Geomorphology
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Lecture-05
Process Geomorphology-1

Ok, so, in the last class we are talking something about this geomorphological processes and material management. So, energy and material how to manage in geomorphic system and we concluded in the last class that if the energy and material are not managed properly, then the geomorphic system will not sustain for longtime. So, today we will talk about this process geomorphology, what is geomorphic process and what is process geomorphology.

As you know if we have material and we have energy, then using this energy and material, the landforms are formed, so process works in between. So, that means energy plus material through which the landforms are formed, this bonding, this gap or this process, this medium, these are called the processes, they are called the geomorphic processes. That maybe constructional processes, that may be destructional processes.

But irrespective of their nature, this function that energy and material by which that will transform to landforms, these are called the geomorphic process. So, let us discuss elaborately, now process geomorphology is the study of processes, responsible for landform development.
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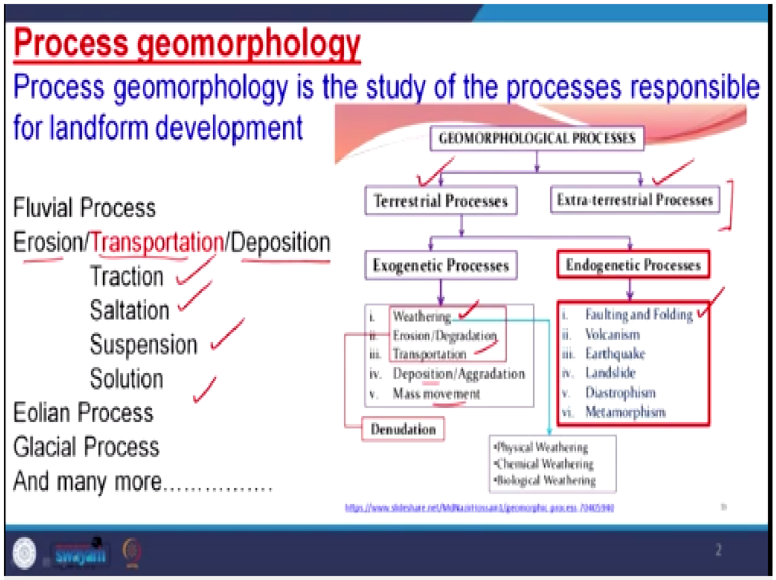

Now, what are the processes, fluvial processes, eolian processes, then glacial processes. See these are the broad sense of classification of geomorphological processes, but again and again if we zoom it. So, fluvial processes for example that can be again divided into erosional process, transportation process, deposition process. Similarly, in erosional process again if we zoom it, that erosion maybe by physical weathering process, by chemical weathering process, by biological weathering process.

So, that means, more and more we zoom it, the scale of looking at the object is increasing. So, that means more and more detail we are going into. So, each process will take one or more hour discussion. So, that means, today we will discuss about broadly about these different processes, how they work 24X7 to form the landform, what is their geographical constituents, what are their geological constituents, is not it.

If you see here erosional process, transportation process and depositional process, there are 3 principal process associated with each of these geomorphic process. In fluvial process, we will have erosion, transportation, deposition. In eolian process, we will have erosion, transportation, deposition, in glacial process, erosion, transportation, deposition. So, if we zoom these processes, in every cases, we will have erosional, transportational and deposition.

So, now again if we zoom again in transportation through traction, through saltation, suspension and solution. So, that means, I want to say, each geomorphic process that is involved 3 principle sub processes, that is erosion, transportation and deposition within that there are different parts, different sub parts, they are responsible. And second thing is that each process work similarly, not in some way.

For example glacial erosion, it will be definitely different from fluvial erosion and it definitely different from the eolian erosion. Though erosional process is there, but the nature of erosion is different by looking a valley, you can say whether this erosion is due to fluvial or due to glacial. For example, we know that the V shaped valley, it is a characteristics erosional feature of fluvial system, U shaped valley, it is a characteristics erosional process by glaciers.

