Geomorphology
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Lecture-44
Fluvial Process

So, friends, good morning, welcome to this lecture series of geomorphology and today we are going to start a new topic it is called fluvial geomorphology. So, if you remember our earlier classes if we summarize our earlier classes, we are talking about these geomorphic processes and they are the surficial processes, eolian processes is there, ocean wave processes are there, glacier processor there though glacier process we have not covered yet in the future classes we will talk about the glacier processes

but those geomorphic processes, they have their characteristics domains that are confined in a particular geological environment where they are more active or they modified the landscape within their own domains. But this river processes fluvial processes mean river processes so the river processes, they are the most dominant agent of landscape development. Because if you see this eolian processes for example, in Indian context if we talks about in Indian context the eolian process mostly it is confined in the Rajasthan, Thar desert.

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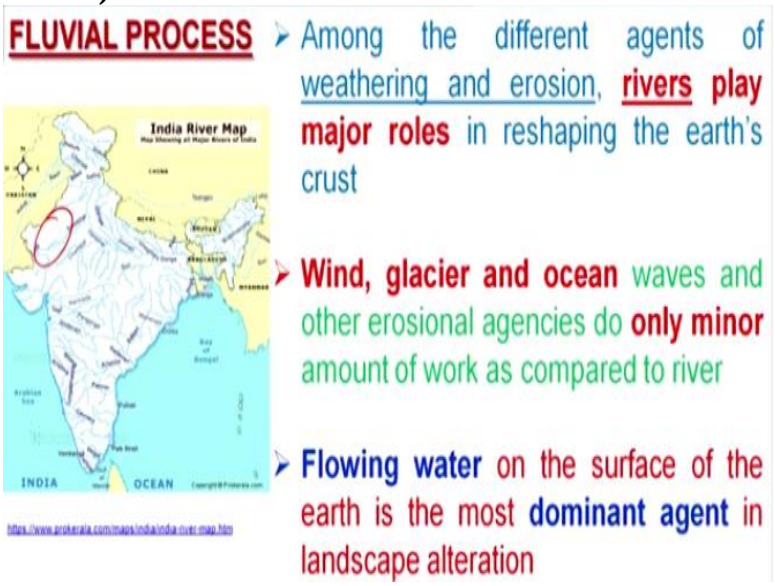

These eolian processes are along this coastal plain few meters or few kilometers away from this coast and this glacier process in advance if I take you to this glacier environment, it will mostly confind in the higher altitudes. But if you see this figure of Indian, if you see this rivers, they are well dominated, well developed and well distributed throughout this subcontinent so that is why we can say here, they in comparison with the other geomorphic agents.

The rivers play major roles in reshaping the earth crust similarly, winds glacier and ocean waves, though they work, but their works are confined to certain parts of this continent or certain parts of this globe. For example, glaciers, they are at the higher riches and higher latitudes. Similarly winds or an arid zone they are confined to particular geological environments, particular geographical regions, but river has no boundary.

Even if you remember, when we are talking something about arid zones geomorphology there are river existing. Similarly, in glacier, river existing or whether glaciers, they are the rivers origin from this glaciers, so that means river processes they are well distributed throughout the globe and that is why a river plays a major role in reshaping the earth crust as compared to other geomorphic agents.

Flowing water on the surface of this earth is the most dominant agent in landscape alteration. So, if you talk about this flowing water processes depend upon the terrain. For example, if you go to this alluvial terrain, alluvial fields terrains like this Ganga plain Indian context and we compare with these peninsular river, the Ganga plain rivers they are glacier fed, they are very highly dense network and they readily modify the landscape.

Even if we did 100s of years, you will find changes similarly at the coastal plains even Kaveri, Godavari, Mahanadi all this rivers, if you compare it the time series data from this deltaic regions, you will find the changes, but if you go to this internal part or this interior of this Indian subcontinent where the rivers are confined in the hard rock terrains their changes are there but these changes mostly they are very few as compared to these alluvial rivers.

So, that means though flowing water plays as major role, but they are mostly they are there that means frequent change of this river work is confined or that can be noticeable in this alluvial planes as compared to this hard rocks terrains.

