REMOTE SENSING FOR NATURAL HAZARD STUDIES

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Lec 18a: Remote Sensing for River Health Part A

Hello everyone, welcome to Lecture 18. Today we will talk about remote sensing for river health. So before we start the remote sensing aspect, let us talk about river health and what exactly we mean by river health, why it is important, and why remote sensing is required as a tool to study or investigate river health. So, you might have seen a river and its different forms, So, let us understand what we mean by river health and why it is important. So, river health is important for maintaining the ecological balance. So, you might have some idea about the ecological balance.

Then, it sustains biodiversity in that particular river, supports groundwater recharge, and is crucial for water quality regulation and agricultural activities. The cultural livelihoods of riparian communities depend upon the health of the river. If the health is not good, if the water quality or the water discharge is not within the regime of this particular river, then everything will become imbalanced. So, why is this river recovery important at all? So, the importance of river health, which we discussed in the previous slide, helps to maintain the ecological balance, sustain biodiversity, and also supports groundwater recharge.

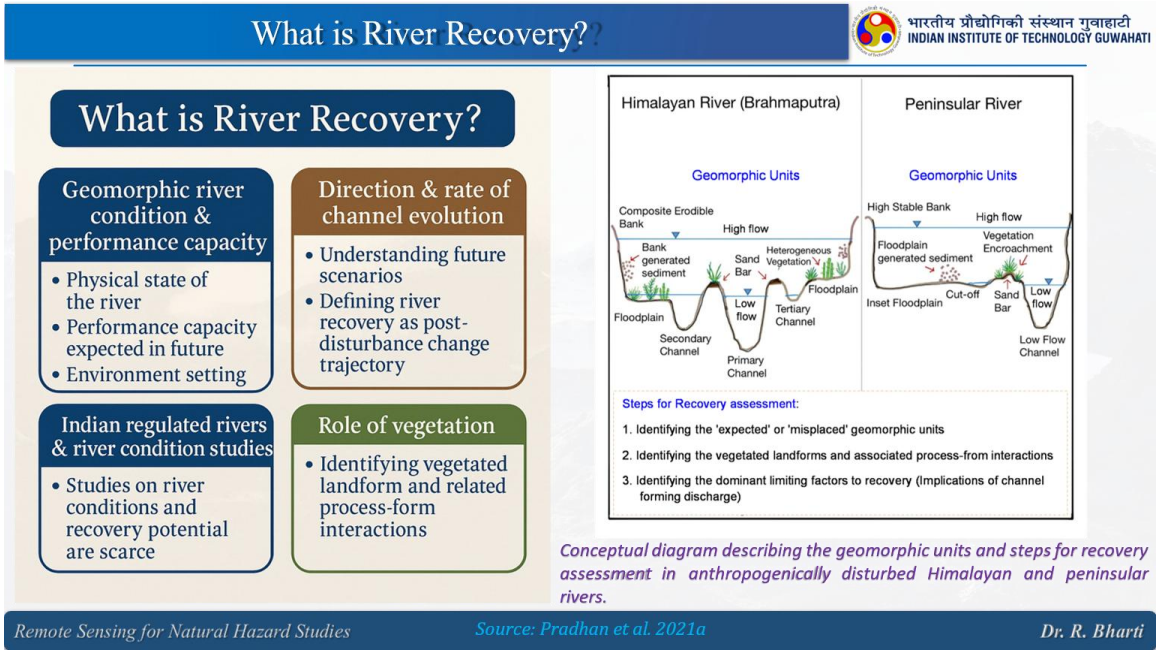
And this is very crucial for water quality regulation, agriculture, and the cultural livelihoods of riparian communities. The impacts of anthropogenic activities and climate-induced hydrological changes. These two are the major factors that affect the river's health. So, when we talk about the impacts of anthropogenic activity, Let's say, dam construction in a particular river channel definitely disrupts the natural flow regime of that river, alters sediment transport, and fragments habitats. Land use changes, like urbanization and mining, increase runoff, erosion, and pollutant loads that also have a direct impact on river health.

Then come the climate-induced hydrological changes. So, it alters the monsoon pattern and increases the frequency of extreme flood and drought conditions. Reduced snow or glacier melt changes the flow timing in Himalayan rivers like the Brahmaputra. So, these two are the major factors that actually affect river health, and that is why we are talking about the concept of river recovery. Whether a river can recover its original state or whether it can stabilize so that the ecological environment is rebuilt.