So, that means, I want to say though erosion, transportation and deposition, they all these 3 are related to each geomorphic agents but their nature is different, characteristics feature is different. Similarly, during transportation, transportation, suspension, saltation and this traction, there their associated with fluvial and eolian system. There will be no saltation, there will be no suspension, which is associated with the glacial system.

Similarly, erosion as far as erosion is concerned, the deepest erosion it is occurred by this glacial system and the finest erosion it is by the eolian process. So, that means, I want to say though we have common geomorphic processes associated with fluvial, glacial and erosional systems. But it is nature and a degree, it varies from place to place, varies from geographic position, varies from agent to agent.

So, here we have geomorphic processes thus divided into terrestrial process and extra terrestrial process. Extra terrestrial process, here we do not want to discuss because mostly extra terrestrial processes they are related to mars geomorphology, lunar geomorphology. Whatever the geomorphic discussion we will continue in future classes, we will restrict our self in terrestrial processes, that is within our earth system only.

So, territorial processes again it is divided into 2 parts, one is your exogenic process, another is endogenic process. So, geomorphological process broadly if we say it is a surfacial process, you can look on the surface of the earth. The river it is eroding it sediments, it is transporting it sediments, it is depositing it sediments, we can see at your naked eye. But some of these processes they are though not visible to the surface of the earth.

But they are acting 24X7 below the surface, they are called the endogenic processes, we have certain examples here weathering. Weathering it is a surfacial process, is not it but this cause of this weathering is due to is the combination of surfacial process and the subsurface process. For example, suppose we are increasing heat, we are putting a magma chamber near to the surface, the heat is increasing.

So, once the heat is increasing, the rock has to change its form. So, that means, the rocks weathering starts due to heat the rock weathering start, structures are developed and finally the rock weathering starts. That means, weathering it is a surfacial process, but it is dragged by the increase of heat, it is an endogenic process endogenic process.

So, that means I want to say similar there are many examples, I want to say, though the geomorphic processes are exclusively the surfacial processes. But there are many endogenic processes, they are promoting their forms, they are promoting their existence. For example, if you see here, weathering, erosion, denudation, transportation, deposition, mass movement, these are surfacial processes or the exogenic process.

Endogenic process, we have faulting and folding, foldings it is special the folding, folds never formed in the surface. So, that means whatever the folds you are looking nowadays, in millions of years back, they were formed at their subsurface. Because folding means the rock has to be ductile, faulting, the rocks has to be brittle. So, once this rocks were in the subsurface in kilometers depth, there was a high heat environment, high pressure environment, whenever we pressed it in to different directions it is caused fold, so it is an endogenic process.

Similarly volcanism, volcanism it is a subsurface process, earthquakes, it is triggered from the subsurface, diastrophism, it is subsurface, metamorphism it is a subsurface. So, that means I want to say, though we have surfacial processes dominant exclusively, it is seen on the earth surface by geomorphic agents. But there are exogenic agents, they are promoting to work for this external processes to promote the formation of the landforms, so these are the process and this form relationships.

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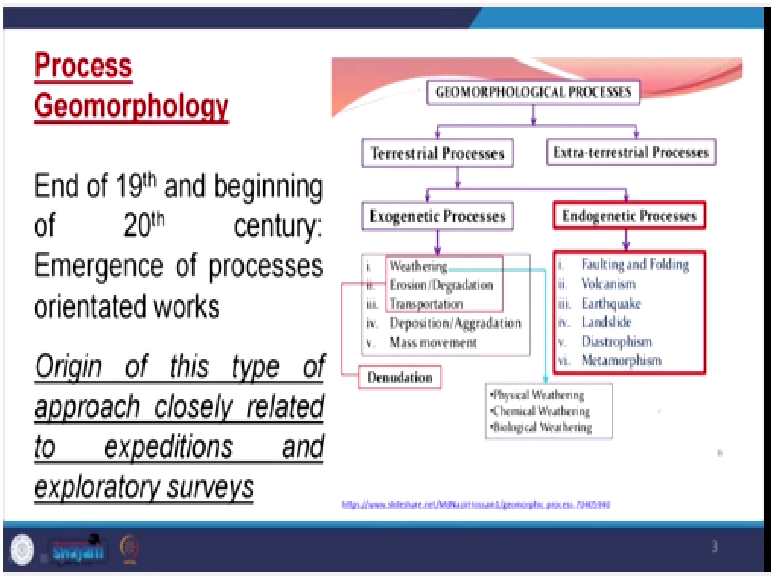

