Watershed Management

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Lecture No. # 06

Soil Erosion and Conservation

And welcome back to the video course on watershed management. In module two on sustainable watershed approach, and watershed management practices. Lecture number six, we will discuss today soil erosion and conservations.

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So, the topics covered in today's today's lecture includes soil erosion: Causes, processes, erosion factors, water erosion, types of water erosion, estimation of soil loss, wind erosion, and soil conservation practices. So, some of the important keywords in this lecture are soil erosion, water erosion, wind erosion, and soil conservation.

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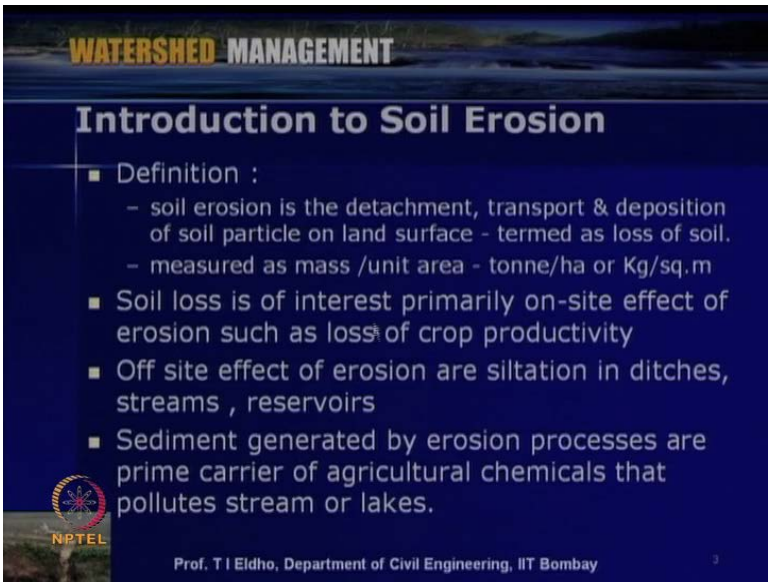

So, we have already discussed earlier the various problems in a watershed, and then what are the the causes of that problems, and then the deterioration of watershed. So, one of the important issue, which we have discussed during that lecture is the soil erosion. So, soil erosion is a major problem of the the deterioration of the watershed. Since, the soil erosion me happens, then the fertile soil will be lost, and then the agriculture yield will be reduced. So, soil erosion is a major problem

So, the soil erosion we can define as, soil erosion is the detachment, transport, and deposition of soil particles on land surface termed as loss of soil. So, this we can measure as a as mass per unit area, like a tones per hector or kilogram per square meter. So, so soil erosion is one of the major problem in most of the watershed, and a today we will be discussing the, what are the aspects various issues as far as the soil erosion is concerned, and then what are the causes of soil erosion, and then a how we can control the soil erosion. So, these issues will be discussed today in today's lecture.

So, soil loss is of interest primarily on site effect of erosion such as loss of crop productivity. So, as I mention when fertile soil is gone due to erosion problems, then say the crop productivity will be reduced. So, the we have to deal such conditions. Then off site effect of erosion are siltation in ditches streams, and reservoirs. So, you can see that when they when the soil is eroded, this as sediments this soil will be carried by the

running water or the within the runoff. And then, that will be taken in through the streams rivers, then it may reach to lakes, and reservoirs, and finally to the ocean.

So that way, there is problems of say sedimentation in in reservoirs, and a streams, and then lakes etcetera. So, the sediment generated by erosion process are prime carrier of agricultural chemicals, that pollute the streams or lakes. So, another the another problem related to the soil erosion is the sedimentation sediment generated by erosion. So, that will be also carrying the the contaminants or the chemicals, like a pesticides, then fertilizers etcetera. And that will be especially a non points source of pollution in in rivers, lakes, ocean, etcetera.

So, with this introduction, let us see what are the important problems as far as soil erosion is concerned, and then what are the causes of soil erosion.

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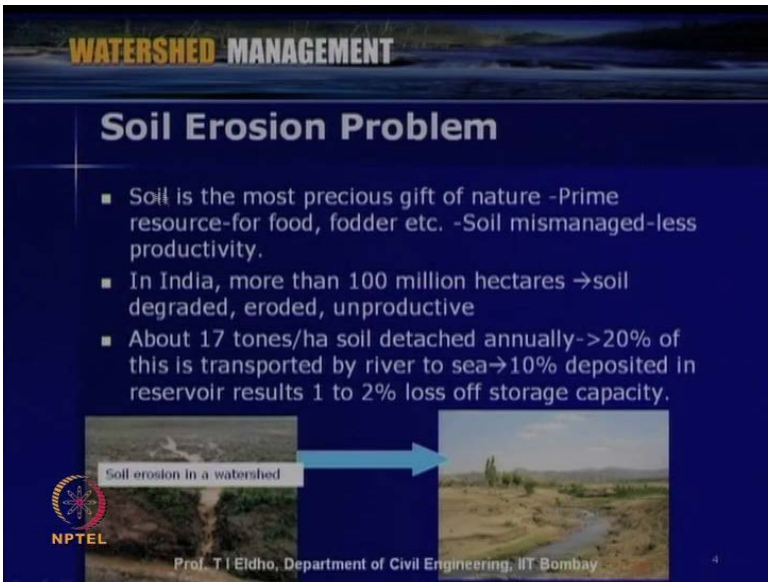

