Soil and Water Conservation Engineering
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Lecture – 03
Factors Affecting Soil Erosion and Effect of Soil Erosion

Hello friends welcome back to NPTEL online certification course in title Soil and Water Conservation Engineering. I am Rajendra Singh, professor in agriculture and food engineering department of IIT Kharagpur.

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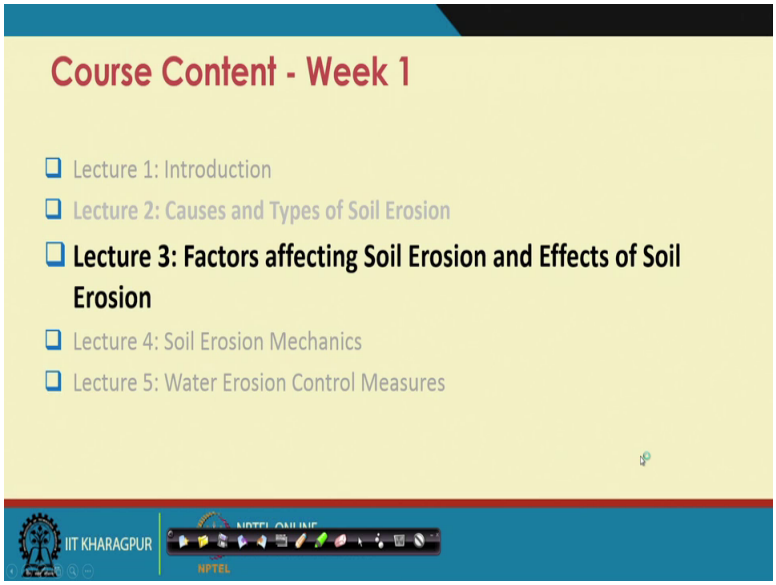

And we are in lecture 3 of week 1 and today's topic will be Factors Affecting Soil Erosion and Effects of Soil Erosion. Just to remind you of the course content of this week, in lecture 1 we started the introduction, a lecture 2 we covered causes and types of soil erosion and today's lecture we will discuss factors affecting soil erosion and effects of soil erosion and following lecture will be where will discuss about soil erosion mechanics and lecture 5 of this week we will go into the control measures that could be adopted to tackle water erosion.

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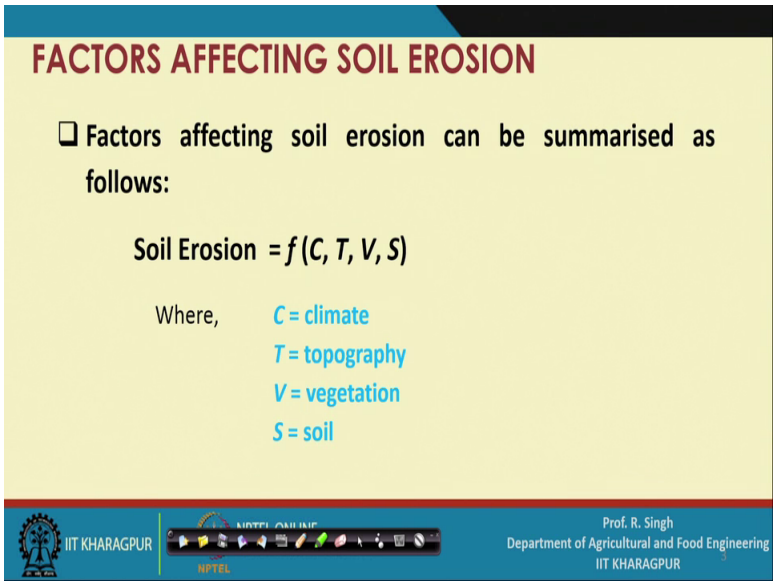

So, let us begin with factors affecting soil erosion and effects of soil erosion factors affecting soil erosion, the factors affecting soil erosion can be summarized in a very simple affection is follows. Soil erosion is a function of C, T, V, S, C, T, V, S where C stands for climate, T for topography, V for vegetation and S for soil. So it is very easy way of remembering the factors that affect soil erosion remember soil erosion in the function of C, T, V, S, C stands for climate, T for topography, V for vegetation and S for soil and then in the subsequent slides will one after the other see how these factors affects soil erosion.

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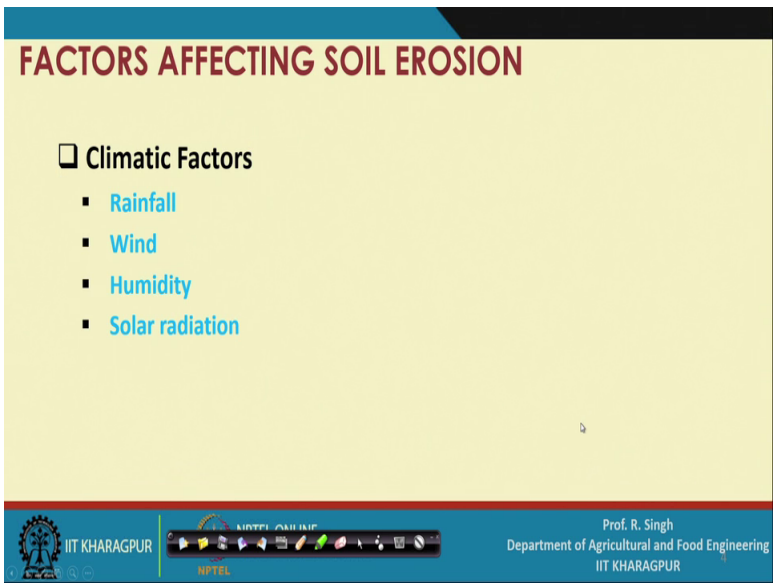

So, let us start with climatic factors and the climatic factors that impact the are affect the soil erosion are rainfall, wind, humidity and solar radiation these are the four climatic factors that affect the soil erosion.

