Sustainable River Basin Management

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Module – 03

Lecture - 11

Part - 01

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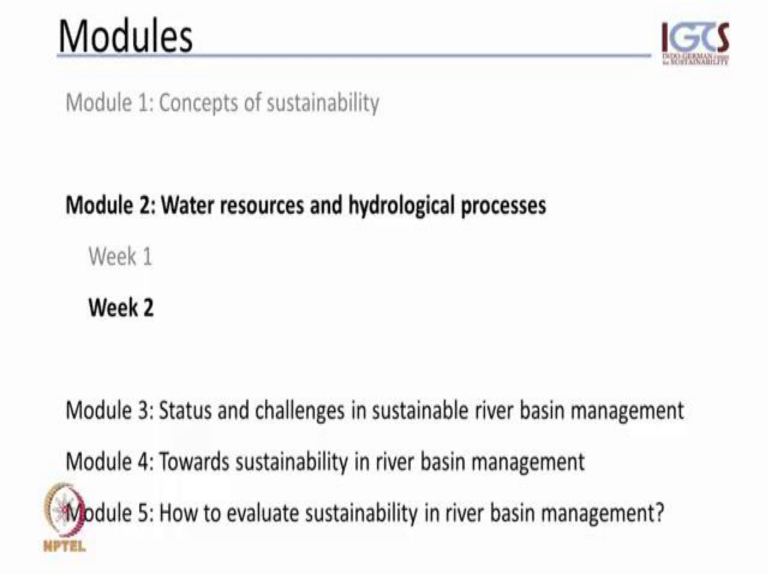

Welcome back to Sustainable River Basin Management, the second part of module two, part one. Let us just have a look at what we have been doing and what we still have to do. We have completed module 1, concepts of sustainability and we have completed week 1 of module 2 on water resources and hydrological processes and we are now starting this week 2 on module 2.

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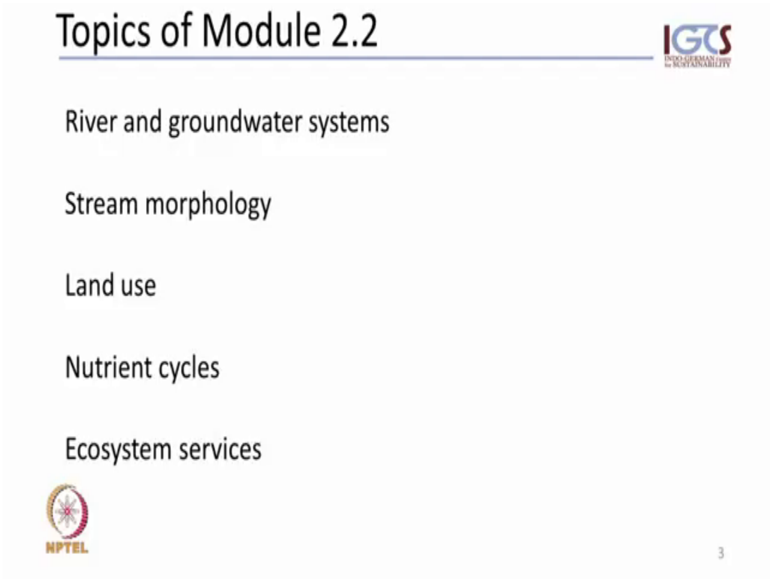

The topic that we want to cover to in the session is river and groundwater systems, stream morphology, land use, nutrient cycles and ecosystem services. We start today with river and groundwater systems.

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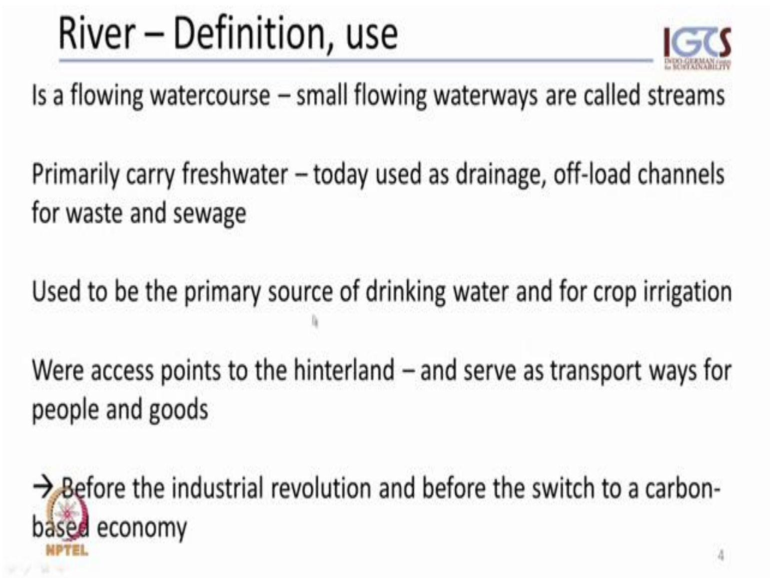

