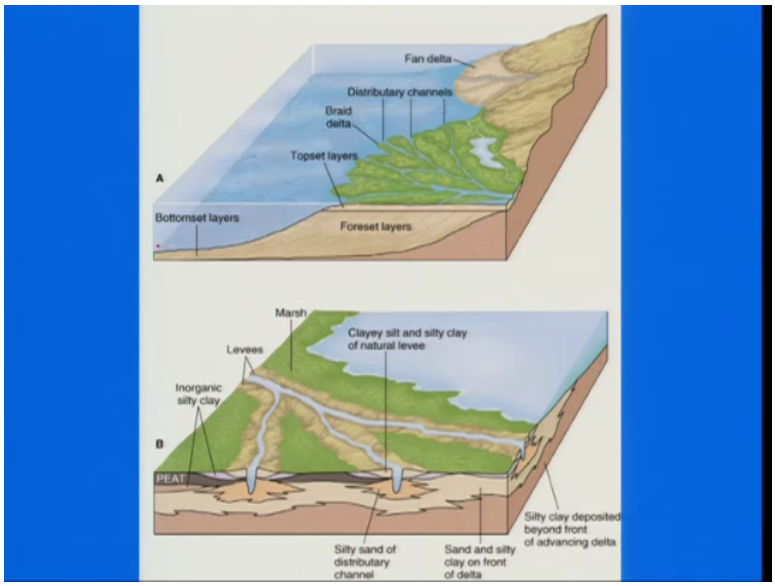

So this is what you one can see okay close to the the the front you are having. You may be have the fan deltas okay and then you have, you may have the braided deltas okay.

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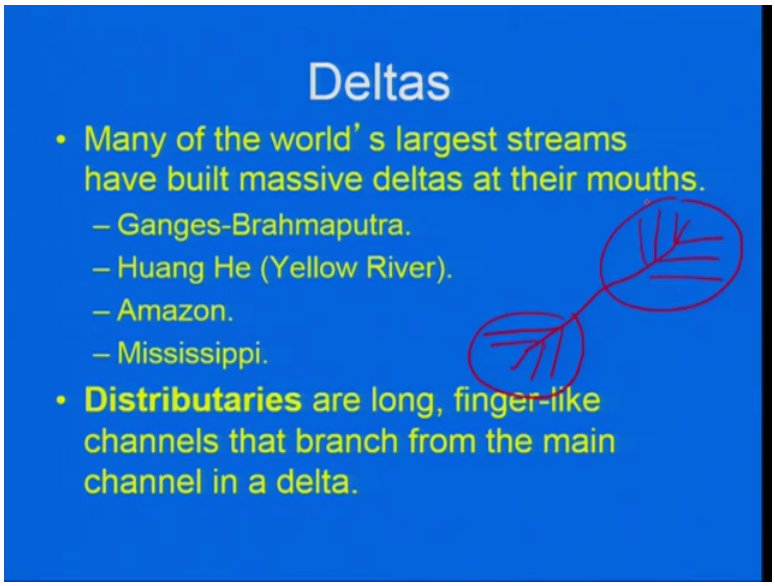

So for example, you have many of the world's largest one okay and the massive deltas. One of is from the Indian subcontinent or Ganges Bramhaputra delta okay. So distributaries are long here. Finger like okay channels that branches from the main stream okay. So this is almost like the inverted part which we we were talking about that a when if if if stream is flowing like this okay so initially what we are having, you are having the collecting one so you are having the drainage whereas at the end, it will disperse like this okay so these are what we see the distributaries okay so this form, result into the formation of delta and this is the watershed (ar) area you are having.

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So this is an similar example what we were talking about the deltas.

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And this is the delta forming into the lake.

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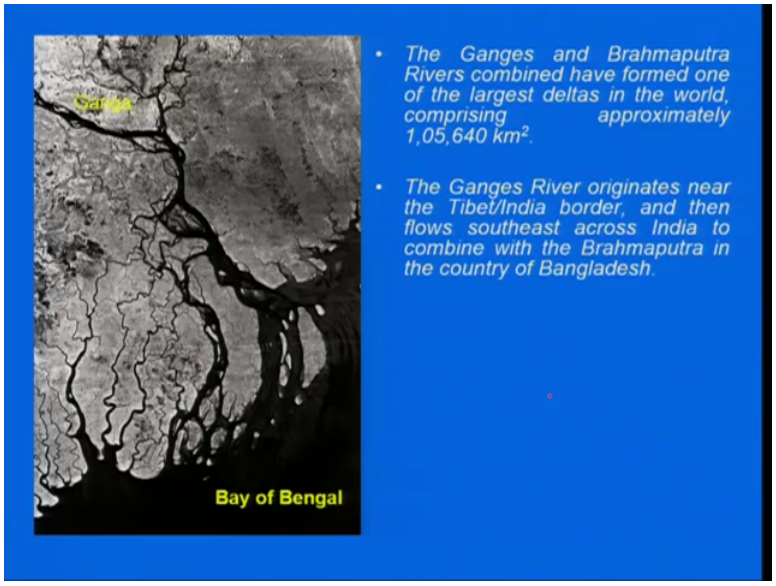

Example of one of the the largest one okay, the Ganga and Bhrahmaputra river.

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Now this is an example which I would like to quickly discuss is the the hazard related to the alluvial fan okay and this river which you see here is the Kosi river and which experiences, most of the times experiences the floods during monsoons and this part is marked as the Himalayan front okay so you are having the Himalayas here and that is the Shivaliks and you are having the

Indo Gangetic plain and the shape if you take this one here, this is very much what we were talking about the the fan shape okay. So the present day river, it flows along this path okay but it changed its course in 2008, it flowed through this okay.

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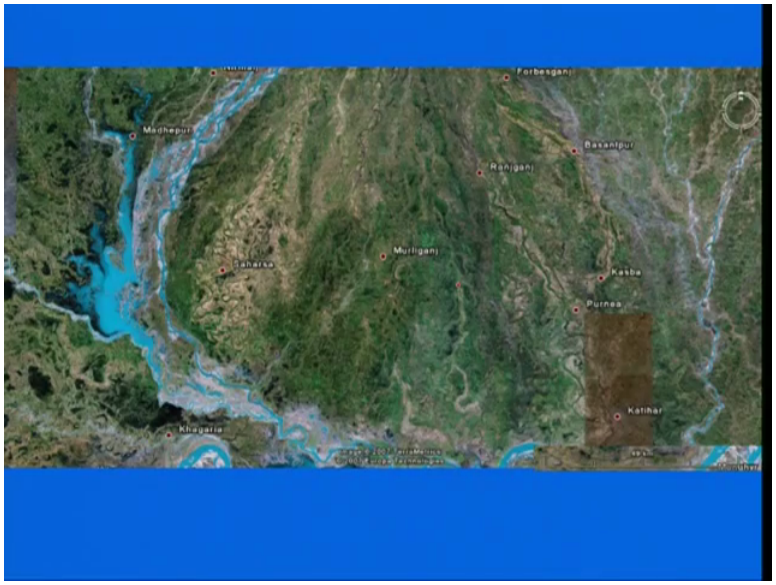

And if you see some lighter layings here okay and some features here which I was talking, there are you can see the meanders here okay so these are all the part of the active flood plains okay and in 2008, it flowed through somewhere through here this region okay. It took its or reoccupied its own channel so I will stop here and we will continue it in the next lecture. Thank you.