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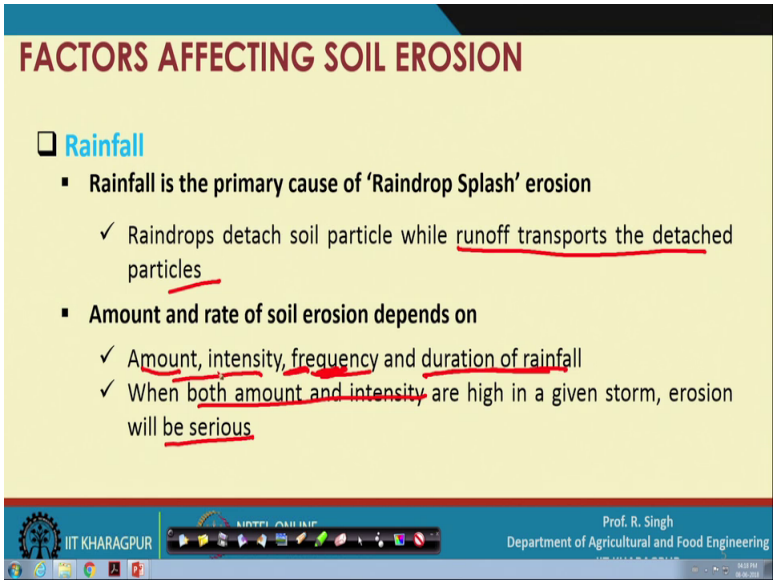

Now, we start with rainfall, rainfall is the primary cause of raindrop is splash erosion and raindrops detach soil particles, while runoff transports the detached soil particles. Remember in your previous class while classifying the water erosion we saw the raindrop is splash erosion is the first level of water erosion and their we discuss that when rain drops occur raindrops hit the bare soil particles, because of their velocity or because of their kinetic energy they disaggregate the soil particles and is results soil particles gets splashed and obviously, that that splash means that there will be detach soil particles all around the surface, wherever rainfall each occurring or wherever raindrop impact has taken place.

We also discuss further that when rainfall occurs, it first satisfies the infiltration capacity of the soil and after satisfying infiltration capacity of soil if rainfall is still continues then it gets converting into overland flow; that means, overland flow phenomena starts and that is basically nothing, but runoff and that once the loose or detach soil particles are there on the surface then run of will transport the detach soil particles; that means, the entire soil and water soil erosion process will be there, you remember we define soil erosion is detachment and transportation of soil particles.

So, here we see that here we see that raindrops detach soil particles and runoff transports the detach soil particles. So detachment and transportation of soil particles both occur and that is primary the factor responsible for that is rainfall. Then amount and rate of soil erosion primarily depends on amount, intensity, frequency and duration of rainfall. As you can logically think if the intensity of rainfall is more; that means, the rain storm event or rainfall event will satisfied infiltration capacity of soil much faster and then excess rain will be convert into overland flow.

Similarly if the amount of rainfall is more then also the same phenomena will occur that the rainfall infiltration capacity of the soil will be quickly satisfied and excess amount of rainfall will get converted into overland flow, if the frequency of rainfall is more then also, I am in if today rainfall occurs then of course, soil be moist and suppose again tomorrow rainfall occurs then because the infiltration capacity of the soil or even if it is reduced it will be requirement will be very less to satisfied infiltration capacity, when that is why when the frequency is more then also the overland flow process will be much faster and same process is with true with the duration of the rainfall.

If rainfall continuous for a longer period of time then; obviously, infiltration capacity we have satisfied capacity of the soil will be satisfied very quickly and for reminder of the duration period whatever rainfall occurs that will get converted into runoff and that simply means that run of will transport the detach soil particles and when both amount and intensity are high and given storm erosion will be serious.

So, we just now saw independently how amount and intensity could result in soil erosion, but you can easily guess than when in a given storm rainfall storm a both amount and intensity are high then; obviously, it will very quickly satisfied infiltration capacity of the soil and; that means, the amount of runoff will are overland flow we sevier or it will be much larger and; obviously, the erosion capacity or the capacity route transport the detach soil particles of such a event will also be very very high.

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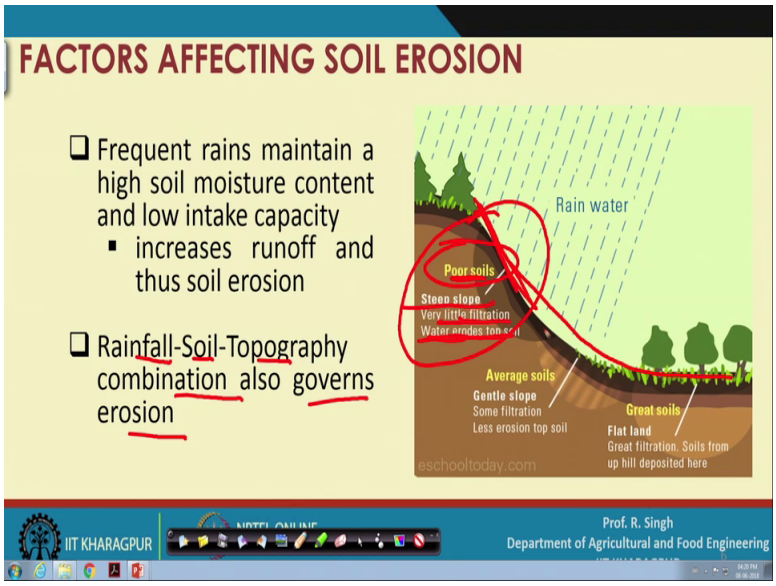

Now, continue with the rainfall, frequent rains maintain a high soil moisture content and lower intake capacity which is increases runoff and thus soil erosion, just now we saw we discuss the frequency.

So obviously, the same thing is here in the frequent rainfalls occur then; obviously, the soil moisture content will be at a very high capacity high capacity and; that means, the infiltration capacity or the intake capacity of the soil will be very very low and in such a case runoff will be very high and; that means, the erosion capacity of the overland flow are the runoff that will be much higher and thus soil erosion will be increasing or it will increase or it will be much higher. And continue with this rainfall soil topography, rainfall soil topographic combination also governs soil erosion which is quite logical.

So if you look at a kind of a hill it rain like this then typically on this portion there will be more of rocks or stones; that means, the soil quality will be poor and of course, the slope will be steeper and in that case because the soil quality is poor the infiltration capacity will be much lower; that means, very little rainfall will get infiltrated and that simply means that more of the rainfall will get converted into runoff as we have seen all processes and that means, the top soil will be rewarded fast from this portion.

If we go certain down along the slope then will reach a place where the soils are average and the slope becomes gentle, here the soils were poor and slope was steep here soils are

average and slope is gentle and that simply means there will be some infiltration taking place in here.

And that simply means that amount of runoff that is generated from the rainfall occurring over this portion will be much less and thus the erosion of the top soil will be much lower, but if we reach the belly bottom of the slope that is this portion where we can see that lot of plantation and glasses are also there then that place which is expected the soil will be a good quality and the land is flat in nature, with simply means that infiltration of capacity of the soil will be more; that means, soil will be more; that means there be much lesser overland flow much lesser runoff getting generated also because there are vegetation here.