So, the key components of river health are hydrological integrity, morphological structure, ecological health, and biological indicators. So let us see them one by one. So, if we talk about hydrological integrity, here we include the flow regime. Water quality, sediment transport, base flow stability, and hydrological connectivity. So, here you can see that this is a conceptual diagram.

The second one is the morphological structure. It assesses the channel's form. So, basically, the geomorphology is right. Bed composition, bank stability, sediment dynamics, and floodplain interaction. So, here you can see that the bed composition, sediment dynamics, and floodplain interaction are part of this morphological structure.

Then comes ecological health; it focuses on biodiversity and ecosystem function. Habitat diversity and the presence of invasive or indicator species. So, that actually helps to establish the ecological balance in a particular river system. Then comes the biological indicator; here we try to monitor the fishes, microinvertebrates, riparian vegetation, microbial activity, and trophic structures, So, here are the four different key components of river health. These are the indicators of whether a river is in a degraded form, recovering its original state, or in a normal state.



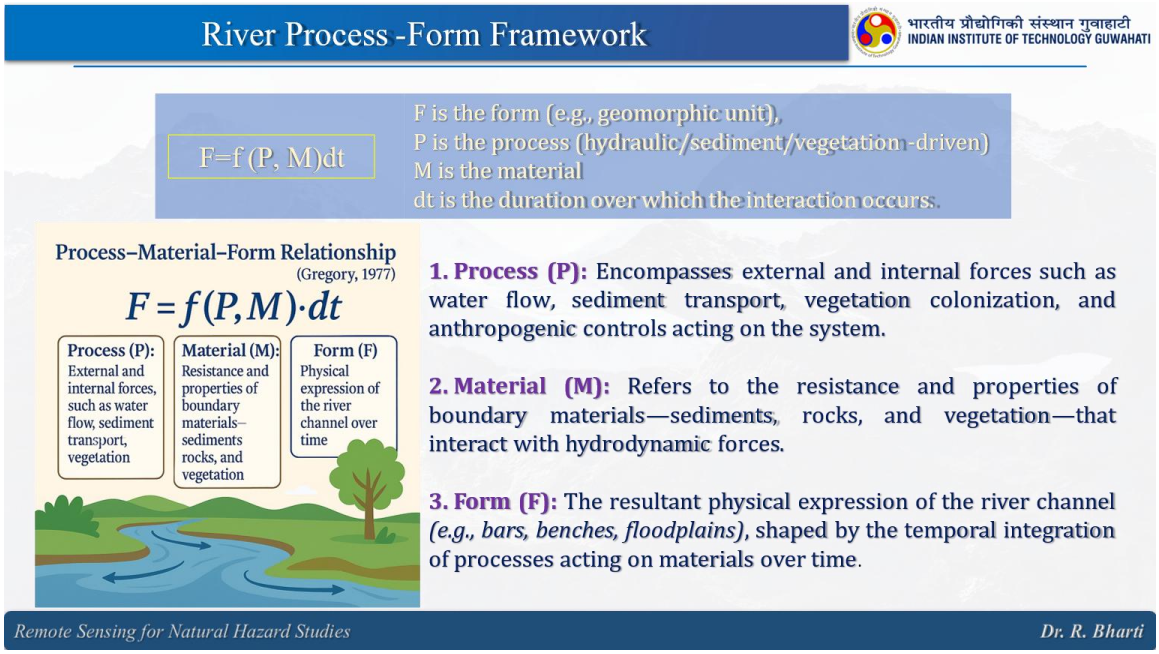
The geomorphic river condition is related to the physical state of the river, which measures the capacity to perform functions that are expected of the river type and the environmental setting. A solid understanding of the direction and rate of channel evolution is also necessary to predict the likely future scenarios of that particular river. River recovery is defined as the trajectory of post-disturbance changes towards a degraded or improved condition and assigning the accurate physical state. So let us say you have a river system

here; because of the external changes or external forces, what happens is it changes from a straight river to meandering and from meandering to braided. So, that is also a possibility.