So, as mentioned here in this slide, soil is the most precious gift of nature. So, soil is the prime resource-for food, fodder, etcetera. Since, we have to grown plants we have to say the for the agriculture products say, all this plants are growing in the soil.

So, that way soil is the most precious gift of nature. So, we have to we we should have fertile soil for better agricultural production. So, that way the soil mismanaged, then there will be less productivity. So, for better productivity fertile soil is essential. So, we have to stop this soil erosion.

Say for example, if you consider India say more than hundred million hectares; that means, more than one third of the land, there are various problems of soil erosion. Like a soil is either degraded, eroded or a some places, it is the soil is unproductive. And about seventeen tones per hectare soil is detached annually. So, this is an like approximation as far as the erosion problem in India is concerned, and then 20 percent of this is transported by river to the sea.

So that means, So, this much this much of sediments which is the the soil due to the soil erosion is generated, and that is a transported through the river to the sea, and then also 10 percent of the deposited this sediments are deposited a in a many of the major reservoirs, and that results one to two percent loss off storage capacity.

So, there are various issues as far as the soil erosion is concerned, one is the loss of the fertile soil. So, that agriculture productivity will be affected. And then, the secondary issues like a the the pollution which will be coming to the the water resource, say like a rivers, lakes, etcetera. And then, we have the problem of the siltation or the sedimentation of the lakes, rivers, and other water body. So, that there will be storage capacity will be reduced.

So, we can see that here in this photo, we can see that due to the rainfall. So, much of soil is eroded, and then that is a going through the the flowing water, and it is reaching to a small string here. So, if it keep up keeps on going, then you can see that in this other figure here. You can see that, so much of the banks of this river is eroded, and then so so many places the fertile soil is eroded. So, that these are the... So, we can see that the fertile soil in the land is gone, and then many places we can seen the exposed a rocks. So, that way the agriculture or the the farming become say difficult, and the productivity will be reduced. And also the nearby the reservoirs, there will be sedimentation problem and its capacity will be lost.

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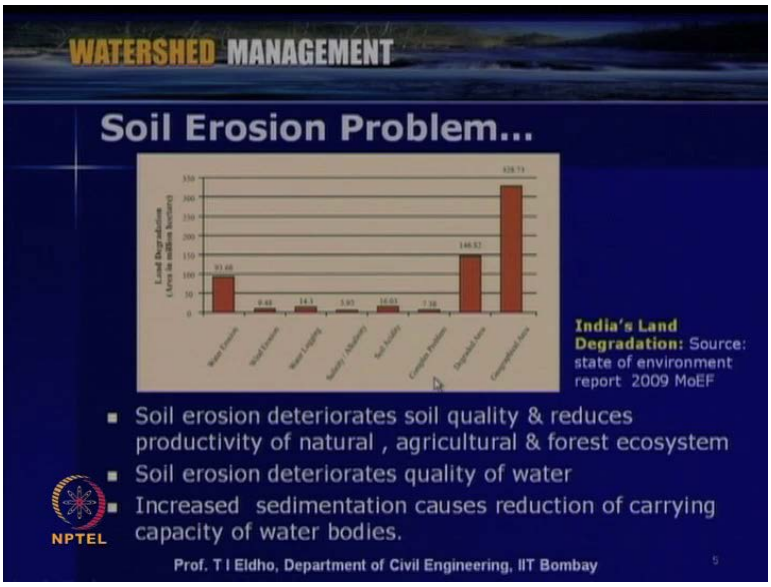

So, as far as soil erosion is concerned as per India's land degradation as per the state state of environment report ministry of environment forest, here the the land degradation say area in million hectare is shown here in this graph.

So, here you can see that water erosion problem is there for about 94 million hectares, then wind erosion is affected about 10 million hectares, then a water logging in about 14 million hectares, then salinity in 5.95 million hectares, then a soil acidity in about 16 million hectares, then complex other all this many other problems like land degradation you can see. So, the degrade degrade area is say about 146.8 million hectares.

So, that way the total geographical area is only 329 million hectares, out of that you can see that in lot of. So, many problems related to the soil erosion. So, it can be either water erosion or wind erosion or it can be the the the degraded land. So, all this issues are coming due to the soil erosion. So, so as far as in watershed management is concerned, soil erosion is a major problem. So, soil erosion deteriorates the soil quality, and reduces the productivity of natural, agricultural, and forest eco system.