Let us first of all start with the definition and the used definition of rivers. What we mean by river is a flowing watercourse. And when we talk about streams, then we actually mean small flowing watercourses, sometimes mix those terms loosely. It is, river is a primary carrier of freshwater usually. But we know, that today we use our rivers as a drainage; we use it to offload waste and sewage. It is, it used to be the primary source of drinking water and also the primary source for crop irrigation.

We also used river as access points very much in the past to the hinterland to come in to, to end our continents and we use water courses as the transport way for people and goods still today. Most of these uses, which are so important and relevant, the most relevant before the industrial revolution and before we switched our economy to a carbon based economy. So, many of the uses are now defunct because of water pollution and of drying up of rivers.

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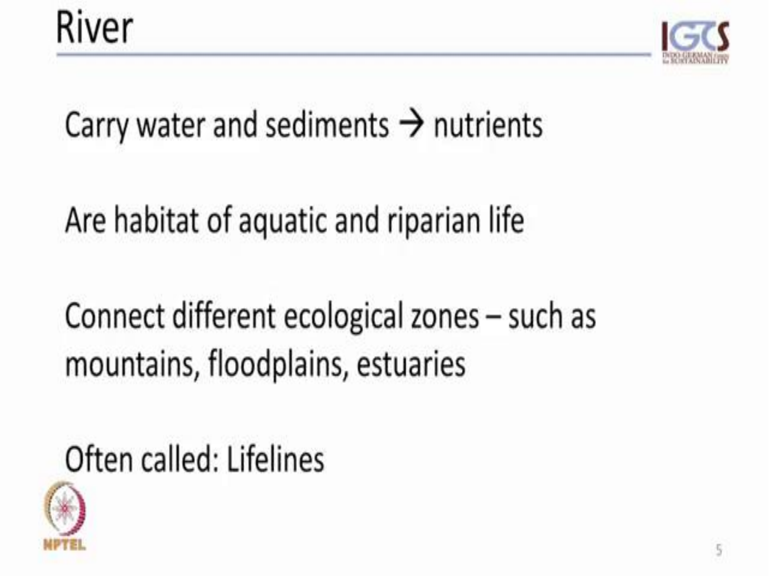

Rivers are not only what I have listed already, lead carrying water, but they also carry sediments and by carrying sediments they carry nutrients. They are also habitat of aquatic and riparian life and they connect different eco zones, such as for instance, a mountain, to floodplains, to estuaries and for that reason we also call rivers as our lifelines.

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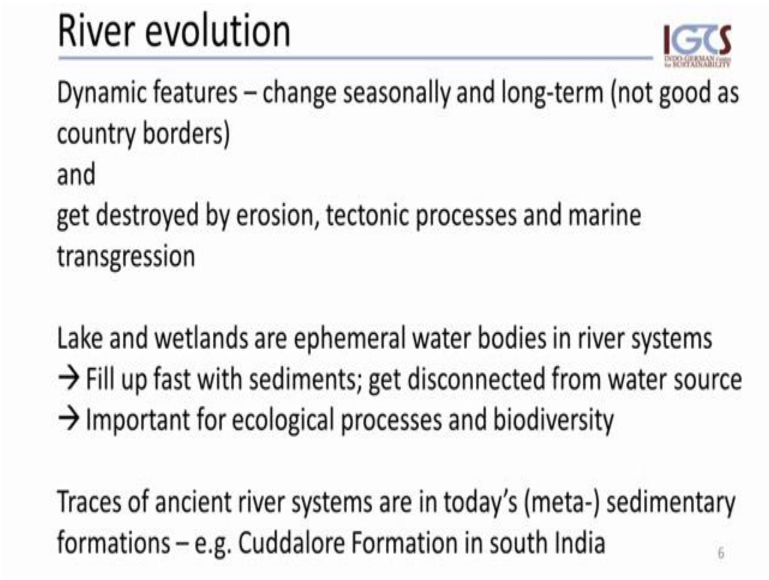

I do not want to go in to all of the details on rivers because most of this you have heared in grade 6 in school already. So, let us just look into some of the aspects, which are relevant to water management and especially to the sustainability aspect. Let us start with river evolution.