Now process geomorphology it has become very much important in 19th and 20th century. Because in the earlier forms when geomorphology was there, but only the products were considered. That means the landforms were considered, but how the landforms were form, this process involved for formation of the landforms, it was ignored. But once science developed, the process behind it the science behind it were explored.

And finally, some understanding we have reached, how the process and forms are related. And if you remember your last class, we were talking something about the theory of uniformitarianism. That means the process which going on nowadays, the same process was also going on in geological past, but may or may not be in different rates. So, that means, we have modern days geomorphic processes occurring in front of us, modern days landforms.

We are find on in front of us, it is formation of the landforms, erosion of the landforms. So now if we correlate those landforms in the past geological record, past rock record. That means we are correlating these processes which are acting on nowadays, those might have been acting in the geological past or formation of this landforms. So, that means, nowadays in 19th and 20th century, this understanding of the geomorphic process is an emerging field.

Origin of this type of approach closed related to expeditions and exploratory surface, why it is important, it is for expeditions and for exploratory surface. Exploratory surface exploration, mineral exploration, hydrocarbon exploration, exploration of proper type of soil, which type of crop will be useful or appropriate for which type of area, so these are these things we have to explore.

So, process geomorphologist, they have done their subject at least 3 great jobs, what are those. First they have built up database of process rates of various parts of the globe, we have globe, we have different geomorphic processes acting in different parts. For example, we have arctic part which is dominantly by glacier system. We have Kalahari, we have Sahara which is dominated by eolian system, arid topography.

We have ocean margins geomorphological process, we have intercontinental geomorphological process, we have mountain front geomorphic process, we have intermountain geomorphic process. So each type of geomorphic environment has been properly studied by this process geomorphologist. And first what they have carried out, they have built a database of process rate, process rate it is very much important to note here process rate.

Process is going on, erosion is going, depositional going on it matters at what rate it is going on. That means quantification, not qualification, quantification it is most important than qualification. So here this process geomorphologist they have quantified those processes, if the system is going on, if erosion is going on what rate at Tundras what is the rate of erosion, at Kalahari’s, at Sahara's at Thar deserts what is the rate of erosion.

In Ganga basin what is the rate of deposition, in Amazon basin what is the rate of deposition. So, that means different geomorphic processes which are dominant in different geographical region. This process has been quantified by the geomorphologist and for each region this quantities has been averaged out.

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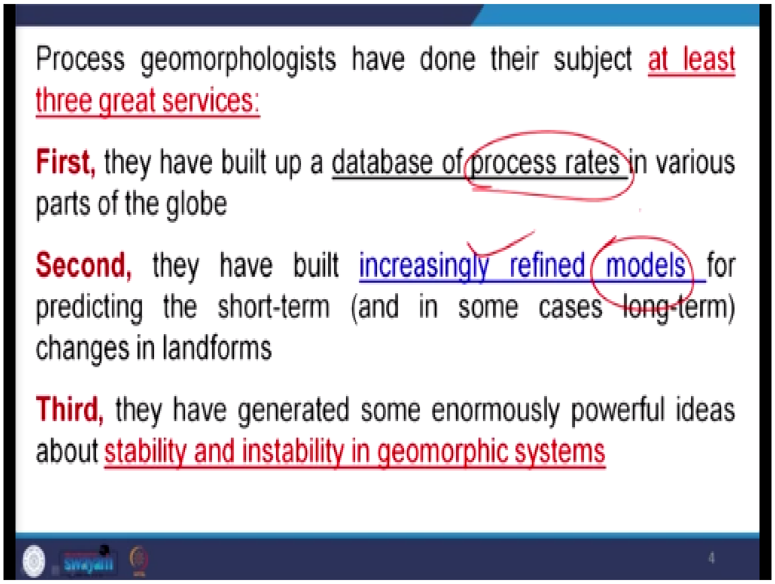

Second process or second work this geomorphologist have been done, that they have proposed they have built increasingly refined models, that is very much important. Increasingly refined modeling, that means models in geomorphology, why we do modeling. Modeling is nothing, it is to understanding the processes going on in different rate, forming a particular geomorphic feature and understanding the process predicting the future, that is why models are rated.