So, whatever soil gets eroded and get transported that will be arrested by the by the vegetation cover here and that means, most of the soil will get deposited at this point of place.

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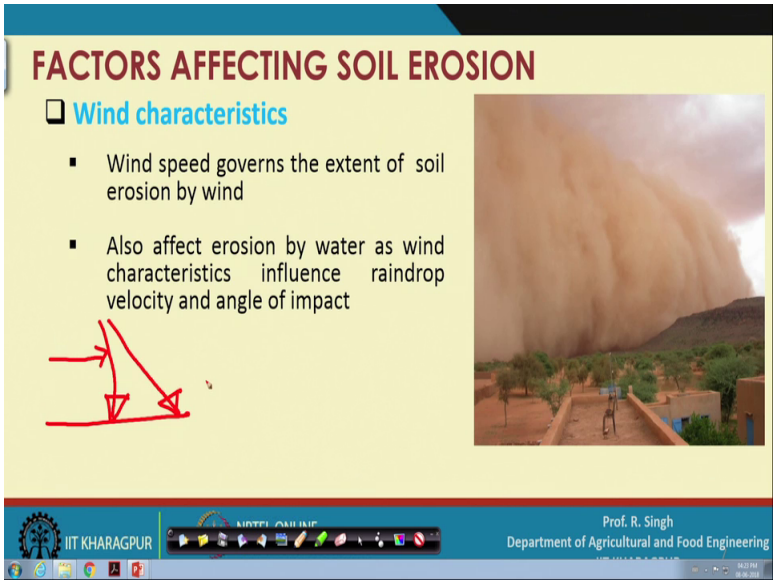

Then next age wind characteristics, if you look the wind characteristics then; obviously, wind speed governs the extent of soil erosion by wind we saw in previous class we discussed that when wind is light, then it rolls soil particles, but if wind is speed is greater then there is a dust storm. So basically wind speed governs the extent of soil erosion by wind also it affects the erosion by water because the wind characteristics they can influence the raindrop velocity and angle of impact that simply means that generally

typically if soil surfaces like this and raindrop is falling vertically, but in case there is a wind blowing then; obviously, that will change the angle of impact and change changing the angle of impact of the rainfall; obviously, will have a different raindrop result in different raindrop impact and a different kind of erosion.

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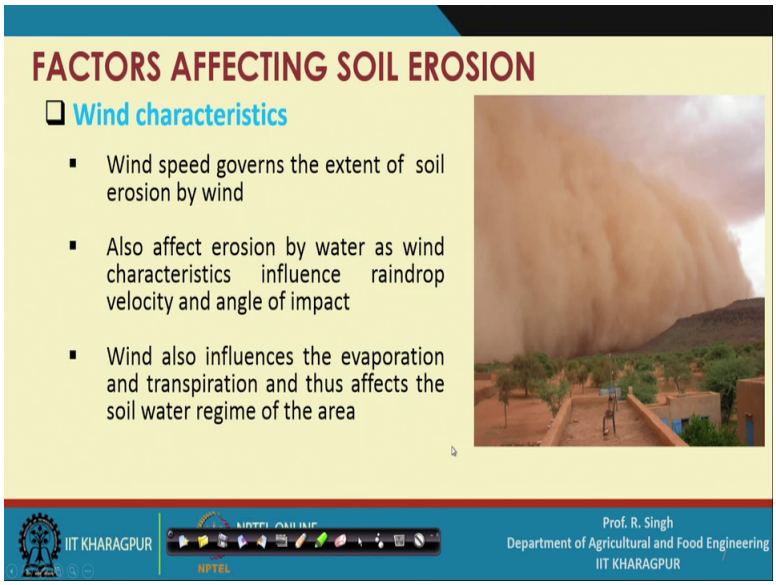

Wind also influences the evaporation and transport transpiration and thus affects the soil water regime of the area.

Because if the wind is more than evaporation and transpiration will be more; that means, the soil water requirement to fill the soil reservoir or the soil moisture or infiltration capacity that will be more; that means, in that case overland flow will be less and erosion will be less. So depending upon wind speed on one side code increase the erosion, but on the other side because of indirect effect on evaporation transpiration it could also result in decreased erosion so there is a trade off or there is a palace one has to be and even has to analyze.

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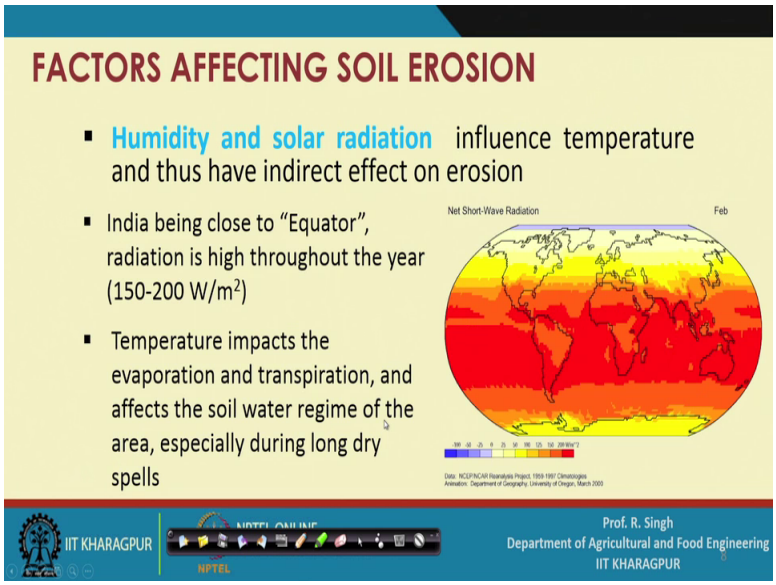

Then of course, humidity in solar radiation they also influence temperature and thus have indirect effect on erosion and as we know that India is close to equator somewhere here you can see.

So obviously, radiation is high throughout the year and it is in the range of 150-200 watts per square meter and temperature also like wind impacts evaporation and transpiration phenomena and affect the soil water regime of the area especially long dry spells. If they are long dry spells, then there can be two possibilities one is the soil moisture will be less or whenever rainfall occurs the more amount of water will be required to fill the soil water regime, but on the other hand if the soil is very dry then also there could be loose soil particles on the surface so if wind is there or even lighter rain is there that will have a tendency to take away the lighter soil particles or loose soil particles that are lying on the surface.