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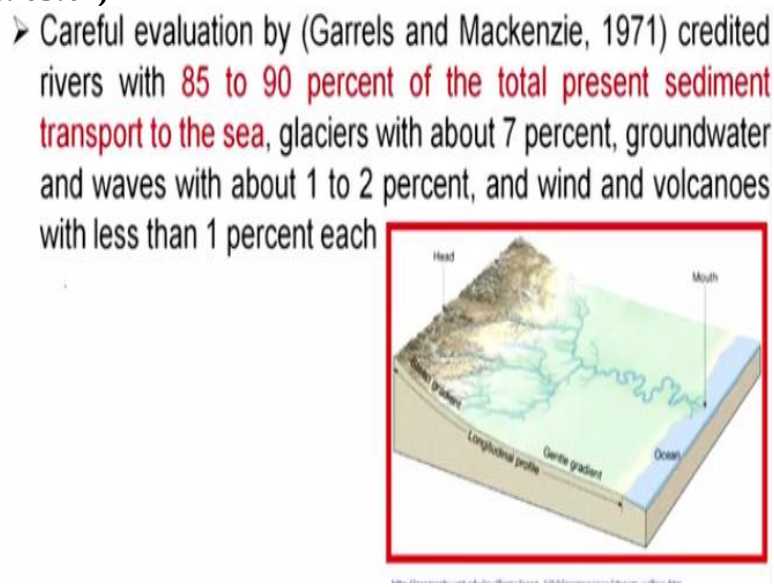

Careful evaluation by this gentleman credited rivers with 85 to 90% of this total present sediment transport to the sea, glaciers with 7% groundwater and waves 1 to 2% and wind and volcanoes with less than 1%. So, that means whatever this ocean sediments are there nowadays we find 85 to 90% they are contributed from the rivers that means, they are the terrigenous sediments, they are deposited and transported and deposited mostly. Around the river mouth and they are redistributed and rearranged by some of this littoral currents some of these waves like that, but their origin is from this continental site or terrestrial sites,

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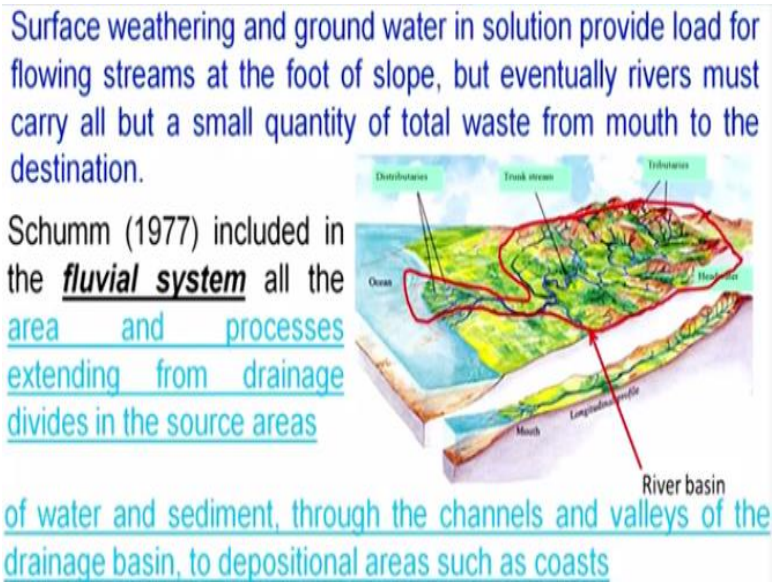

Surface weathering and groundwater solution provides load for this flowing streams at the foot of the slope but eventually, rivers must carry all but a small quantity of the total waste from mouth to the destinations. So, here if you it is very important to understand though this river system or the tributaries, this catchment area, they produce huge amount of sediment, but not all sediment they reach up to this sea also not to the sink or the depositional site.

Most of the sediment they are distributed redistributed rework and confined within the floodplains. So, very less amount they reach up to this same ocean and finally, till then it is contributing 85 to 90% of the total sediment of this ocean system. Schumm 1977 included the fluvial system, as the area and processes extending from the drainage divides into the source area. Now, you see here if you see this is the river basins and this the basics of basin is that this area

Which is totally influenced by a river, it is called river basin it is marked as this red boundary and these are these tributaries they contribute, they collect water they contribute sediment and water to this trunk river and this is the main stream or the trunk stream and here these are the distributaries so the tributaries, the distributaries and the trunk system, trunk river system the collectively called the river basin.

And the river basin mostly from these higher reaches or the tributaries, either irrespective of their order there tributaries, they collect water and sediment they contribute water to the sediment to

this trunk river and their trunk system they are transport it to this distributaries through the distributaries that distribute but that does not meet during transports there will be no deposition there are during flooding there are huge sediments are transported.