We have to acknowledge that rivers are very dynamic features. They change seasonally and they change their position, their flow long term, so and for that reason they are often not good as country borders. And they also disappear or get destroyed by erosion and by tectonic processes and by repeated marine transgression. So, rivers come, change their location, change their flows and eventually disappear from the landscape. It is one of the very highly dynamic features of rivers systems.

We need to mention lakes and wetlands and they are highly ephemeral water bodies, which means, they fill up fast with sediments and, or get disconnected from the source of water and for that reason disappear from our landscape and... Although they are very important for ecological processes and very important for their biodiversity, especially for us. So, traces of ancient river systems are found in today's sedimentary formation and those sedimentary formations may form our today's aquifer systems. For instance, Cuddalore formation in South India.

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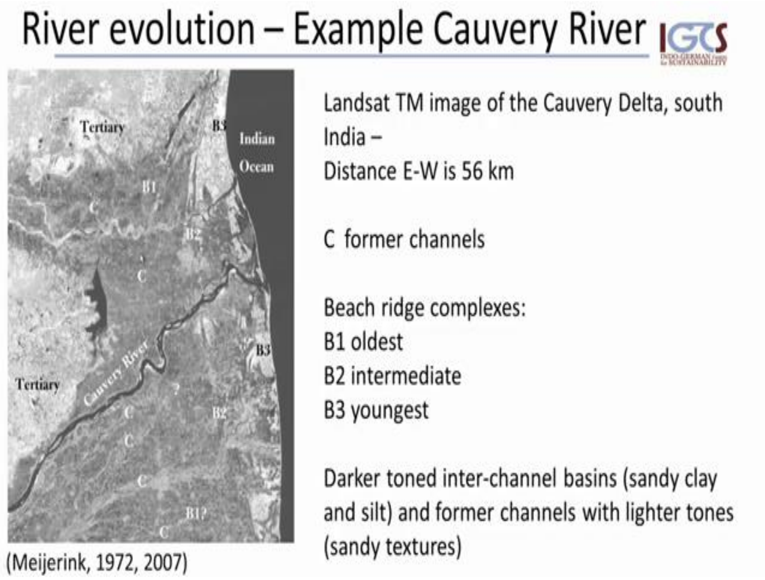

Let us look in to an example that may be familiar to you, the Cauvery River in south India. And here, we have satellite image of 1984 Landsat TM image. Just black, black, white, black and white here showing us the Cauvery river here, in blue this is the today's channel and the Indian ocean here in black and we have various formations here, tertiary formations, which are very visible here. And sedimentary formations, the greyish white in the areas here between the ocean today and this whole picture has a width of about 56 kilometer.

So, these darker tones here in this sedimentary portion of the image are inter-channel basins. They are composed of sandy clay and silt. And then, we see lines here, which have lighter grey whiter tone, which represent sandy textures. And from this, we can see very clearly Paleo channels of the Cauvery river. We can see those channels here and we can see channels here, we can see them here in between. We sharpen our eyes for that.

So, let us see here indicates those formal channels of the Cauvery river, which also the landscape has been worked and cultivated over so many centuries by farmer, farming community, still those Paleo structures are very visible on such images. And, what you can also see is the old beach line in the dooms, which appear here is white, whitish, white sand formations here, they are far inland today.