So, there will be a change in the geomorphic river condition. Then further, what happens because of this understanding of direction and rate of channel evolution? So, then you can predict what the scenario will be after 25 years, 50 years, or maybe 10 years. So, that will help you establish the current state of that particular river based on the geomorphological condition. River recovery potential is also related to the connectivity of the reach throughout the catchment and to interpreting the limiting factor for recovery. So, this river recovery, whether a river has the potential to recover to its original state or not, is what we are going to study.

In an Indian regulated river, when we talk about a regulated river, it means that particular river has a dam. So, we are regulating the water, and because of the dam construction, what will happen? The sediment flow will not be in its original form. So, that will accumulate in the dams, and in the lower reaches, you will have less sediment transport, So, here in Indian regulated rivers, this study dealing with river condition and recovery potential is scarce. Vegetation can play a key role in the long-term landscape adjustment of regulated Himalayan and peninsular rivers. Thus, framing the role of vegetation in the recovery potential of Indian regulated rivers requires identifying the vegetated landform and its associated process-form interaction.

So, first you need to understand here in India. There are very limited studies available that talk about river recovery or river health. So, framing the role of vegetation and recovery potential in Indian rivers is very much required. For the Indian scenario to establish the river recovery concept, we need to have this process form interaction knowledge. So, what is this process for interaction? So, the geomorphological processes and the discharge of the sediment should all be known for a particular river, and only then will we be able to talk about the river's health or recovery.



So let us understand this river recovery in these 4 components. So geomorphic river condition and performance capacity refer to the physical state of the river, the performance capacity expected in the future, and the environmental setting. Then we have the direction and rate of channel evolution. So, here we talk about understanding future scenarios and defining river recovery as a post-disturbance change trajectory. For the Indian regulated river and river condition studies, the research on river condition and recovery potential is very limited.

Then comes the role of vegetation, identifying vegetated landforms and related processes of interaction; it is very much required to establish the river recovery concept for Indian regulated rivers. So, here you can see we have two examples: one is the Himalayan river, which is the Brahmaputra, and the other is a peninsular river. So, here, if you compare the geomorphic units of these two different sets. So, here you can see that this Himalayan River is very complex, So, here if you see, you have flood plains, secondary channels, primary channels, tertiary channels, and then again you have flood plains. When we talk about this peninsular river, here you have a floodplain, low-flow channels, and a few sandbars.

So, steps to recovery assessment include identifying the expected or misplaced geomorphic units, identifying the vegetated landforms and associated process-form interactions, and then we need to identify the dominant limiting factors to recovery and the implications of channel forming. discharge. So, this is a conceptual diagram describing the geomorphic units and steps for recovery assessment in anthropogenically disturbed Himalayan and peninsular rivers. So, these two different types of rivers dominate in India. So, that is why we are having both components in our river recovery assessment.

So, when we talk about this river process form framework, here you have this form which is equal to the function of p. And M, so P is the process, and it can be hydraulic; it should have sediment, or it can be vegetation-driven, and M is the material. So, whether it is gravel, sand, silt, clay, or a mixed one, the Dt is the duration over which the interaction is taking place. So here you can further understand this concept. So, the P is the external and internal forces such as water flow, sediment transport, or vegetation, and M is the resistance and properties of boundary materials, sediment, rock, and vegetation. F is the physical expression of the river channel over time. So how is it going to express the relationship between the material and the form? So, here the same thing has been explained. So, the process encompasses external and internal forces such as water flow, sediment transport, vegetation colonization, and anthropogenic control acting on the system. Where M is basically the material, it refers to the resistance and properties of boundary materials, sediments, rocks, and vegetation that interact with hydrodynamic forces. Then, we have F, which is the form.