And river is overflowing and the sediments they are distributed within that floodplains. So, once this floodplain is deposited and gradual year by year, deposition of sediment they promote this soil development and after soil development the system is kept and it is immobilized. So, that is why the sediment which is originated from here, it is transported through this trunk river. Within that time they may there are chances within the flood plains they confine themselves. But very less sediments, they are transported to this river mouth and distributed and 85 to 90% of this sediment reach here, they are contributed to this ocean system.

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So, river system can be divided into 3 subdivisions as we discussed, one is the collecting system, collecting system means the tributaries, they collect water and the transporting system or the trunk river, the transport and the distributing system or distributed distributaries mostly it is founds at river mouth. So, here consists of a network of distributors of the mouth of the river delta, where sediment and water are dispersed into ocean, a lake or a dry basins.

So, depends upon the basin position, either it will be the sink, the basin position, either it will be in the ocean basin or it will be a lake or it will be a dry basin like this playas in arid zones. So

irrespective of this, there are 3 main system of the river. One is collecting system, that transporting system and a depositional system.

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So in your lighter moment in this class, we can hear in quote, a gentlemen word In 1980, Dr. Jeff Kennedy, former director of Iowa Institute of hydraulic USA, is compared to the river with a woman with some justification, I am quoting his own words "Rivers like women are sustainer of life", yes, that is why if you see.

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Our earlier this is the figure, we can see here, these are these rivers, these are this civilization sites and the all the civilization sites, if we join them they are running through this

paleochannels. So the rivers, they are sustainer of life, second thing that "the rivers can change their moods frequently as women". They may flow very gently at one moment and may great flurry in next moment.

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And this third comparison was "Of course, they are not fully understood yet". This may be supported by a quote from preface of a book by Miss Morisawa's entitled "Streams" "Man's attempt to control rivers had little or no success. In fact, many times his efforts have complicated the situation. The greatest natural disasters come as a result of ignorance or even worse half-knowledge".

So that is why these are the few reasons that can be compared when that is why our ancestors perhaps realized these aspects of rivers carefully and gave feminine names to rivers like Kaushiki, Narmada, Mahanadi, Godavari, Kaveri, Yamuna, Ganga. So that is why we can say the rivers they are the sustainer of life because our unseen civilizations like Mohenjo-Daro, Harappa or Kalibangan.

Whatever the situations are there in this map we can say that all these cities all these systems that means all these locations of this ancient civilizations they are falling on the river basins similar nowadays also this a river basins are this river, near to this river, the population is more as

similarly near to the coast, the population is more as compared to the other part. So, that is why rivers are very important in human life.

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So, beauty of a river depends upon its cleanness of water and utility to mankind development a river which is flowing through a barren land without the use of its water of less importance as compared to other part. Rivers are reaching well, irrigation water, coal, petroleum, mineral drinking water and finally the peace. So many of these river basins like this Subarnarekha this Markanda the river through rivers we are getting placer golds.

Similarly placer minerals are deposited coal most of the rivers Jharia Coalfield whatever the coalfield earlier was there most that fluvial and lacustrine environment. Similarly petroleum river basins are rivers sediments and rivers sediments are source for and reservoir for petroleum hydrocarbon in many cases so, the river string that is called soul string sands they are very good producer of petroleum hydrocarbon.

Similarly, irrigation waters river basins in Indian context if you see this North India system that is this Ganga plain, this plenty of water is available though it is depleting nowadays due to over use of this water, but river basins they are the source for groundwater and finally peace if you compare our if you analyze your ancient Vedas, you will find the most of these river basins are the along this river at the bank of the river.

These people who are getting meditated they are doing meditation and this great Buddha also got this Nirvana around Ganga river also. So that mean rivers in every stage of our human life river is important starting from its water, its wealth, it is peace and added economic minerals. So we are getting from this river that is why a river is important.