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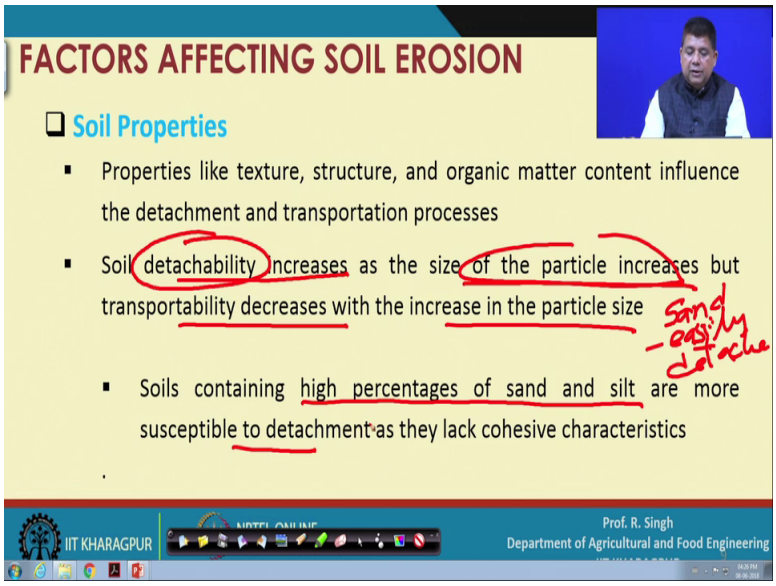

Then comes the soil properties like texture structure in organic matter content influence the detachment and transportation of soil particles and is a general rule soil detachability increases as the size of particle increases, but transportability decreases with the increase in soil particle size.

That simply means that if the size of particles is more they can be easily detach for example, if there is a sand particle sand is there it is can be easily detached, but the same soil particle because it is size is more. So it the transportation will be much difficult in this case and soil containing high percentage of sand and silt or more susceptible detachment that is the reason that the detachability is more is the lack cohesive characteristics.

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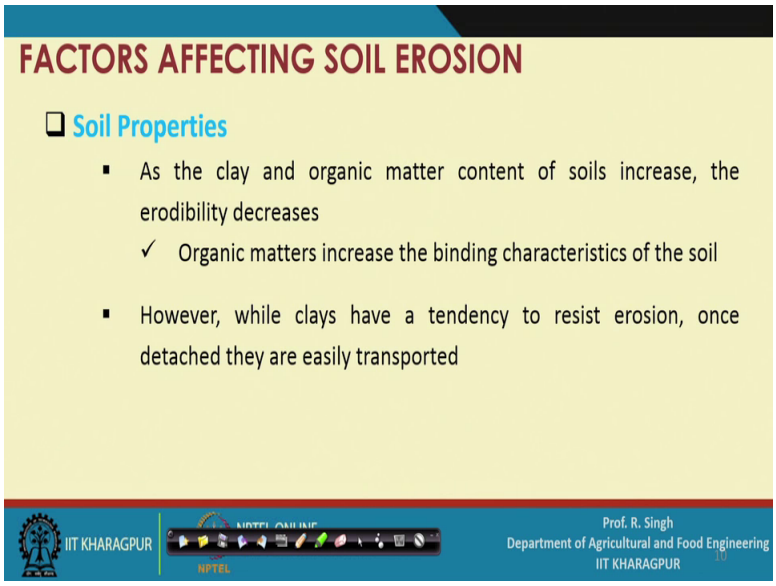

Continuing in the soil properties is the clean organic matter content of soil increased, the erodibility decreases because of the simple reason that organic matters increase the binding capacity of soil; that means, soil aggregate is bound tightly and; that means, the soil drop impact a much higher raindrop impact will be required for breaking down that kind of soil aggregate, where the organic matter content is high.

However clays have a tendency to resist erosion, once detached they are easily transported that is simply because of size that because we have already seen that detachability is less for smaller particles, but transportability is more for such kind of particle. So because clay is smaller in size so detachability is difficult, but it can be easily transported.

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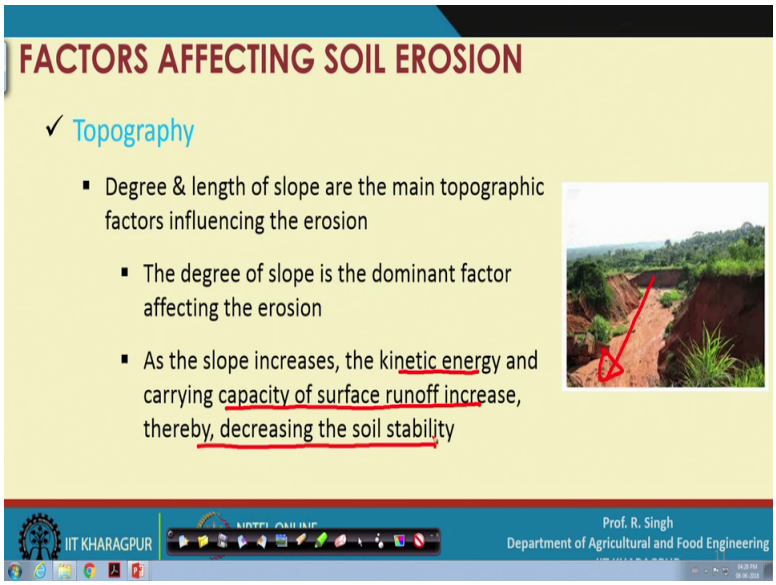

Then next factor is topography and degree and length of slope are the main topographic factors that influence the erosion. And degree of slope is the dominant factor that affects the erosion and because of the simple reason that if slope is more, then obviously, the velocity of flow will be more and velocity of flow is more means kinetic energy of the flowing water will be more; that means, it will have much higher erosion capacity and same thing is it and here as the slope increases the kinetic energy and the carrying capacity of surface runoff increases, thereby decreasing the soil stability; that means, erosion will be more in such cases.