Because we cannot understand the whole Himalayan system 2500 kilometer and 300 meter width at a stretch. So that is why what we do, we do modeling, we use different materials like this whatever this material available in the Himalayas. Similar materials we use in the laboratory we prepare model. For example, if we consider the Himalayan system to study as a model, we have 3 prominent thrust like HFT Main frontal thrust, main boundary thrust, main central thrust.

Within that we have outer Himalayas, middle Himalayas or the Sivaliks and the higher Himalayas. Higher Himalayan crystallines, we have fluvial system, by the Sivaliks and marine system, the lesser Himalayas. So, that means I want to say once we are preparing a model, we have to choose those materials which are suitable for that particular domain. And similarly Himalayas you know it is tectonically very active mountain.

Within this tectonic though it is tectonically active mountain but the rate of subsidence, the rate of upliftment, the rate of movement is not same throughout. That is why what we do, that means once we are preparing a model, we have to consider those aspects too. So, within a to scale out this gigantic Himalayas in front of a table, it is not very easy tasks. So, we precisely prepare a model using those materials.

And these rate of subsidence or rate of upliftment, we do some mechanisms, so, that the upliftment can takes place here or subsidence can take place here. And there different faults has to be precisely placed and different respective geographical locations. Then, we start comparison or whatever the processes going on in the Himalayas, we do it. So, now we have to see in which area is the uplifting fast, which area is subsiding fast, which area erosion is going on fast, in which area new rivers are created.

So, that is why the whole Himalayan system or the whole mountain system that can be understood in front of your table on the your tabletop, so this is modeling. So, modeling means it is to understand the processes behind this model sorry behind these geomorphic landforms. And if and the rate is very important at what rate the system is working, at what rate the Himalayan is uplifting at a particular segment, at what rate subsidence is going on.

So once we do this type of exercise, we can predict which part of this area, which part of this model will respond to this geomorphic process. So, that is why we can predict this area is going to face the earthquakes hazards, this area is going to face the landslide hazards. So this area is going to be flooded in future, so that type of prediction can be done by modeling. Then third work that they have generated some enormously powerful ideas about stability and instability of a geomorphic system, very important.

Stability and instability of the geomorphic system, last class if you remember we were talking something about this material and energy management. If the material and energy are not properly managed, a geomorphic system will not sustain for long time. So, that is why, it is a open system are more preferred rather than the closed system because we have already discussed the closed systems they are very rare and very short life.

So that is why stability and instability of a geomorphic system that can be predicted through modeling. So that is why the process geomorphologist have done 3 great jobs, first they have worldwide measure the rate of processes going on. Second thing is that they have prepared models, third thing, they have a predicted whether the particular geomorphic system in a particular geographic region that will sustain in geological future or not.

If it will sustain to what extent it will sustain or it will convert to other geomorphic system, that they have predicted.