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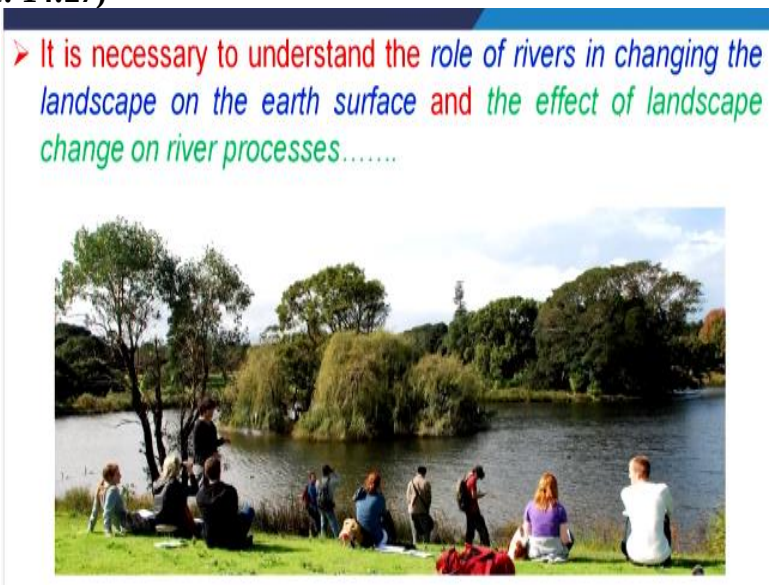

It is therefore necessary to understand the role of river in changing the landscapes on the earth surface and the effect of landscapes change on river processes, how the landscape change also, the effect the river process and how the rivers change the landscape both are important to understand one is influencing other and other really influencing one.

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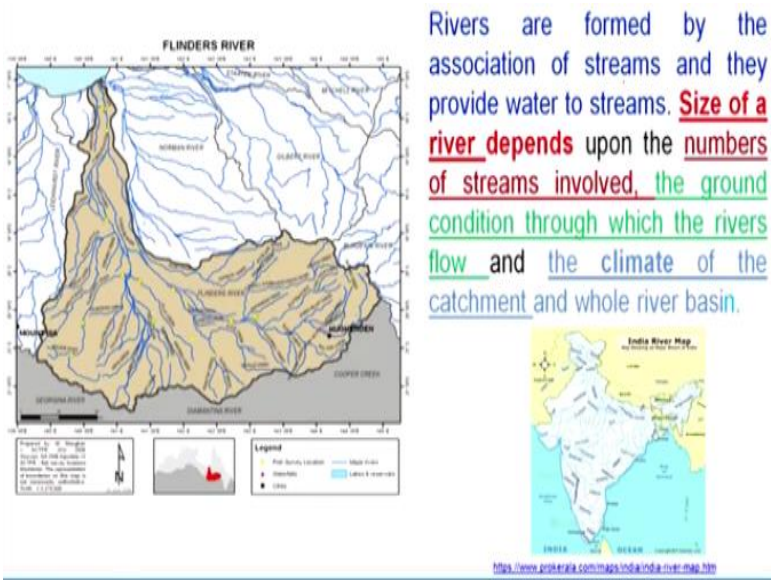

So now here, if you see here, rivers are formed by this association of streams and they provide water to streams size of river depends upon this numbers of streams involved the ground condition through which the river flow and the climate of this catchment and whole river basin. So, here are 3 points to be understood here, one is size of a river depends upon the number of streams involved.

For example, if you see this river basin yet numbers of streams more number of streams involved, larger the river basin. Similarly, the ground conditions through which the river flow ground conditions ground conditions either it is flowing through hard rock terrain and it is flowing through soft rock terrain or even it is hard rock terrain if it is passing through sandstone, it passing through granite passing through limestone like this.

For example, suppose a river is flowing through sandstone which is porous and permeable so, that means here most of this river water will percolate down form groundwater. So, that is why there will be less water in the surface that will transport further downstream. Similarly, rivers passing through limestone, there are many chances that some of this limestone or karst topography will form and the river will grow on the ground.

But rivers it is which is rivers which is flowing along this granitic terrain, there are granite which is hard and compact more porosity and permeability, so, entire surface runoff will be there. So, here rivers size will be larger. So, that depends upon this substrate ground condition through which the river is flowing through. Then climatic conditions, climatic condition that means, suppose, for example, we take this case of a markanda, markanda is originating from sivalik and through Rajasthan through Haryana it is passing through and in Rajasthan it is finishing somewhere.

So, it is terminating there, but had it been in the other part like this UP near to this Ganges part. So, it might have flowed somewhat more distance and reached to certain extent or to further downstream so, that means, depends upon the climate. So, if it is arid climate, there will be more chance that there will be more evapotranspiration's evaporation will be there. So, less water will flow along this surface of this river.