So, these are the major concern, and soil erosion deteriorates quality of water also. So, we have seen a sediments will be carrying this pollutants, and that will also deteriorate the quality of the water. Then it increases the sedimentation, and that cause reduction of carrying capacity of the water bodies like reservoirs, lakes, and the rivers.

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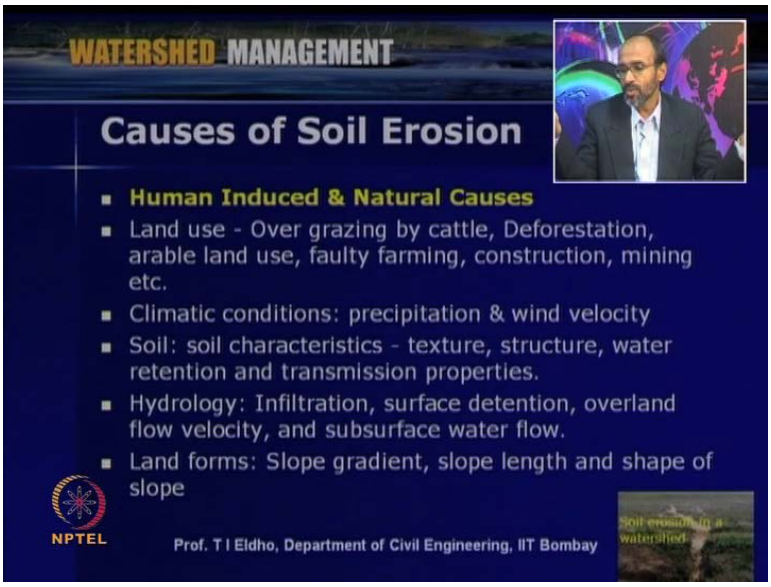

So now, with this background, let us look into the various causes of soil erosion. So, as far as the causes are concerned, we can classify into mainly into two - one is the natural causes, and second one is the Human Induced causes. So, a natural causes anyway, we have a limited control over the natural causes, like a due to the climatic climatic conditions, then the hydrology, then the the flooding problems or the earth quake problems, so some or landslides. So, like that those kinds of natural causes it is difficult to control, but then so many other problems, like a human induced problems are also there.

So, some of the causes important causes related to either human induced, and a natural causes are listed here. So, like a land use; so, land use changes mainly taking place due to the human induced causes, like over grazing by cattle, then deforestation, then arable land use, faulty farming, construction activities, mining, etcetera.

Then, as far as natural causes like climatic conditions, precipitation like high in dense rainfall, then high velocity winds, so these are some of the climatic conditions. Then also they the soil erosion depends upon, what is the nature of the soil. So, the soil characteristics characteristics are very important. So, this some of the important characteristics... So, which is affected as far as soil erosion is concerned, like a texture of the soil, structure of the soil, then water retention, and transmission properties.

Then Hydrology of the of the locality of the watershed is concerned, like a how much is the infiltration, then surface detention, overland flow velocity, subsurface water flow etcetera. So, these are some of the hydrological issues, which causes soil erosion, then as far as land geography is concerned. We can see that what is the slope of the land, slope length, shape of slope, slope pattern physiographic of the land. So, all this send put lot of inputs or causes, the soil erosion as far as a watershed is concerned. So, we may heard to when we are dealing with the soil erosion, we have to deal with not only human induced causes, but also the natural causes as discussed here.

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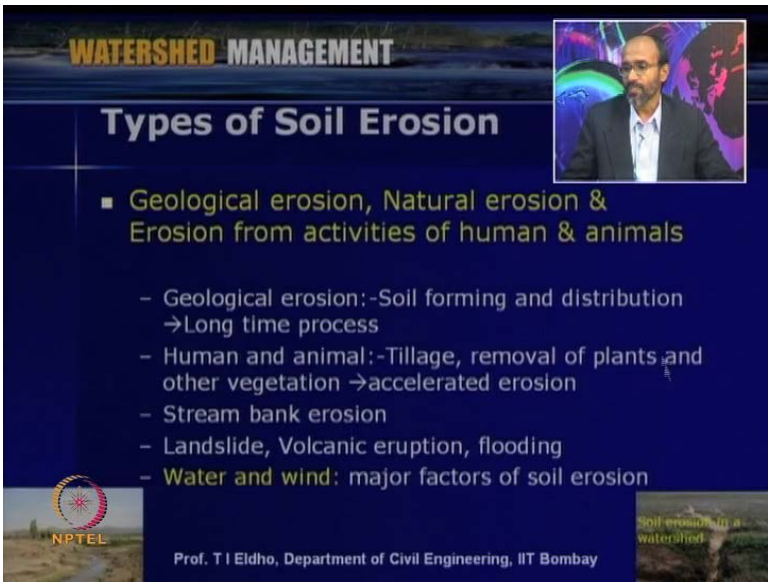

So now, now let us see, what are the different types of soil erosion? So, we have seen various causes. Now, we can classify the soil erosion into like a Geological erosion, Natural erosion, and Erosion from activities of a Human, and animals.