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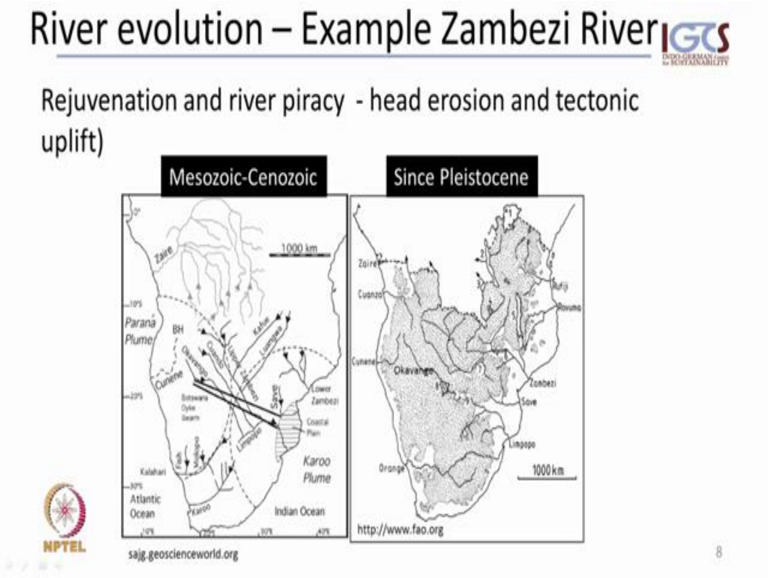

This is one example where we can reconstruct the river evolution. And another interesting example is, I want to demonstrate you here is the Zambezi river in southern Africa. One of the major river systems linking about 11 countries where we can see the rejuvenation and river piracy, so called the head erosion and tectonic uplift and how this changes water systems entirely.

Here, we have southern Africa and we have the major river systems and the familiar names here. Limpopo is one major river system. Today is our Zambezi River and Okavango River that you also may be familiar with. And we see, that all of those river systems, actually Okavango and Zambezi at that time, were captured by the Limpopo River and the Limpopo itself formed a major delta at that time. ((Refer Time: 08:28)) this was in during Mesozoic and Cenozoic times and then, major tectonic events took place, which then rivers flows and captured major part of the Okavango river and channel them into today’s Zambezi river.

This map here shows us what we see today, this should be familiar to you, the Orange River one of the few rivers draining into the Atlantic Ocean and then, the Okavango delta, which became a terminal delta in desert region today due to these tectonic movements. So, this is the situation since about Pleistocene time.

So, how do we know all this? This is known due to tectonic studies first of all, seismic studies to physical studies, as well as ecological studies where fish species occurring in these different rivers were compared and where we can, where the separation of these river systems could be traced fairly accurately.

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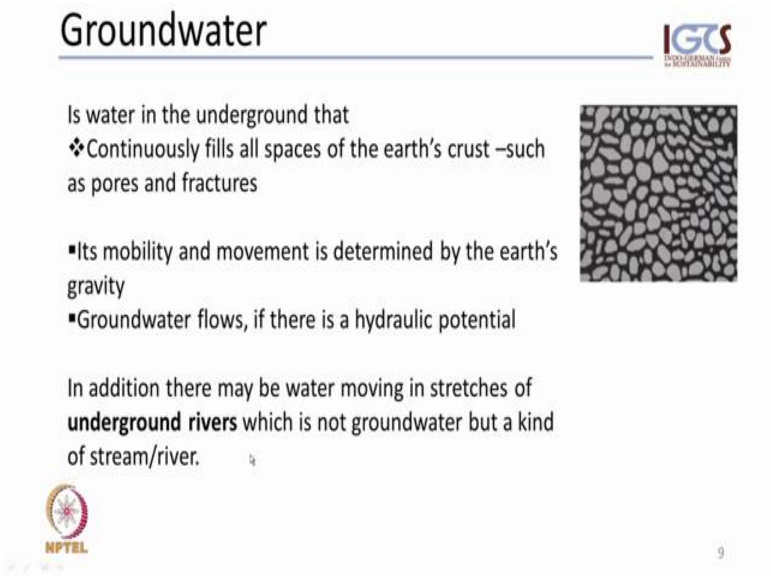

Now, I want to stop at talking about rivers and come to the groundwater component, which in many cases has been forgotten or left out entirely. What we mean by groundwater is the water store occurring in the underground, which continuously fills all of the spaces, on our earth's crust and those spaces could be porous or fractures or both.