So, that is why depends upon this climatic condition if it is moving through a humid climate, so, the river water the amount of water increases further downstream, but if it is moving through arid climate so, the water is decreasing when downstream. So, that is why it is this number of streams involved that is substrate or these subsurface topographic, subsurface lithology and this climatic condition through which the river can pass through that says about that what should be these size of the river

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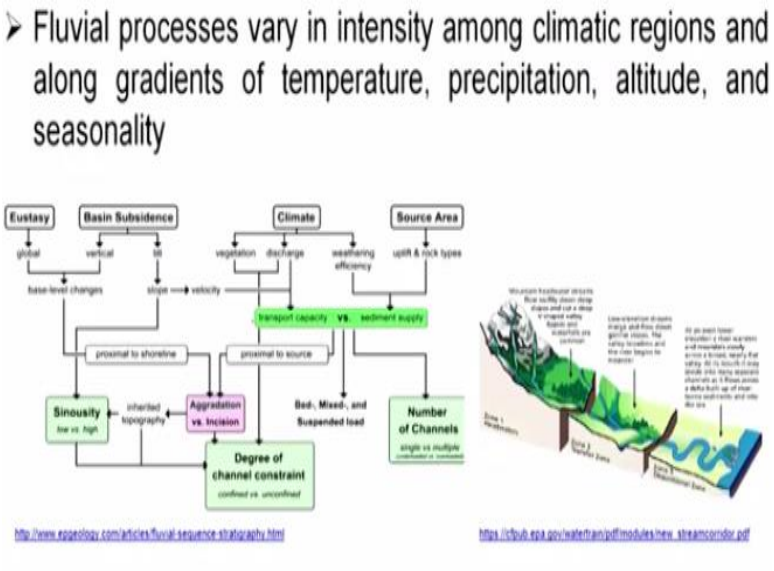

Fluvial processes vary in intensity among climate regions and along gradients of temperature, precipitation, altitude and seasonality, it is important here temperature, we have discussed precipitation, more precipitation, more water will be added to the system altitude, if it is from the higher altitude that means glaciers if they are glaciers fed or it is it is from plain fed or is mountain fed so, depending upon which part of the which reaches this. What is the source of the water for the river and seasonality is a seasonal either there will be seasonal river that means ephemeral streams they are seasonal during rainy seasons, they are getting water to the streams.

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- Perhaps one-third of the land surface has no runoff to the ocean
- However, even arid regions with drainage into closed intermontane basins have landscapes of branching stream valleys
- *Infrequent or brief seasonal stream flow* can shape otherwise dry landscapes

Perhaps one third of this land surface has no runoff to the ocean. However, even arid regions with drainage into closed intermontane basins have landscapes of branches of streams and valleys, infrequent or brief seasonal streams flow can shape otherwise dry landscapes. So, if you see, we have already discussed about this arid zone geomorphology we are already talking about this pediments, pediment evolution the playas.

And How this pediment is developed and how this surface is sediment surface is curved or convex upwards towards the mountain. So, all these regions if we analyze in the geological past or the present also, we will find the river the presence of rivers but some of these rivers they are permanent. Some of the rivers they are ephemeral or seasonal, but rivers presence will be there, channel presence would be there.

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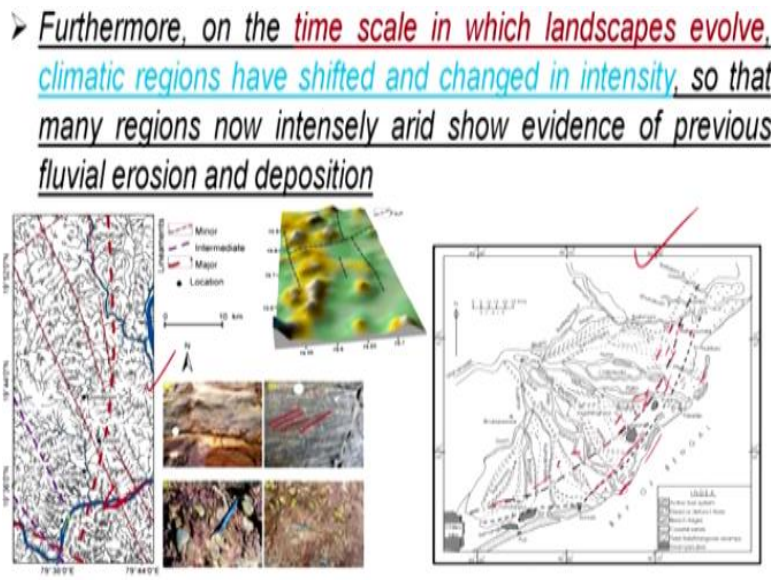

Furthermore, on the timescale with which the landscape evolves climatic regions have shifted and changed in intensity, so that many regions now intensely arid, so, evidence of previous fluvial erosion and deposition. So, that means, the paleodrainage system, the paleoclimate, the paleolatitude longitude geographical locations that also depends upon how a river system will be a for example, if you take here.