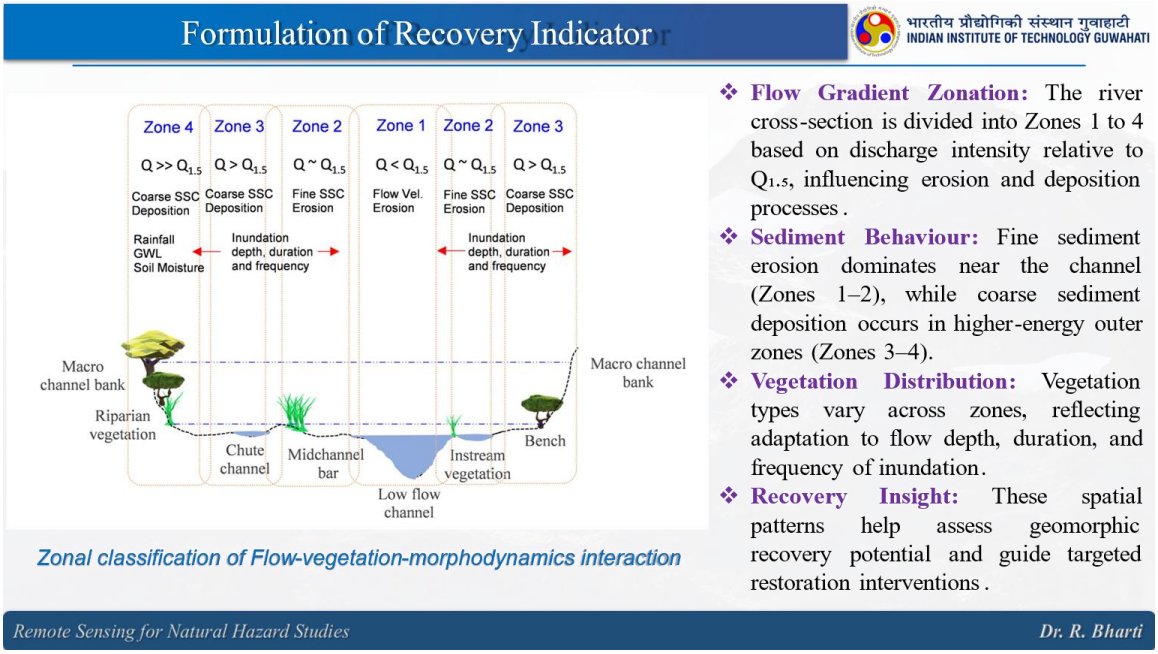
So, the resultant physical expression of the river channel, for example, bars, benches, and floodplains, is shaped by the temporal integration of processes acting on materials over time. The morphological continuum represents the natural progression and transformation of river channel forms. From straight to meandering to braided, driven by variations in slope, sediment supply, and discharge. So, you all will agree that the transition from straight to meandering in this transformation is driven by the slope, sediment supply, and discharge. So, it reflects channel dynamics and sediment mobility.

Indicators include sinuousness, bar formation, channel splitting, and braid plane development. So, here you see this particular example is for the straight one; then here you have the transitional phase, which is basically the meandering, and then here you have the braided one. It helps assess the geomorphic condition and recovery stage of rivers. So, this particular slide is meant to explain what the river recovery stages are. So, whether a particular river is moving towards the degraded form or, when we have external forces or anthropogenic activities, whether it is going in these two directions.

One can create a condition. and another is the restored condition. So, this is the recovery phase, and here suppose this is a straight channel. So, here, because of these anthropogenic activities, whether it is going to be a meandering channel or a braided one. So, this will be coming here in the created condition. So, this is the turning point at which we have anthropogenic activities.

So, it can go in this direction or it can go in these 2 directions. So, this is a conceptual framework used to assess geomorphic river condition. The vertical axis on the left represents the spectrum from an intact to a degraded river state. Two distinct recovery pathways emerge on the right: one path leads to the restored condition, and this one gradually returns to a state similar to its original form. So, it will both will be almost similar.

The other path moves towards a created condition representing irreversible geomorphic change that results in a new altered reverse state because once it has changed from straight to meandering or braided, it cannot go back to being straight. So, that is what we are saying: that it is irreversible. Here are some indicators; when we go to the field, we have these parameters. So, we can see the channel's platform. So, given the prevailing slope, grain size, valley width, discharge, and upstream catchment area, it is appropriate that we assess the channel platform.



Then we have channel geometry; then we have geomorphic units. Then we have bed bank character and material caliber distribution. Then we have vegetation characteristics and coarse woody debris loading. So all of these can be observed in the field when we go for the field investigation. Then we have anomalous processes or accelerated rates of activity.

Channel floodplain links and hydraulic relationships. So our roughness characteristics and hydraulic diversity along the reach are appropriate for the river style and reach setting; then, sediment regime; then we have these geomorphic changes. So, is the reach resilient or sensitive to changes? What are the types and patterns of change that could occur along the reach? Are there any signs of instability in the reach? All of these can be identified.