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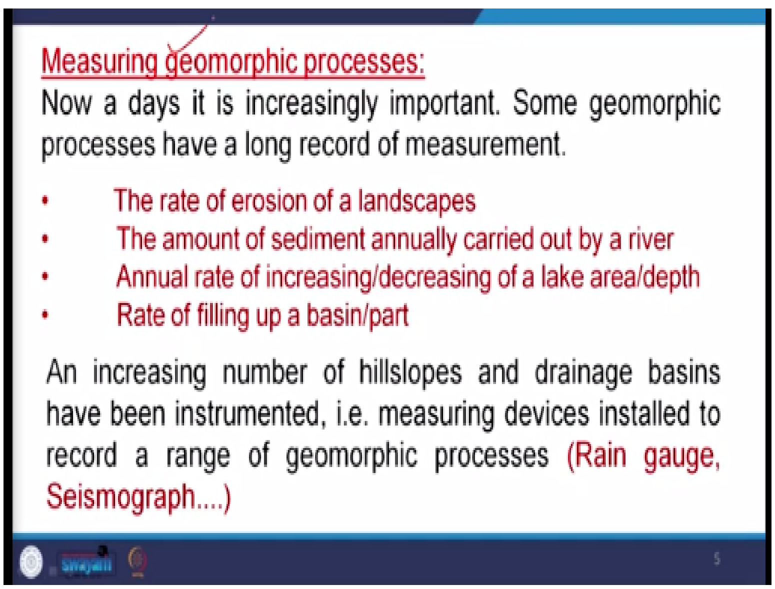

Measuring geomorphic processes, nowadays it is increasingly important, because we want to know the rate, the rate of change that is important, the quantification it is important. Erosion is going on, it is going on no doubt but at what rate in erosion is going on, if we cannot quantify we cannot predict. For example, suppose we are working as a geomorphologist on a river valley, river valley development project like this along with Sabarmati river valley development project.

Like this Gomti development projects, the Ganga river valley development project. So, valley once we are working we have 2, 3 things we have to consider, one is flooding event, one is your erosionable valley erosion and third is that the deposition. So if we can predict that this is the rate of erosion which going on. So we can predict after 20 years, after 50 years, or after 100 years, the valley width will be this much.

So that is what we can predict the people, so you have to construct your home or any development project, the government is proposing that has to be this much distance from this river valley. So that is why it is increasing the importance to measuring the geomorphic process, what rate it is going on. Some geomorphic processes have been long record of measurement, what are those, the rate of erosion of landscapes.

Erosion rate, worldwide it has been measured, and it has been measured for decades, for centuries. We have data of centuries different river valley, what is the rate of erosion, we have mountain front what is the rate of erosion, we have that data. The amount of sediment annually carried out by a river, that is also we have data. Major rivers like for a Indian context, if we say we have Ganga, Godavari, Yamuna, Brahmaputra.

All those major rivers the rate of sedimentation, the amount of sediments annually carried to the Bay of Bengal or any they are seeing that has been measured, we have data. So, to conclude, whether these type of measurement will be useful or not, this to predict, this type of data is useful or not, we have to go for the past. Past data analysis, present day observation based on those we can predict a model and we can predict for the future, yes, this will be the future scenario.

Then, annual rate of increase or decreasing of lake area and depth, it is very important for this hilly Terrains. For example this lake mostly you might have heard about this glacial lake flood outburst. This is mostly in the upper reaches or this Himalayan system or anywhere the glacial system is there. If we are increasing annually these lake area, that means the lake submerged area is increasing annually at higher rate.

That means we can say on the otherwise this glaciers are melting at the higher rate also. So, once the glaciers are melting what will be the probable cause, it that means either it is this environmental change, environmental increase of heat or that is a subsurface heat supply. If it is aridity is coming up, if the environmental change is going on, we can predict that there will be a climate change.

If subsurface heat is there then we can say there is a tectonic process which is going active tectonism is going on or magmatism can be predicted in future or any of that region. So, that means I want to say annual rate of increase or decrease of lake depth area that can also predict in a different way, that can also analyzed in different ways to predict for the future. Then rate of filling of basin and basin part.

So rate of filling of basin, suppose there is a basin, suppose for example this Ganga basin, the rate of filling is more, rate of filling means the sedimentation rate will be more. So, sedimentation rate means we have to erode at higher rate the Himalayas, higher rate of Himalayan erosion means tectonics, climate change. So, that means, if we have one clue, we can backtrack it, we can go for predict, what would be the different causes responsible for that, so that is the quantification.

And if we can quantify those things, that means, we can prepare a proper model, proper predictive model, until unless erosion is going on, basin is filling, so it does not it mean anything. It means something that if we can quantify it, so the increasing number of hill slopes and drainage basins have been instrumented, measuring devices installed to record the range of geomorphic processes rain gauge, seismograph, then sedimentation pattern.