This system where it is a part of it is a drainage map part of Pranhita-Godavari valley in Maharashtra you see, this nowadays the river, the main river it is flowing here in westward and finally moving south and now, if you analyze it in the geological past some of this evidence are there within that river basin that these are the cross beddings with a river was migrated river was flowing to the west and now this river is flowing to south.

So that does not mean the same river is continuing but that means I want to say it is the topography, which topographic inversion now seen in this earlier times when they see Indian subcontinent was in northern latitude about 45 degrees and so. So, during protozoic time, this particular area has a topography which is sloping towards west. So, nowadays this particular area is sloping in slope towards the south.

Who is following these major rivers that means, I want to say with time with changing topography, which change in geological time scale, the rivers also change their properties, rivers also change their sediment products on their change in their characteristics. So, that means, in a

particular time scale also it will landscape evolve similarly, the fluvial system evolved so, this fluvial system evolved.

Sometimes it is climatic control, some types of tectonical control, sometimes a tectonic climate both control. So, that means depending upon this changing scenario of tectonics and climate, depending on the rivers basins, they also change accordingly. Similarly, in this coastal plain rivers, if you see here that depends upon this change of sea level here if you see these are these changes of sea level marked in earlier times.

When these solid lines are there, this here earlier all the rivers are debouching this line and later they debouch here. Now, they are debouching here so, once these rivers are debouching, here that means, sediments are distributed somewhere here. Now, sediment deposits here and now, it is depositing here. So, that means with changing scenario with changing sea level, river their shift, river shift their positions.

And there is shifting there is also affect these sediment transportation, sediment deposition sediment or redistribution like that. So, that means geology of a river basin geomorphology and geology of river basin that depends upon many factors that is sink position and climatic conditions substrate number of streams, sea level fluctuation or this base level fluctuation and local base level fluctuation depending upon these either that is a lake or the river id debouching it is not related to the sea.

So, that means, I want to say the local base level fluctuation, the number of streams involved, the substrates, the climate and all that tectonics all those factors they work independently or together to define the characteristics of the river basin to define the sediment production of the river basin the flood plains like that.

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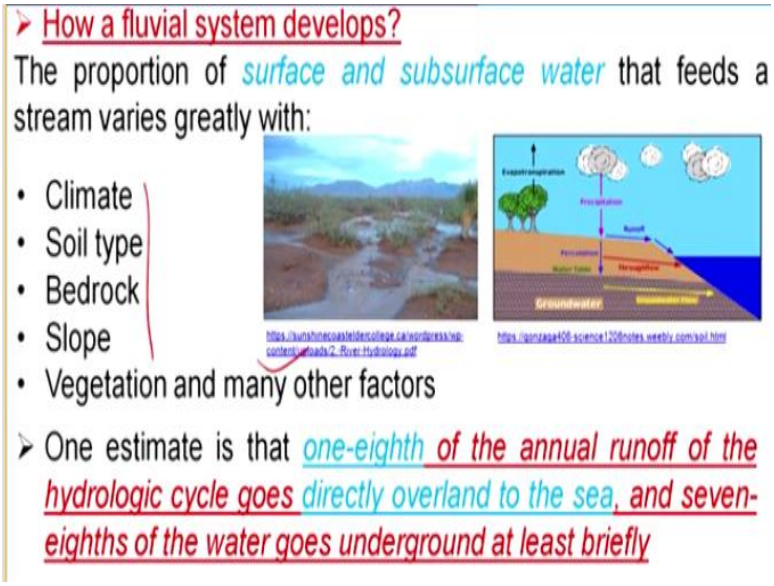

How a fluvial system develops, that all we have discussed about the fluvial system, this characteristics. Now, the question arises, how a fluvial system developed here the proportion of surface and subsurface water that feeds a stream varies greatly with climate, soil type, bedrock, slope, vegetation, and many other factors, these are the prominent factors and some other factors also there here once we say a river, a flowing stream,

Not only the surface water is contributing it is the subsurface water also which is contributing to the system. So this, subsurface and surface water both they contribute to the stream I that is why the river or the stream can be said it is influent or effluent rivers. So, I will talk about later what is called influent or effluent River. So, one estimate is that 1/8th of this annual runoff of this hydrological cycle.