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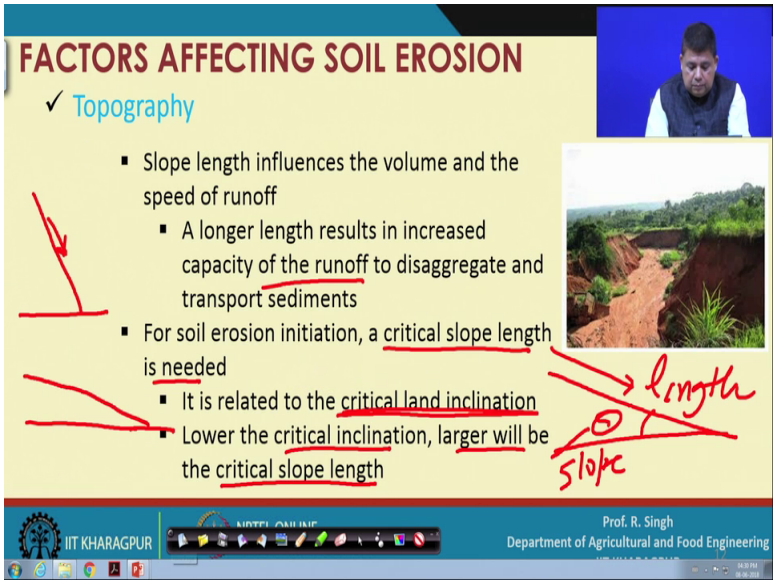

And slope length influences the volume and the speed of runoff of course, that is also a factor that it is not only the magnitude I mean we are talking about two things one is say this is theta.

So, this is slope and this is length so we are talking about two different things slope and lengths. So we solve it is slope and now you are talking about slope length it influences the volume in the speed of runoff; obviously, if the slope length is longer, then that means the more of flow will get aggregated and capacity of runoff will be higher and that means, it more soil will be transported.

Similarly for soil was initiation a critical slope length is needed; that means, a minimum slope length is required for initiating the soil erosion and of course, it is also related to critical land inclination; that means, combination of slope and length that is theta and length that are the smalls (Refer Time: 18:13) lower the critical inclination larger will be the critical slope length. So obviously, if it is a we are talking about two soils two, two lengths slopes one is much flatter and one is much steeper.

So, here a very smaller length will be required for initiate thing the slope where in here much larger length will be required.

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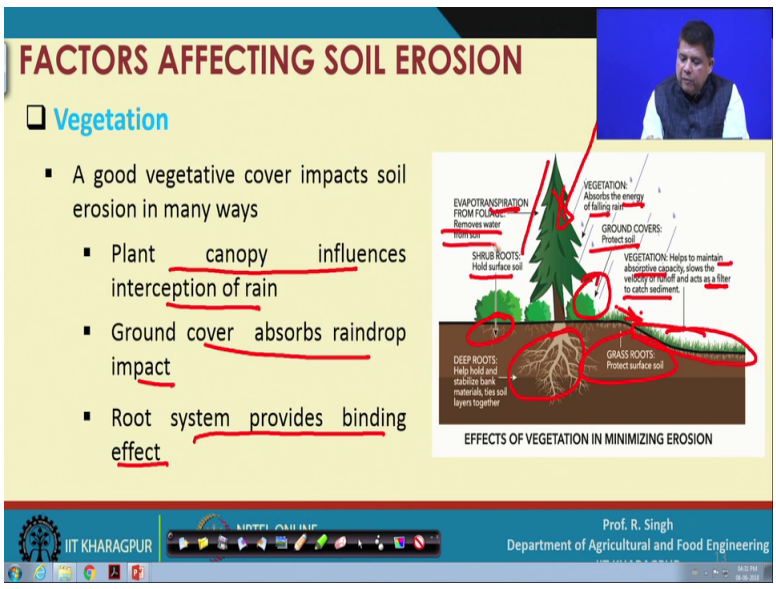

Now, the next factor we are talking about is vegetation and as we know that a good vegetative cover impacts soil erosion in many ways like plant canopies influence

interception that we have already seen, ground cover absorbs or raindrop impact and root system provides binding effects. Since yesterday we have discussing that plant canopy is very important, so if you look and this diagram then every component we can discuss one by one so obviously, well if you talk about the plant canopy it absorbs the energy of the filled falling raindrop and also it intersects the rainfall. If we talk about the ground cover here, then it protects the soil, that make absorb the kinetic energy.

If we talk about the vegetation that are growing here they help in maintaining absorptive capacity and slow down when the winder velocity of flow is there then they will flow down the flow velocity; that means, they will filter is catchment sediment. If we talk about grassroots they protect the surface oil, if we talk about the deep roots they help the stabilize the soil particles, same thing is through is the sub routes they hold this soil particles.

That means, the aggregates are hold together and it is they are difficult to detach and of course, from the plant surface evapotranspiration take place which removes water from the soil; that means, the soil reserve will be empty and that means, more amount of rainfall will be observed by this soil that means the resulting runoff will be less and; that means, the erosion capacity of water will be less in that case.

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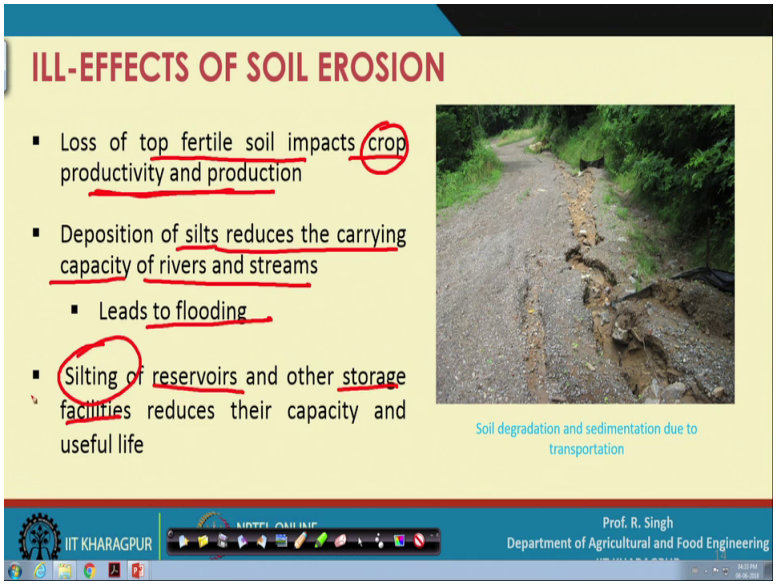

Now, coming to ill effects of soil erosion, we have seen that what are the factors that impact now what are the ill effects of soil erosion. Now first one is that of course, we

loss the top fertile soil which impacts the crop productivity and crop production. We have already seen that after the raindrop impact the (Refer Time: 21:00) erosion starts and they takes away the top fertile soils away and obviously, that will had impact or negative impact on crop production and crop productivity.