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We have different instruments, this rate of movement of a plate we have GPS and DGPS the rate of annual rain fall, we have this rain gauge. And similarly we have different earthquakes sorry if you see here these are the different earthquakes they are arranged in this yellow dots and these are the GPS stations, they are here. So that means these areas either it is mountain front, it maybe a cultivated land, it may be a river, it may be a river valley or it may be a tectonically active region or inactive region.

Irrespective of their geographic region all those area they are instrumented. So, due to this instrumentation we are getting data 24 into 7. So, those data has to be accumulated, those data has to be analyzed and a proper geomorphic model has to be prepared. So that it can predict for the future, how and which what is the rate of our land use, what is the rate of our resource utilization, what is the rate of frequency of the earthquake we can predict.

So, there are different ways we can analyze this data, what is the rate of flooding, what is the frequency of flooding, is not it. So, that means, I want to say if we have quantified data, we can prepare better and precise models. The present day geomorphology has been evolved to estimate the rate of these processes and hence preparing the model for predicting the future. So, that means, the rate of processes if it is known to us, we can predict for future.

Because we have past data, we have present day observation, which is going on in front of us, so, that if we can put it in a graph, that the graph can extrapolate the predicting the future. So, this is the way to predict a quantified geomorphological model.

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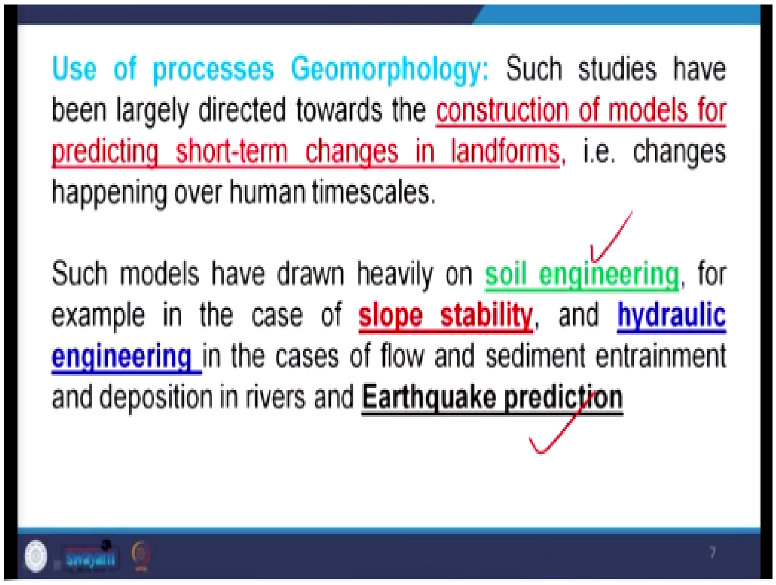

Use of process geomorphology, how to use these processes, such studies have been largely directed towards the construction of model for predicting short-term changes in the landform. We have already discussed, why we are using these things, why you are using the processes, why you are measuring the processes, because we want to predict the future. If future can be predicted, then the geomorphologist that means we can say it is the proper use of the geomorphology.

So changing happening in the human lifetimes, that can be predicted. So, our sustainable development that can be predicted, such models have drawn heavily on soil engineering. They are the different domains of this work, one is soil engineering, it is very much important. Because to the growing population, we need accommodation space and accommodation space only not only accommodation space is required.

We required also food, we need cultivated land, we have a proper land for cultivation. So, soil engineering we can predict which type of soil it is suitable for which type of crop, that can be predicted from this data. Similarly for slope stability it is another important because for slope stability It is other way it is called landslide hazard zonation. Landslide hazard, we have a hill terrain development, we have SEZ special economic zone development.

We have river management, we have river valley management, in those cases slope stability is very much important. Until unless we can identify a stable slope we cannot go for infrastructure development. Then hydraulic engineering, hydraulic engineering in this suppose for example, we have river valley project, river linking project, river linking project is not fruitful until unless we understand the hydraulic engineering.