We can, in which, in this way we have mineral, minerals here you may have particles composed of base minerals here. And then, the spaces, in between the dark spaces would be filed by water. The mobility and movement of the groundwater is determined by our earth's gravity and any flow occurs whenever there is a hydraulic potential. I do not want to go into more detail about this as it is not relevant right now here. You may have seen and or heard about underground river systems. Those occur and are very important in some areas, but this is not called groundwater. It is still a stream or river and managed accordingly, classified accordingly.

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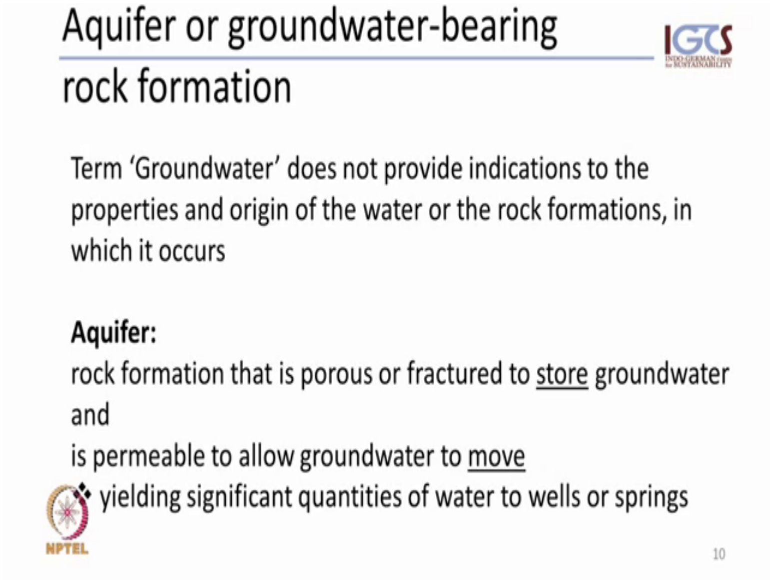

Now, let us talk about aquifer or groundwater bearing rock formations. When we speak about grounds water, we do not include or define the properties or the origin of the water itself. And we are also not defining though rock formations in which this water occurs and for that we use the term aquifer.

So, aquifer rock formation that may be porous or fractured and store ground water and either to move to allow ground water movements. So, they must be permeable too for this to occur. Also this definition is only relevant. Because of this condition aquifers must yield a significant quantity of water to wells or springs. So, that becomes useful for our water abstraction, for water management.

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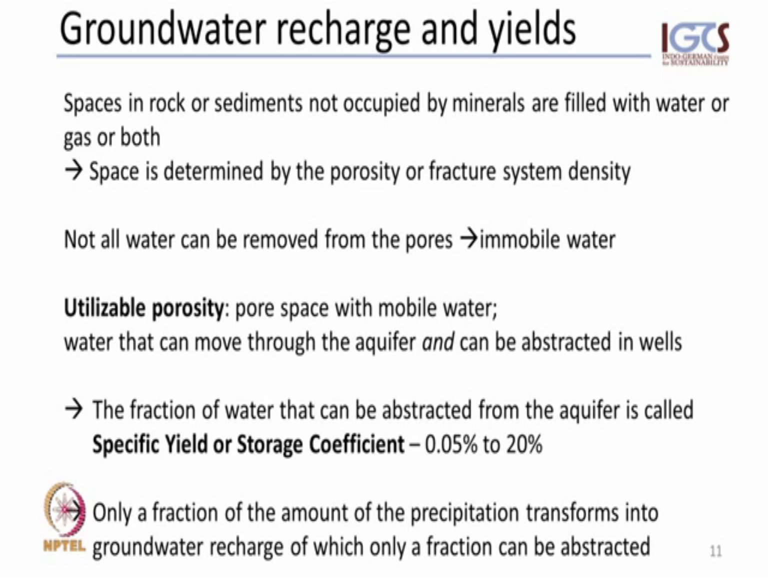

Let us look into the groundwater recharge and yield that comes becomes important when you talk about aquifers. As I have said, any of these spaces in rock or sediments, which are not occupied by minerals are filled and they are either filled by water or by gas, air for instance, in most of the cases or by both of them. And that space is determined by a property called porosity or fracture system density.

Now, not all of the water that is occurring in these spaces can be removed from these and we call this water, immobile water, and for that reason we are not looking at porosity, but the overall porosity of a rock or an aquifer. We are looking at the utilizable porosity, which is the pore space, which is occupied by mobile water, that is, water that can move through the aquifer and it is this water that can be extracted in a well. This is what is relevant as from the water management perspective.