Then these soil particles which are carries down they get deposited into the rivers and streams and that simply means that if they get deposit rivers and streams the carrying capacity of these rivers and streams will be reduced and that simply means they will be more chance of flooding, because the capacity will be less; that means, with whenever flow occurs the thus tanks will be over toped and that means, there will be flooding all around.

Similarly if the silted water reaches the reservoirs and other storage facilities for example, the tanks or ponds then obviously, because of this silt being carried with water it will reduce the storage capacity of the reservoir or the pond and obviously, it will reduce the life of the structure also. That means, if a reservoir was supposed to last for 50 years, then it will be lasting for much lower, similarly if a pond which was design to last for 10 years then because of siltation is capacity will go down and that means, it will not be able to store the required amount of waterfall which was plant.

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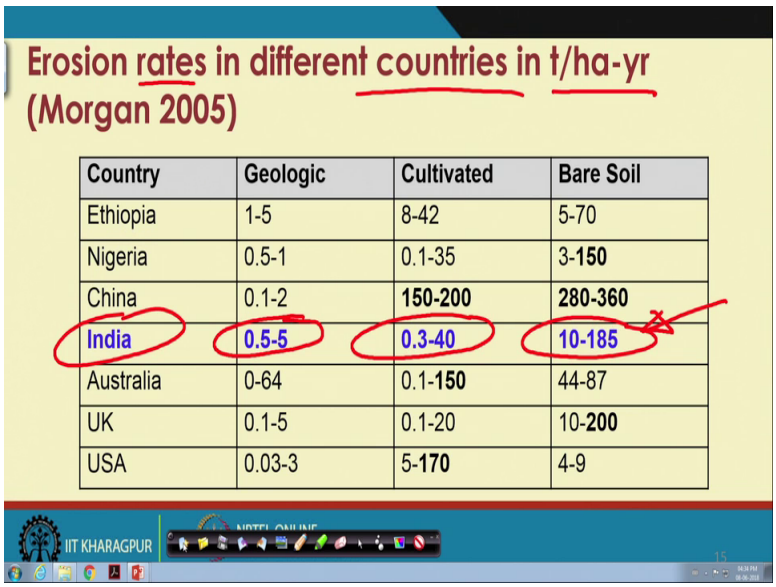

Then in different countries this just a data by presented by Morgan in 2005 that different what are the erosion rates in different countries in terms per active per year we are will

focus on India, so if you look at the India the geological erosion rate is 0.5 to 5 terms per hector per year, the cultivated soils result in 0.3 to 40 transfer hector per year and the bare soil they result in the highest that is 10 to 125 that simply shows that we should be careful about the bare soil we should cover our whenever bare soil is there we should plant grasses so that soil erosion could be arrested.

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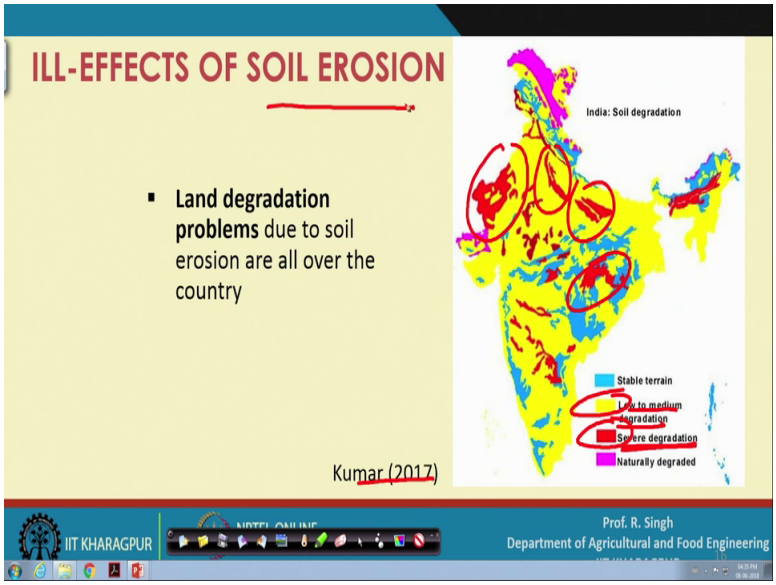

Continuing with the ill effect of soil erosion, then obliviously land degradation due to soil erosion all over the country this the data presented in a recent work by Kumar in 2017 and you can see most of the places you find yellow color, which represents low to medium degradation of the soil and obviously, at certain places red colors are there for example, here you see red colors that means, these are seviourly degraded soils. So I mean soil degradation in everywhere and that means, we have to very careful about the problem of soil erosion.

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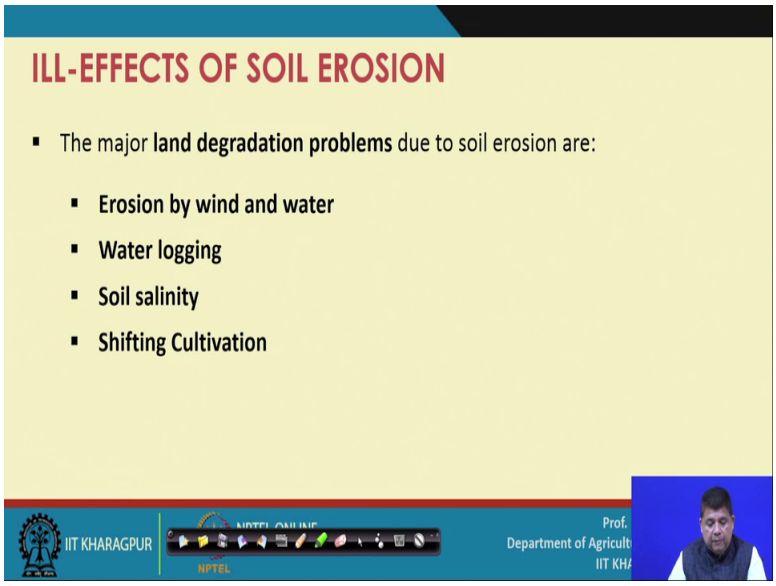

Then major land degradation problems due to soil erosion are erosion by wind, water logging, winded water, water logging, soil salinity and shifting cultivation. So these are the major land degradation problems and will see each one of them one by one.