And that can be done from geomorphological models, a river valley or different river valleys they can be models geomorphologically and find out which was the best suitable path for the river linking. Similarly earthquake prediction it is also nowadays an emerging trend, to predict the earthquake though it is not has been successful very precisely. But still we have progressed to nth extent, this can be done from the geomorphological model.

So, these are the use of this that is quantified geomorphic process. Process studies and global environmental change, process geomorphologist found natural link to other branches of earth science and life science.

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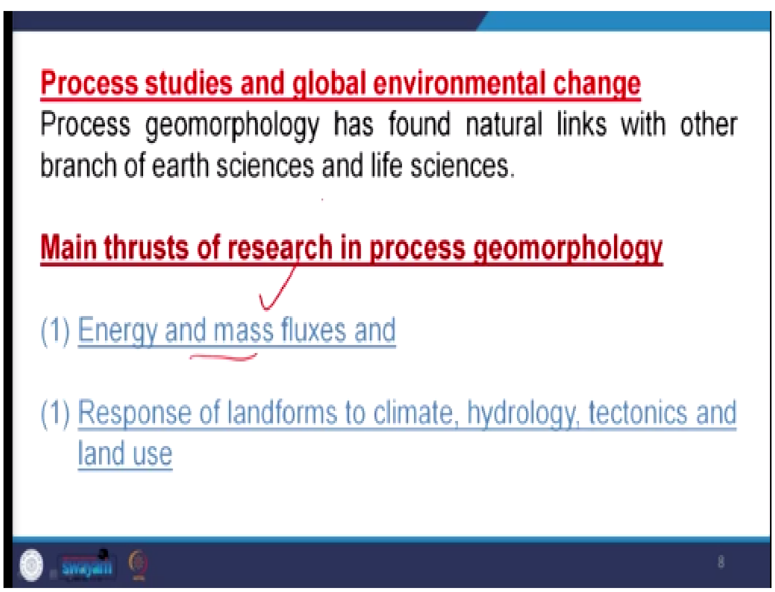

Main thrust area of research, in the process geomorphologies energy and mass fluxes and response of landform to climate, hydrology, tectonics and land use. Energy and mass fluxes, the last class we were talking about, this is the very effective way of energy and mass management by nature. If energy and mass is not properly managed, a geomorphic system will not sustain for a long time.

Similarly responsible landform to climate change to hydrology to tectonics, response of landforms. So, that means whatever the geomorphic process we are talking about, it maybe erosion, it may be deposition, it maybe exogenic, endogenic anything, they all that is reflected on the landforms. So, landform has to respond to the geomorphic system, if landform is responding at higher rate, that means it is a dynamic system or it is not responding at all it is a static system.

That means, if it is not responding that that means the area is very stable, that is that can be used for habitation. For example, suppose we have Kosi projects we have Kosi river valleys development, Kosi from the last 20,000 years it have shifted around 80 kilometers. So, any development project we are proposing at the Kosi river valley, we have to think thrice because the geomorphic system response to this fluvial processes or to this climate change or any type of geomorphic changes are there, it is very fast.

So that means in that area if we want to propose something infrastructure development or anything that we have to think. So that is why we have to know how the geomorphic say how the landform at what rate the landform is responding to the proposed geomorphic system. Geomorphology in environmental planning it is hook 1988, considered the interaction between geomorphology and the public policies.

This it is very much important for the Indian context, public policies. We do not have any policy for example if you see here, this figure it is the Kedarnath tragedy.

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You see Kedarnath the Ganga river has shown it is flooding in a last few years back. So we do not have any policy, river it is own valley, it has to be protected. But you say we have many hotels, many 3 star, 5 star hotels with near to the river valley. We have our homes near to the river valley that the habitation, we have converted to a habitation area. So, that means we do not have any policy, had it been there.

That you have to construct your home, your any developmental work, any infrastructure development that should be this meter either 200 meter away or 500 meter away from the river valley, then these Kedarnath tragedy could have been averted to nth extent. The causalities would have been very, very less as it happened. Similarly, if you see the second figure, the house, it is about to break about to slide, why we do not have policy.