So, as far as geological erosion is concerned like a say for millions of years, the the due to the the say the rock is degraded degraded, and then soil is formed, and then that is also say transported to some other location. So, that is some way the erosion also helps to transport the soil from one place to another place. So, that way Geological erosion is concerned soil forming, and distribution takes place. But only here, you can see that it is a long time process. Then a human, and animal related soil erosion like a tillage; that means, when we plow thus the land, then it is related when the rain comes lot of soil erosion takes place.

Then removal of plants, and other Vegetation. So, these all causes erosion, and in an accelerated way. So, this we can classify accelerated erosion. Then in especially in rainy season, we can see that the banks of rivers or streams will be get eroded like this, you can see that the this is small stream, then its sides are eroded. Here also, you can see then the natural causes like a land slide work on eruption flooding.

So, due to the erosion due to this kinds of we can classify into natural erosion. So, in all these say like a geological erosion, natural erosion or an say the erosion due to activities of human, and animals. Since, the major factors which causes this erosion are either water or wind. So, major factors of soil erosion we can say that, soil erosion takes place either due to the action of water or due to the action of the wind.

So, with this perspective. So now, let us seen the soil erosion processes. So, we have seen that the main agents of soil erosion are water and wind.

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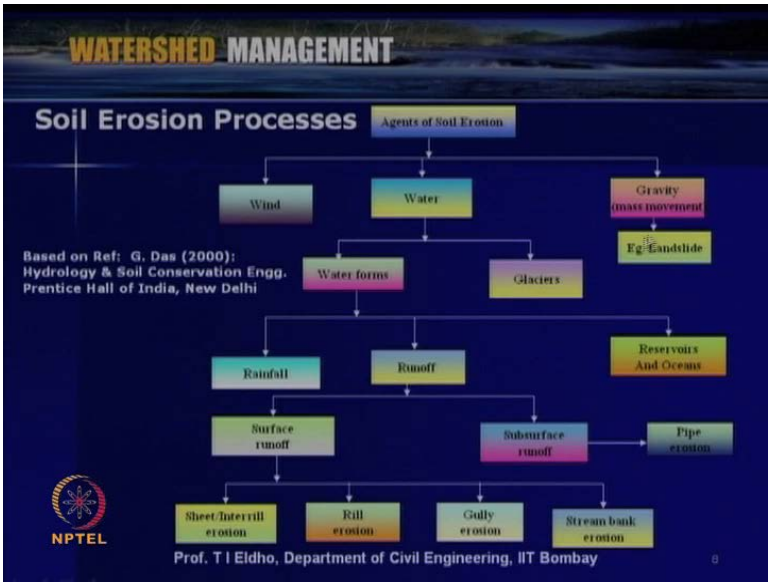

So, the agents of soil erosion in this chart as given by G das in his book hydrology, and soil conservation engineering. So, the agents of soil erosion can be either wind, water or a gravity - gravity means like a mass movement like, what happens in the case of a land slide. So, water is concerned which is the major cause of soil erosion. So, it can be either water forms or glaciers movement of the glaciers or say when snowmelt takes place or due to the precipitation and a runoff.

So, the water is concerned it can be water forms or glaciers, and then water forms again we can classify into rainfall. That means, due to direct impact of the rainfall, the soil erosion takes place, and then the the runoff. So, happening on the over land, over the channels, then also the soil erosion that means, especially deposition will takes place in a reservoirs and oceans. So, that is another water form.

And then as far as runoff is concerned; the runoff can be either surface runoff or sub surface run off. Mainly the major say, soil erosion process is mainly due to the surface runoff. So, that we can classify into sheet or integral erosion, then rill erosion, then gully erosion, and stream bank erosion. So, these are the major processes taking place, as far as the soil erosion either due to either wind or due to water or the mass movements as in the case of a land slide.

So, now say we have what we have seen is various processes taking place with respect to the the erosion, what is happening especially in a watershed or a in a in a river basin. So now, what are the important soil parameters well, let us look into important parameters.