So, that fraction of water, which can be abstracted from the aquifer is called specific yield or storage coefficient. And that can vary for fracture aquifers, around 0.05 percent and in a very good aquifer reach up to 20 percent. So, only we have to keep in mind that only a fraction of amount of the precipitation reaching the surface transforms into a groundwater recharge and only a fraction of this ground water recharge you will be able to abstract from our aquifer system again. So, this is very important to note when we talk about, what are ((Refer Time: 14:40)) and how much water is, can be abstracted form a specific area.

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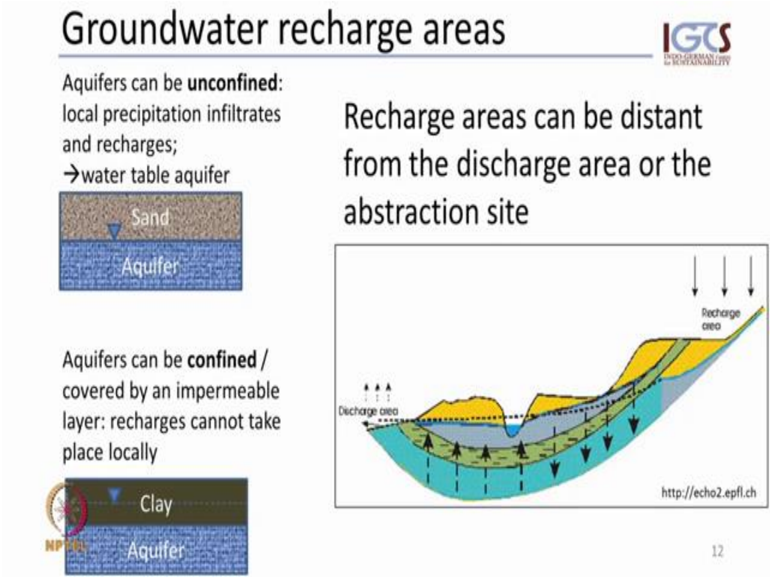

Important besides this are groundwater recharge areas and also, let us look at basics to it. One of the occurring systems could look like this. We could have an aquifer and that aquifers covered by a layer of sand, something permeable, and such an aquifer we called unconfined because local rainfall, local precipitation hitting the surface here can infiltrate and reach the water table and recharge this aquifer. We also call this the water table aquifer.

So, any rainfall here, we can account for as potential recharge to our aquifer. A different situation we have here where we have an aquifer and that aquifer is covered by a clay layer. For instance, it is covered by an impermeable layer. In such a case, recall confined aquifer and in such a case there cannot be a local recharge take place. So, recharge must occur somewhere outside distant from this box area of, where we observe our aquifer, may be want to obstruct water form.

Now, this model here shows us, how this is, this is a, how this occurs. And we have in this case a reverse system here, we have a permeable layer here, which in an aquifer system, which provides, recharges, discharges water into the river and the river itself also recharges the groundwater sometimes. And then, we have an impermeable layer here in between and underneath this impermeable layer another aquifer system.

Now, we can access pores of these aquifers from, from this point here. We can take water from the river, we can drill a well here and extract water from here or we can perforate the impermeable layer to reach the aquifer underneath and extract water from there. However, we are not at this point recharging or able to recharge our aquifer system here. In this case, our recharge area is equidistant from our point of extraction and this is very relevant for management purposes.

If, for instance, there is some open air, it needs to supply water to its citizen. It may use those two aquifer systems that the urban area itself may only be able to control and manage the upper aquifer, whereas to manage the resources of the lower aquifer, the management would have to focus on this area, which may be a mountain area or some other, just like some rural area far away. Now, this is very important and we come back to this at a later stage and we will talk about sustainable, water management practices.