Anywhere we are constructing at the river valleys, at the hill slopes without considering the geomorphology, without considering the geology, we are constructing nth number of construction is going on nowadays. Because we do not have a strict policy that we have to protect this part we have to leave this part and we have to refine our construction or divide our infrastructure development here.

So if we do not have that means, this type of this adverse features that adverse events like this Kedarnath tragedy will continue to happen. So policy formulation, it is very much important nowadays, and it is the help of geomorphology by consideration of the geomorphology. If we do not consider the geomorphology then we cannot save ourselves from this type of tragedy in future. So, applied geomorphologist are ideally placed to work on this mitigation of natural hazard of geomorphic origin.

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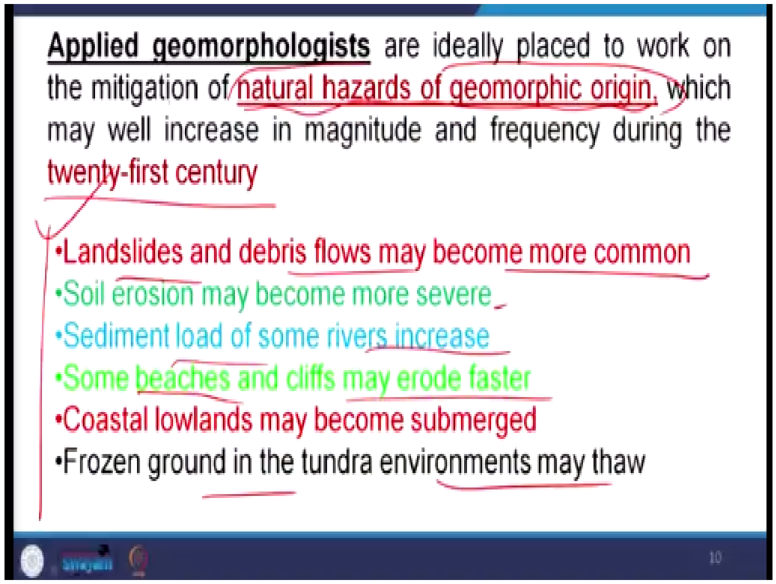

Natural hazard of geomorphic origin, it is very important, natural hazards are many types. But geomorphic origin that has to be predicted it is the use of geomorphologist there. Geomorphic origin means, so for flood event, Flash flood geomorphic origin ok. So, these types of hazards that can be predicted from the geomorphic approach and that can be averted. Apart from that these are the challenges in 21st century that landslides and debris flow may become more common, why.

Improper land use, do not have any policy without considering geomorphology, without considering geology. That is why landside and debris flow may become more common, this is prediction for 21st century. Soil erosion may becomes more severe because we do not have any policy, we do not have in control on the land use, everywhere we were constructing. Sediment load of some river increase, because erosion rate is increasing, climate change is going on, we are going towards aridity.

So, sediment load and human influence it is more, so anthropogenic activities once increases in a river valley, it produces huge sediment. So, if you consider the graphs of the sediment production or sediment load in any river valley before 1800 and present day. Then you can say how the sediment load have increased, how the amount of sediment in a river water is increased, so this is it is the anthropological activities.

Some beaches and cliffs may erode faster, some beaches and cliffs. If you consider our east coast particularly, we have many examples of modern days examples of beach erosion like Gopalpur sea beach, it is eroded, every year river is Changing its coarse. Similarly, many of these coastal low-lands will become submerged, you can consider about this Sundarban delta yesterday last class we are talking about, many of these islands that have been submerged.

So, that is frozen ground in the tundra environment may thaws. So, these are these examples of this geomorphic approach and these are these problems that can be solved by geomorphic modeling by considering the geomorphology. So, if we conclude this today's class, so geomorphic application, it is important in day to day life, in infrastructure development and policy formulation, is not it.

So that means only the geomorphic process is going on, it is not enough, it is enough or it is important to conclude that at what rate is going on. If we can quantify the process, then you can prepare a model accordingly and we can predict for the future, this is all about today’s class, thank you very much.