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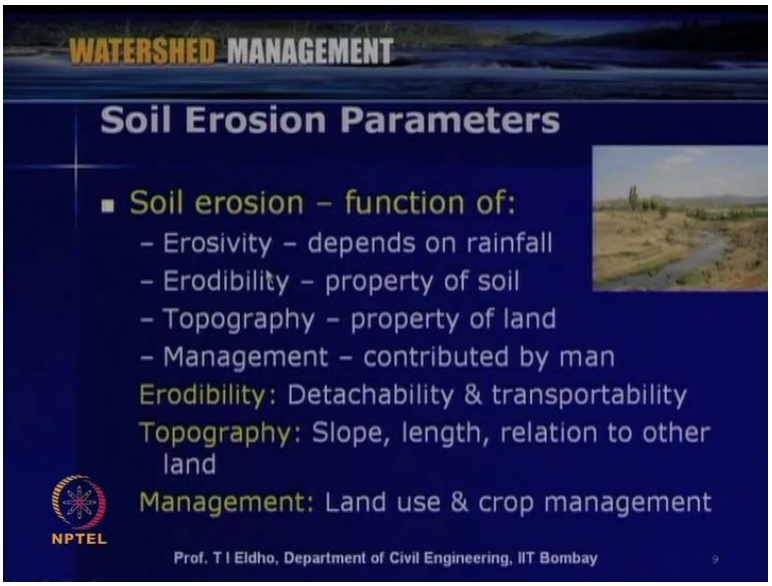

So, soil erosion we can show that it is a function of Erosivity. So, Erosivity means what is the the... So, depending upon the intensity of rainfall, depending upon the drop size of the rainfall.

So, the Erosivity varies. So, the impact on the soil varies. So, accordingly there can be say say more erosion or less erosion. So, see Erosivity which depends upon rainfall, then second one is Erodibility - Erodibility it is a property of soil. So, the say depending upon the nature of the soil, depending upon its texture, depending upon the material. So, the it may be more Erodible or less Erodible.

So, that way another important function or another another important parameter is Erodibility, then third one is as far as a watershed or as far as an area is concerned Topography. So, whether it is a steep slope, whether it is a rocky area or whether it is a what kind of soil, weather a sandy soil or cohesive soil. So, accordingly the the soil erosion varies. So, so it is a property of the land.

Then the forth function is the or the forth parameter is management. So, management of the land especially. So, this management is concerned, the as we have ready seen in the previous slide. This is a contribute by man or a man or a catalyst, and a activities various activities. So, like a it depends upon the land use, and then the the agricultural activities within the watershed or within the area which we consider.

And as far as this Erodibility. So, that is a property of the soil. So, that depends upon the detachability, and transportability. So, detachability means when the say for example, when precipitation takes place that the this splash or the rain raindrop hit on the soil. So, how easily the soil soil grain will be detached from the the land, and then that detached soil particle will be transported from say with the movement of the water from one location to another location. So, this Erodibility depends upon the detachability, and transportability.

And then another. So, as far as Topography - another function Topography is concerned the Topography of the land. So, like a slope length relation to other area. So, like that. So, the depending upon the Topography, the soil erosion varies. So, as I mentioned as far as management is concerned mainly, we have to see the land use, a crop management then grazing by the cattle, etcetera. So, these are some of the importance soil erosion parameters, as far as the soil erosion is concerned. So, we have already seen two important agents as far as the soil erosion is concerned; one is water, another one is a wind. So, now, we will discuss in detail the erosion due to water, and erosion by wind. So, first let us see the water erosion, as far as soil erosion is concerned.

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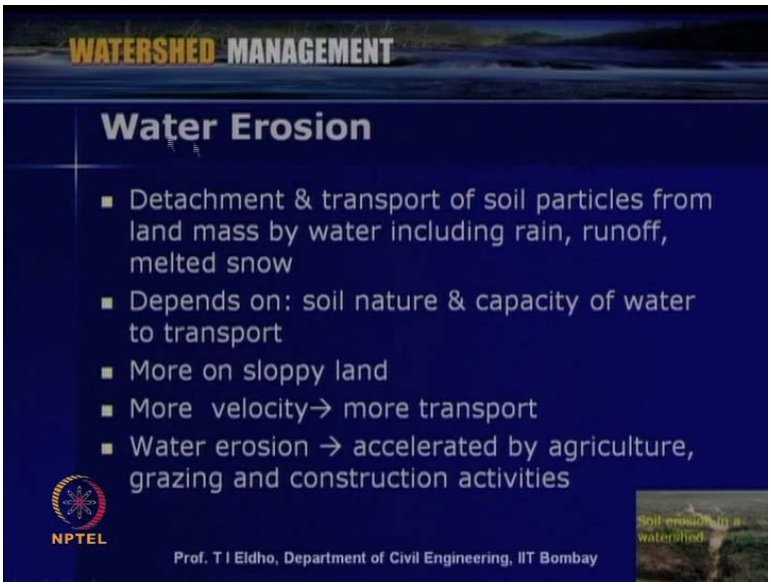

So, as we already discussed, the water erosion happens due to detachment and transport of soil particles from land mass by water including rain, runoff and melted snow. So, these are, this is what is happening as far as a water erosion is concerned. So, the water erosion depends on the soil nature, and capacity of water to transport. So, we have already seen the depending upon the soil texture, soil material. So, the the so, detachability; that means, due to the force of the precipitation or the water movement. So, soil grains will be detached from the land, and that will be transported. So, that way the water erosion depends on the soil nature, and the capacity of water to transport.