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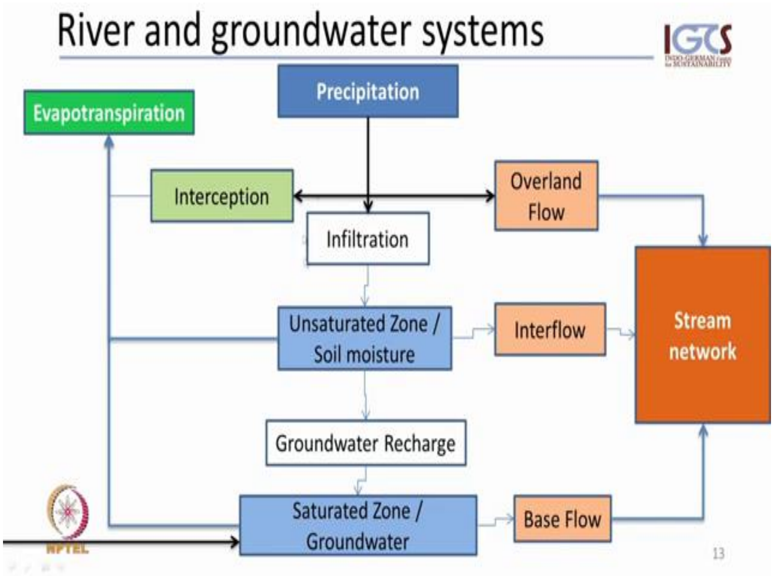

Let us comeback to ((Refer Time: 18:38)) river and groundwater to a, get again in a system and you have seen this before and I want to stretch it here. Again, we have rainfall here, we have our evaporation, evapotranspiration taking place, we have runoff taking place. And then, we have our internal catchment, internal processes taking place in various compartments, the unsaturated zone, the saturated zone, the stream network.

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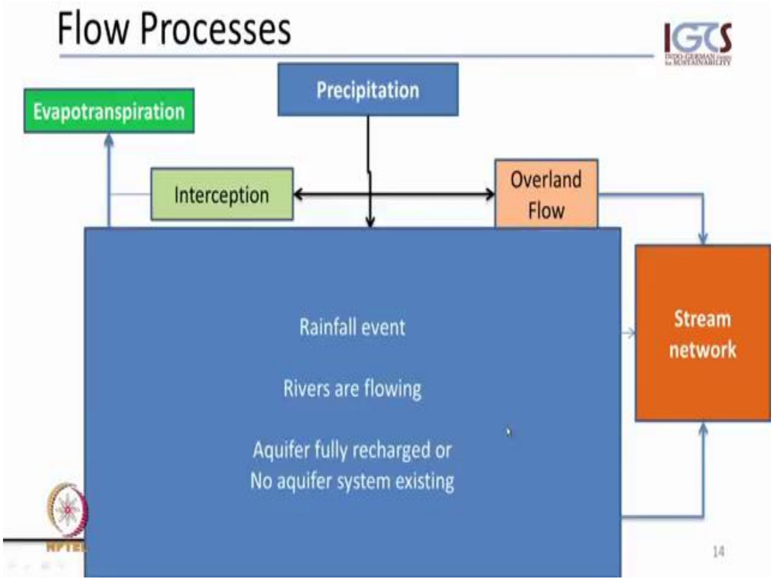

Now, let us cover this part and only look at a situation where we have rainfall event taking place, if rainfall coming here. And we observe over land flow and monitor rivers, we have flow, flowing reverse wide now. If this is the case, then we can assume, that either we do not have any aquifer system in our region, that we may have only impermeable layers in our particular area or that our aquifer is fully recharged.

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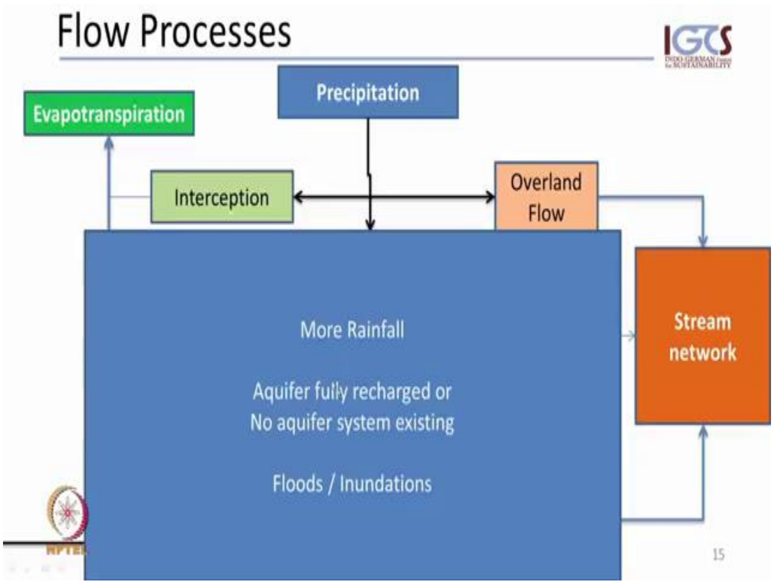