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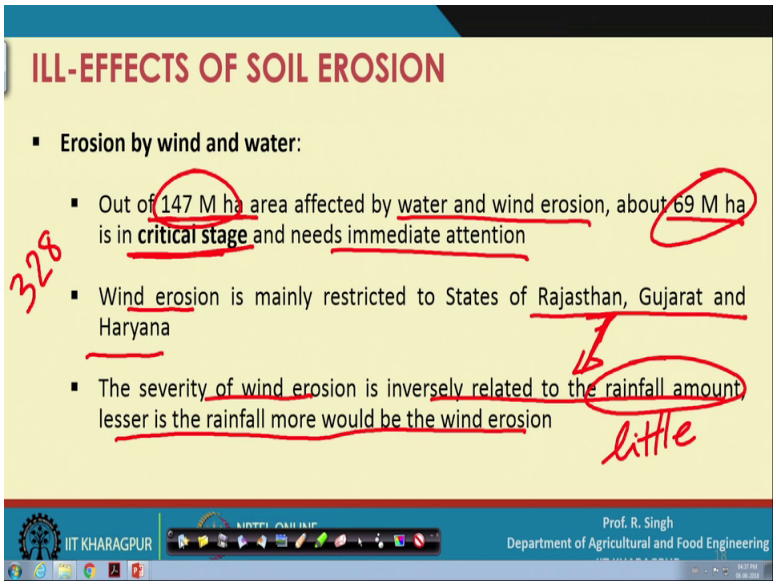

Erosion by wind and water if we look at, then we already saw statistics yesterday that in India out of the total geographical area of 328, 328 million hectares around 147 million hectares is impacted by erosion, various forms of erosion. And out of these 147 million hectares area affected by water and wind erosion about 69 million hectares is in critical

stage critically stage and needs immediate attention. That simply means that now we know that yesterday we saw that 147 out of 328 million hectares was impacted by erosion various kinds of erosion problems.

But now we also have another statistics that it is a 69 million hectares of area which where we should focus because they are in critical stages of erosion. And then wind erosion if you look it is mainly restricted to states of Rajasthan, Gujarat and Haryana and severity of wind erosion is inversely related to the rainfall amount lesser is the rainfall more would be the wind erosion and that is that you can link from here also. If you see the states here rainfall Rajasthan, Gujarat, Haryana they now especially Rajasthan and Gujarat the amount of rainfall amount of rainfall is little and as a result the wind erosion is more prevalent in both states ah.

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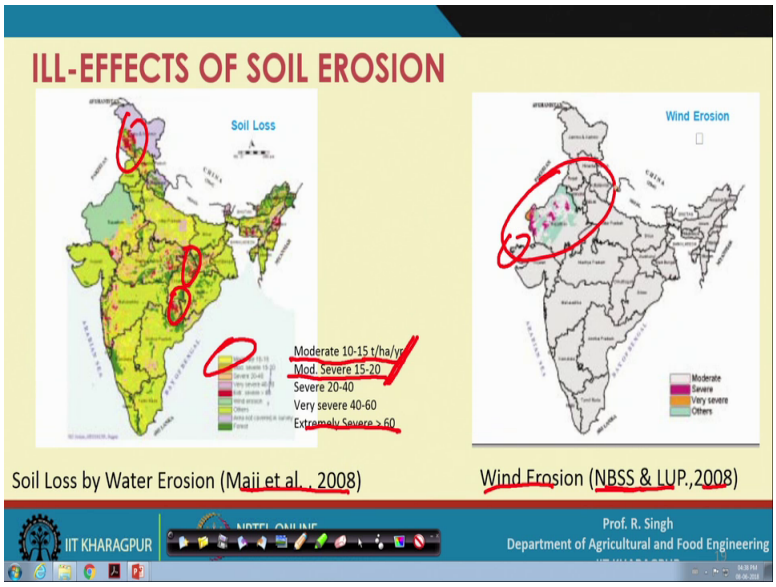

If we look at the some of the data provided by some of the researchers over the period time that is soil loss by water erosion given by Maji and others in 2008 then we see that most of the India we see yellow and green is color which represents moderate that is 10 to 15 tones per hectares of year are moderately severe that is 15 to 20 terms per hectare per year that is the soil loss by water erosion that is a statistics. Some places it is extremely severe that is greater than 60 tons per hectare per year, but those red patches are very limited.

So, but most of the area you see falls on the yellow to green that is moderate to moderate to severe that is 10 to 15 or 15 to 20 terms per hectare per year. On the other hand if you look at the wind erosion data given by land view national bureau of soil science and land use planning 2008 we find that most of the problems are in the state of Rajasthan and some portion of Gujarat that is the places which are more affected by more affected by wind erosion.

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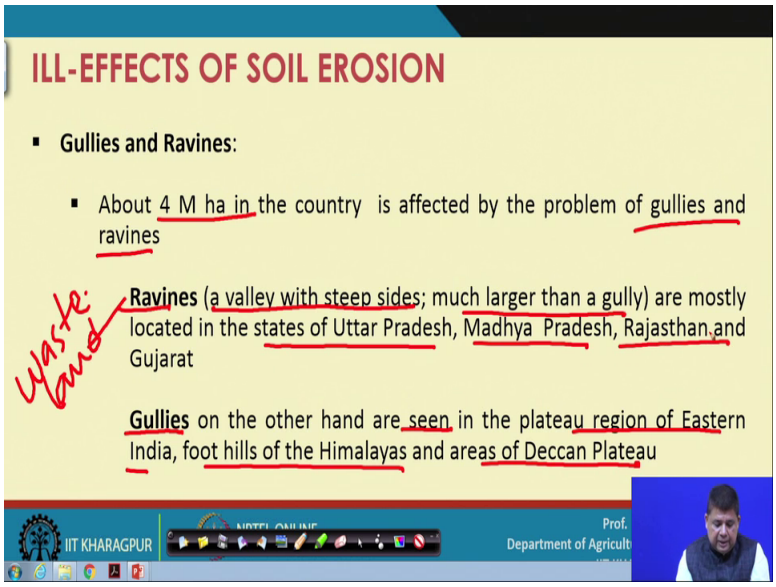

Now coming to gullies and ravines if you talk about gullies and ravines about 4 million hectares in the countries affected by the problems of gullies in ravines, gullies already we have already discussed water gullies. Yesterday we saw the gully erosion and then we know what is gully and they are found in plateau region of eastern India, foot hills of Himalayas and areas of Deccan plateau, where is the ravines which are defined is a valley with steep sides much larger than the gully; that means, a erosion further advance is stage of ravines and when that level comes we call them almost waste land because no agricultural activity can be taken up there.