So, you can see that an, if you go to field during rainfall or due to when the soil water erosion takes place you can see that in, water erosion will be more on sloppy land. So, if the water velocity is higher than more transport will be taking place, more soil will be eroded. So, we can see that water erosion is accelerated by, also the agricultural activities, grazing, and construction activities as far as the watershed is concerned.

So, watershed watershed on watershed basis. So, the water erosion can be increased by agricultural activities, then also grazing and other activities like a say querying, and other activities within the a watershed.

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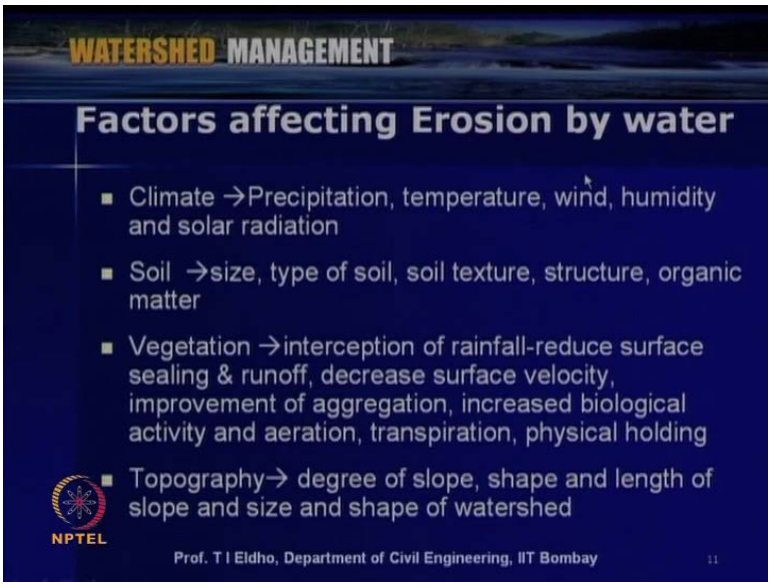

So now, say as far as water erosion is concerned, let us see what are the important factors which affects the soil erosion. So, we have already seen this factors already, but now we are critically analyzing with respect to as far as water is concerned. So, as far as water is concerned climate is one of the important component, say like a the various processes taking place, like a precipitation, then temperature, then a wind humidity, and solar radiation. So, the factors climactic factors mainly it is depending upon the precipitation.

Then soil. So, size of the grain, then type of soil, soil texture, structure, organic matter within the soil. So, depending upon that the water erosion will will be more or less. Then another important aspect is Vegetation cover on the land or on watershed which we consider. So, as we have discussed earlier, say the when rainfall takes place some of the the the say rainfall will be intercepted by the Vegetation cover on the land. So, the interception of rainfall reduce surface sealing, and runoff; and it would decrease the surface velocity, and then that way the soil erosion will be reduced. And then improvement of aggregation aggregation increased biological activity, and aeration, transpiration, physical holding all this helps to reduce the soil erosion.

So, that way as soil conservation is concerned, one of the important aspect in soil conservation is say we can increase the Vegetation as far as the watershed is concerned, say as like in in the case of grass or other other plants, whenever wherever more Vegetation is there, the soil erosion will be reduced. And then next one is Topography,

as we discussed earlier this depends upon the degree of slope shape; and a length of slope, and size, and shape of the watershed. So, on a watershed scale. So, it depends upon the shape of the watershed size, and slope of the area. So now, say we are discussing about the water erosion. So, water is one of the major factor causing soil erosion.

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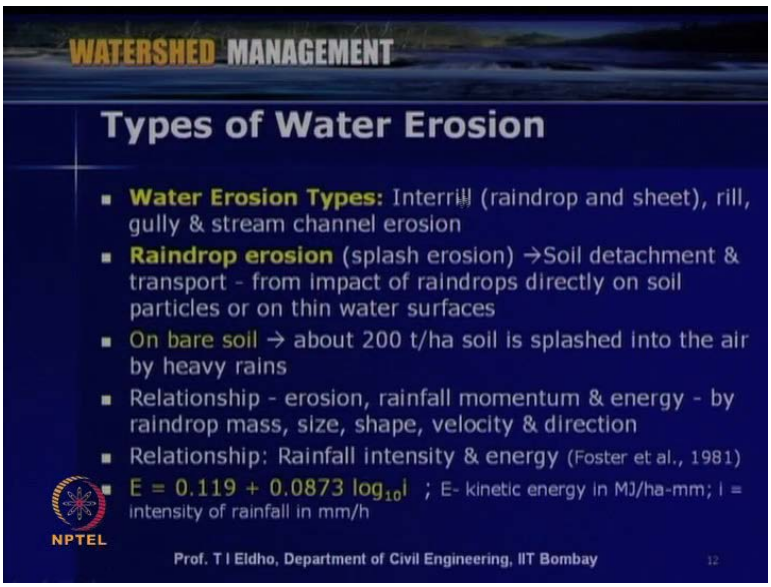

So, depending upon the say a conditions, we can classify water erosion types as as as follows, like a Interrill which is we can combined like raindrop and sheet sheet. So, that is called Interrill, then Rill gully, and a stream channel erosion. So, Interrill erosion erosion say combination of raindrop, and sheet erosion, then a Rill erosion, gully and stream channel erosion. So, that these are different types of water erosion.