Let us now imagine, that our rainfall continues or increases in intensity. Our aquifers are fully recharged or we do not have an aquifer, we do not have permeable layers. Then, what we would see here is large inundations, we would see flood events taking place on all surface here.

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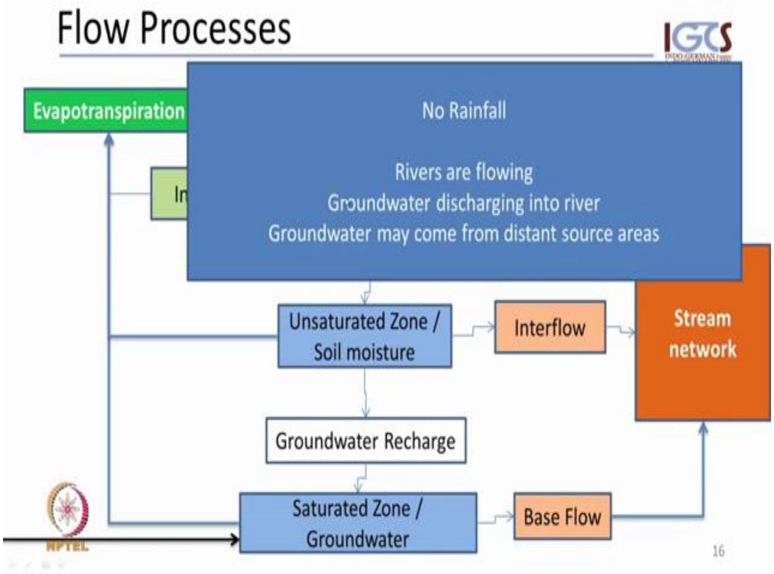

Now, if we take the opposite case, there is no rainfall at all taking place in this area. Yet, we still, if rivers, was water flowing rivers, then this can only take place when inter-flow occurs or when base flow takes place. So, our groundwater systems are discharging into the river network. This groundwater may be coming from this local area, where we have a monitoring station placed in our river. All this groundwater may come from a distant source and so, discharging contribute to our stream network.

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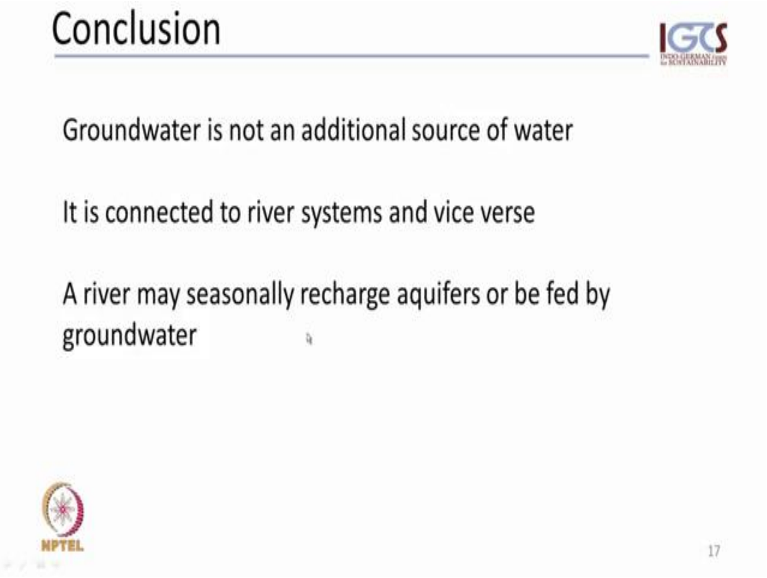

So, what we need to conclude here is that and take home is that groundwater is not an additional source of water. It is not something that can be treated like an additional source, like the ocean water. It is connected to a river system and the river system is connected to a groundwater, both are interconnected. And whether the river discharges or recharges an aquifer may change seasonally in a particular region.