Hydrological cycle goes directly overland to the sea and 7 / 8th of this water goes underground and least briefly. So, that means, 1/8th of the system are the ones river is flowing its water, 1/8th of the river is river water is going to the sea directly it is overland flow and 7/8th is growing on the ground goes underground at least briefly. So, is this underground this depends upon the substrate condition depends upon the climatic conditions

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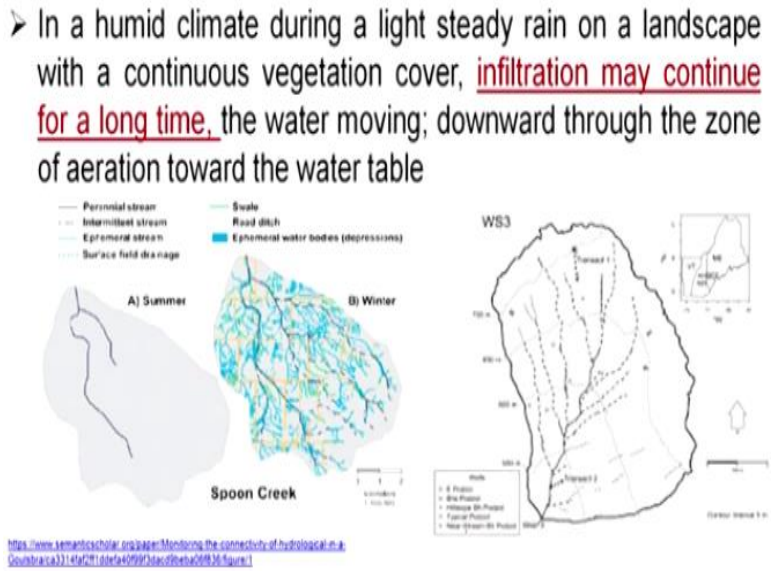

In a humid climate during a light steady rain or land on a landscape with a continuous vegetation cover; infiltration may continue for a long time, the water moving downward through this zone of aeration towards the water table. So, that means it is contributing the subsurface steady rain, it is continuous rain, but it is slow rain, but if it is heavy rain, it is sudden or heavy rain with a few minutes or a few hours.

So, this water will not saturate that much water not able to percolate down so, much water will be over overland flow that we will call called overland flow. So, that means infiltration may continue for a long time if there is a steady and continuous rain with a humid climate with vegetation so, that means it is contributing subsurface flow or groundwater situation.

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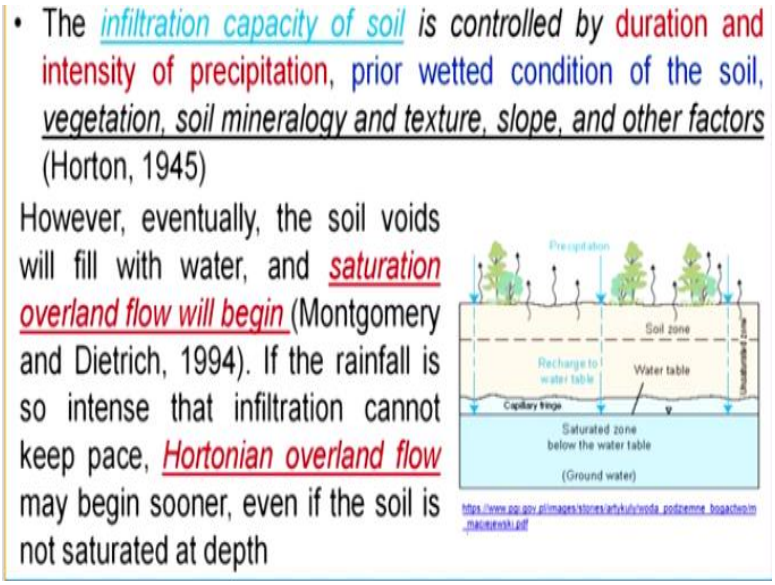

With infiltration capacity of soil is controlled by duration and intensity of precipitation, prior wetted condition of the soil, vegetation soil mineralogy and texture slope and other factors so infiltration capacity of the soil, how much water will infiltrate, how this soil or this substrate is capable to infiltrate downward? So, that depends upon the duration intensity of precipitation duration intensity that means more time it will precipitate more it will go down.