So, let us see first one the raindrop erosion or splash erosion. So, here the soil detachment, and transport from the impact of the raindrops directly on the soil particle or on thin water surfaces. So, when the rainfall takes place, you can see that depending upon the intensity of rainfall; the directly there will be an impact on the soil surface. So, that can cause detachment of the soil particles, say after some time of the rainfall, there may be the runoff will be taking place. So, but that also the the the depth of runoff may be very small. So, still intense rainfall takes place, again this impact will be there.

So, that way splash erosion means, it is the soil detachment due to the impact of the raindrops. So, say for example, on bare soil about say some calculations, says about 200 tons per hectare soil is splashed into the air by heavy rains. So, especially in the beginning of rainfall season. So, say about 200 tons per hectare soil is splashed.

So, we can Identify relationship as far as the the say the various erosion problems like a by considering the erosion rainfall momentum, and energy. So, like a raindrop raindrop mass size, shape, a velocity, and direction. We can get some relationship based upon various field studies. So, one of the important relationship derived by foster, and others in 1981 is relationship connecting the rainfall intensity, and the kinetic energy.

So, according to a foster et al E is equal to 0.119 plus 0.0873 log I normal logarithm I, where E is the kinetic energy in million joules per hector m m, and I is the intensity of rainfall in millimeter per hour. So, like this (( )) depending upon the for various types of water erosion, we can derive relationships based upon the various field experiments, we can derive the relationship as far as the various types of water erosion is concerned.

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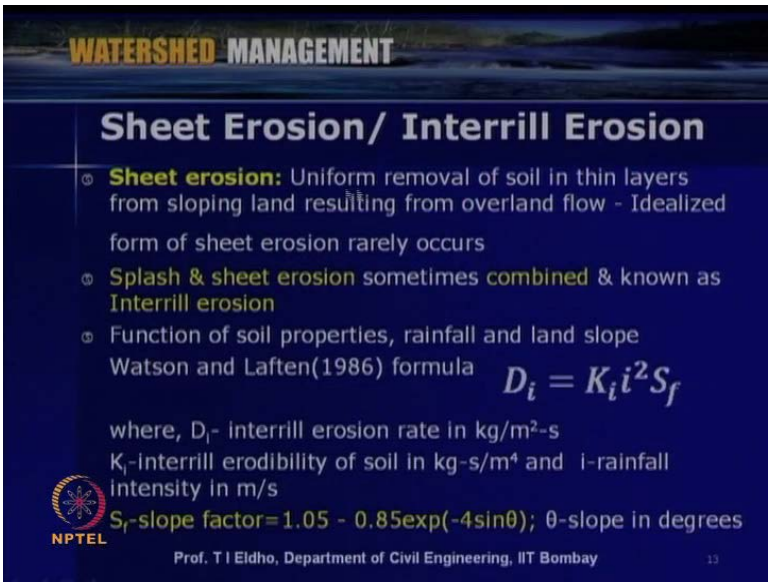

So, now let us look into the Sheet Erosion or the Interrill Erosion. So, Sheet Erosion means uniform removal of soil in thin layers from sloping, and resulting from overland flow. So, actually this is a an idealized type of an idealized form of sheet erosion very rarely occurs. So, generally say the intensity will vary from one location to another

location. So that way, the sheet erosion varies from one location to another location. So, it is the uniform, it is the removal of soil in thin layers.

Then next one is the combination of splash, and a sheet erosion sometimes combined together, and it is known as Interrill erosion. So, Interrill erosion is concerned, it is a function of soil properties rainfall, and land slope. So, Watson and Laften has derived an equation as shown here, D i is equal to K i i square S f, where d i is the Interrill erosion rate in kilogram per meter square second, and K i is the Interrill Erodibility of soil in kilogram second per meter to the power 4, and i is the rainfall intensity in meter per second. And here, S f is the slope factor which is defined as 1.05 minus point 0.85 exponent minus 4 sin theta, where theta is the slope in degrees.

So, like this depending upon the conditions - various conditions, and then a based upon various experiments. Some of the equations are derived by various researchers. So, what we have seen now is the sheet sheet erosion or Interrill erosion. So, now, let us look the next type of erosion, water water erosion called Rill erosion.