So, when ravines are mostly located in states of Uttar Pradesh, Madhya Pradesh especially Bundelkhand here Madhya Pradesh, Rajasthan and Gujarat.

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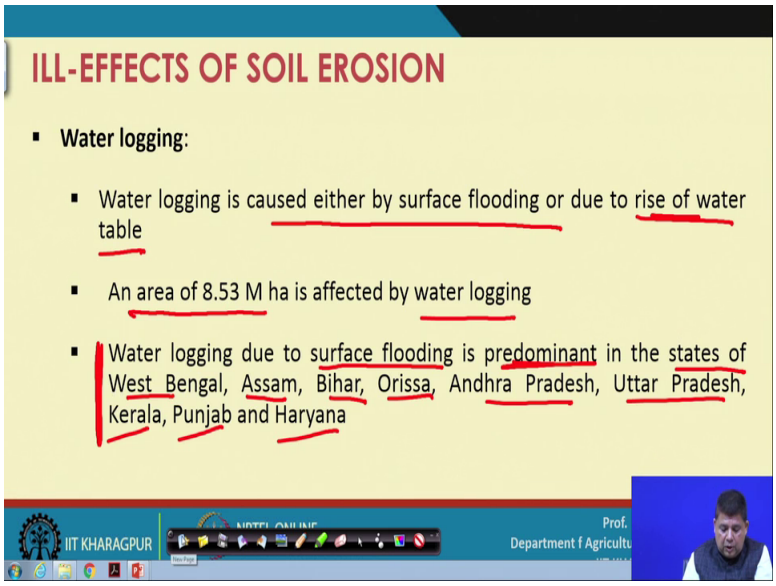

If we talk about the water logging, then water logging then water logging is caused either by surface flooding or due to rise of water table. So both of both possibilities are there surface flooding basically if you irrigate too much and there is no drainage facility or if if you again irrigate too much and their most of the water goes into groundwater reaches the groundwater and if there is no pumping then the groundwater table itself will come up and that causes water logging.

And in India around 8.53 million hectares is affected by water logging and due to surface flooding is predominant in the states of West Bengal, Assam, Bihar, Orissa, Andhra Pradesh, Uttar Pradesh, Kerala, Punjab and Haryana. So that means, you can see almost all the major states of India are having ill effect of water logging, ill effect of soil erosion in the form of water logging.

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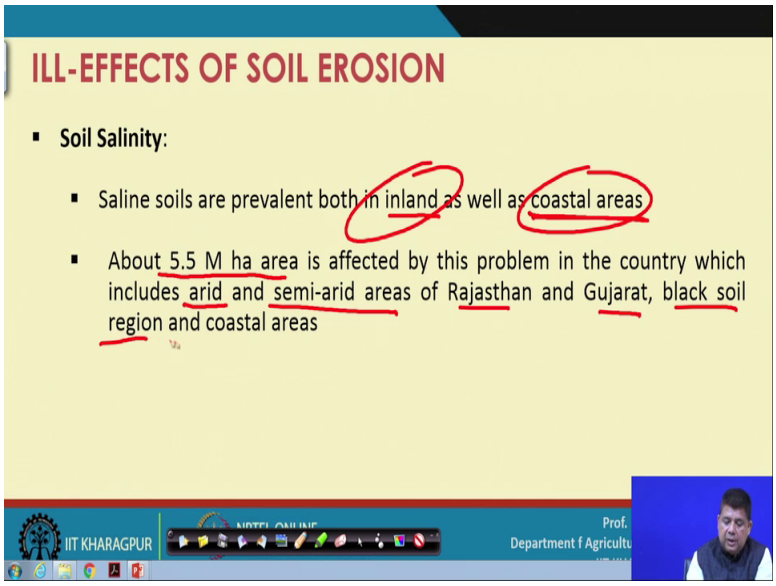

Then if you talk about the soil salinity, then saline soils are saline soils are prevalent both in inland and in coastal areas because of the saltwater intrusion in the coastal areas and because too much salt in the soil that means, poor irrigation management in the inlands. And overall about 5.5 million hectare area is affected by this problem in the country, which includes arid and semi arid areas of Rajasthan and Gujarat black soil regions and coastal areas.

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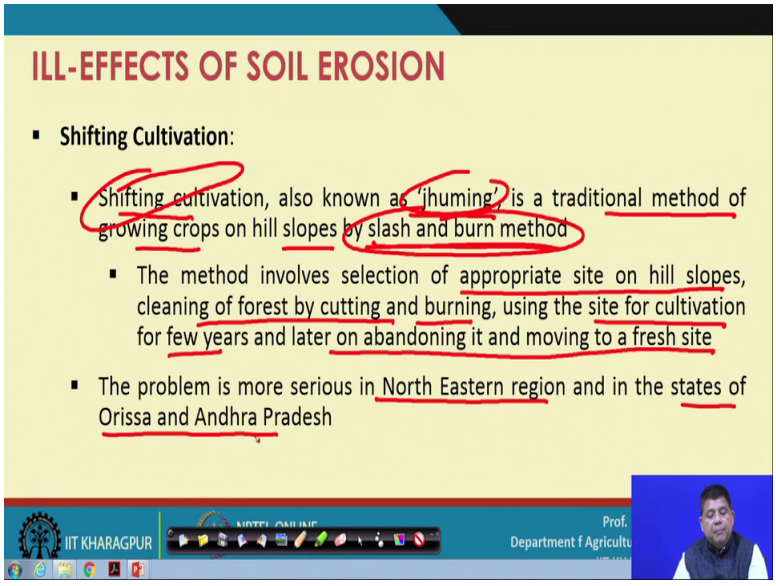

And lastly we talk about the problem of shifting cultivation, this shifting cultivation which is also referred to as jhuming is a traditional method of growing crop on hills slopes by slash and burn method.

So, their three different names shifting cultivation, jhuming and slash and burn methods, so same of cultivation technique could be known by three different methods another method involves selection of appropriate site on hill slopes, cleaning of forest by cutting and burning, using the site for cultivation for a few years and later on abandoning it and moving to a fresh site. And this problem is more prevalent or more serious in north eastern region and the states of Orissa and Andhra Pradesh that means; they are certain tribes which resort to shifting cultivation of jhuming or slash and burn method of..

So that means, in today's class we saw what are the factors that affect erosion just repeat C, T, V, S; climate, topography, vegetation and soil these are the four factors that affect that impact soil erosion and then they are several ill effects of soil erosion that will be we have discussed and in future lectures will see how to control these ill effects.

Thank you very much.