So, prior wetted condition of the soil prior wetted condition means whether this is a dry soil or it is a wet soil, then vegetation, it is barren or it a vegetated land, soil mineralogy, what is this substrate mineralogy is there, if it is clay minerals are there or it is quartz or quartzo-feldspathic minerals out there that means, the minerals which are capable to absorb water, those type of minerals are there or these minerals which are not able to absorb water only these pore spaces will come content water that minerals are there.

Then slope it was higher slope that means sudden water only flow down. If it is lower slope water will interact more time with surface and will percolate downward and some other factors are also there. So, these are these conditions these are the factors that depends upon how much water will infiltrate downward and how much it will contribute from the subsurface and how much you can contribute from the surface.

However, eventually, the soil voids will fill with water and saturation overland flow will begin. So, if the rainfall is so, intense that infiltration cannot keep pace Hortonian overland flow may begin sooner, this is soil is saturated with depth; soil is not saturated with depth.

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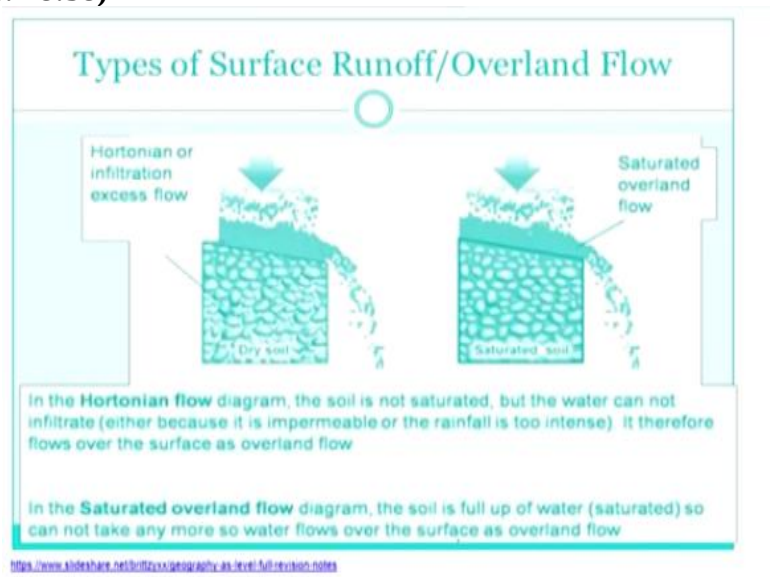

So, you see there are 2 types of overland flow one is called saturation overland flow and other is called hortonian overland flow.

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What is the difference between the 2 if you see here these are the 2 this is called saturation overland flow and this is hortonian overland flow. Here in hortonian overland flow there will be heavy rain and water will flow on the surface without saturating the internal pore spaces of the soil. Now, you see here, these are these boulders and here only these few meters or few depth,

few centimeter or few meters of this part of the soil is saturated and most of this water is going down is the overland flow, but here this overland flow is not due to this.

It is due to the over saturation that means, you see the whole pore space of this system is saturated and that is why the water in the soil cannot absorb more water that is why overland flow is opening this is called saturation overland flow data saturation excess overland flow. But here it is called infiltration excess overland flow there is not much infiltration is able to go down through this soil and this is called also hortonian overland flow.

So, this hortonian overland flow and this saturation overland flow irrespective of their region so, they are contributing the surface flow of this water. When surface layer becomes saturated overland flow begins and soil particles loosened by raindrop impact of turbulence are entrained by this flow. So, now we have water which is flowing and sediments is entrained our soil particles, sand particles entrained through raindrop.

So, that means, now we have water as well as sediment together so they are flowing, that means water sediment together that means erosional capacity is increasing because if you remember our earlier classes when we were talking something about this development of notch in the wave action so, initial time there will be less rate of weathering because water was only agent but later on when more and more sediment is added together.

So, this original capacity of this waves increases and finally the rate of weathering increases and finally, rather in the later time it is also decreases due to absorbance of energy. But here also same similar thing happens when water was flowing alone and water is flowing with sediments. So that means we are increasing the erosional capacity of the water. So, I think we should stop here and in the next class we will discuss about what are the different type of flows and how they contribute for the generation of stream and what is their role in a sediment transport and further more so I think we should stop here. Thank you very much. Thank you.