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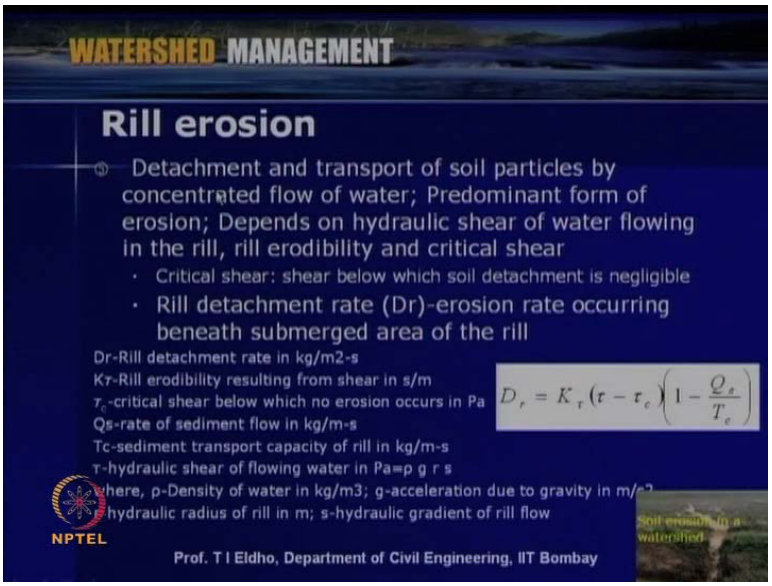

So, Rill erosion means detachment, and transport of soil particles by concentrated flow of water. So, you can see in this figure. So, here this is a watershed. So, due to heavy rainfall say, water is keep on coming from the various locations, and then finally a small small channels. And then, you can see that a soil particles particles concentrated soil

particles have detached, and then transported by a concentrated flow of water. So, this is one of the predominant form of erosion.

So, most of the watershed Rill erosion is one of the major cause type of soil erosion, and a Rill erosion depends on the hydraulic shear of water flowing in the Rill Rill Erodibility, and the critical shear. So here, critical shear means, shear below in which soil detachment is negligible. So, you can see that the especially, when the rainfall high intense rainfall is continuing, then the water is keep on coming from different direction, and then say the Rill erosion takes place, and that become a major cause of the soil erosion.

Then a Rill detachment rate D r - it is a defined as erosion rate occurring beneath submerged area of the Rill as shown here. So, an expression as reported by Raj Veer Singh is written here; D r is equal to K tau tau minus tau c into 1 minus Q s by T c, where D r is the Rill detachment rate, then K tau is the Rill Erodibility resulting from shear. And then tau c is the critical shear below which no erosion occurs, then Q s is the rate of sediment flow, then T c is the sediment transport capacity of the Rill. Then tau is the hydraulic shear of flowing water which can be written as rho g r s, where rho is the density of the water, g is the acceleration due to gravity, r is the hydraulic radius of the Rill which is considered, and s is the hydraulic gradient of the Rill flow. So, like this say we can have an relationship as far as Rill erosion is concerned.

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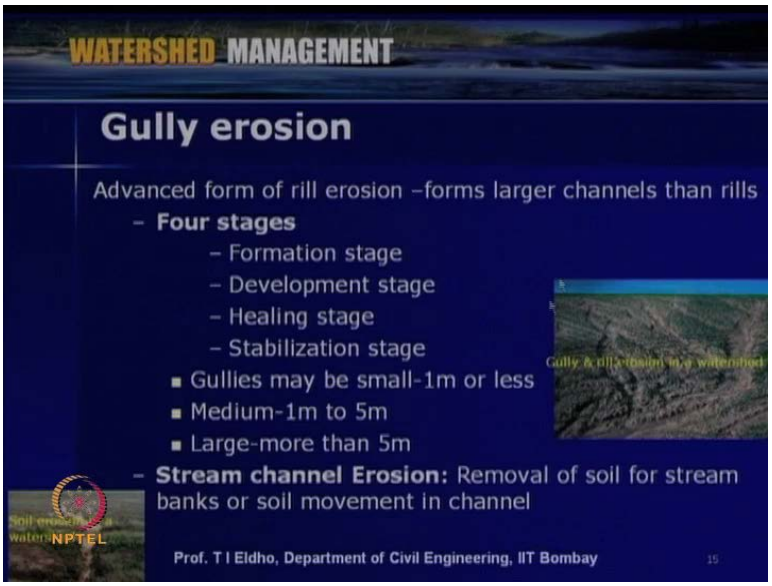

Now, another say important water - type of water erosion is Gully erosion. So, here this is a advanced form of a Rill erosion. So, forms larger channels, then small small rills you can see that, here this is a larger channel where the Gully erosion took place. So, the this is an advanced form of Rill erosions. So, which forms larger channels then rills. So, there can be Four stages as shown here, like a formation stage, development stage, healing stage, stabilization stage. So, like that.

So, depending upon the gully formation, we can have an formation stage, then development stage, healing stage, and stabilization stage. So, Gullies may be small like one meter or less or it can be medium from one meter to 5 meter or it can be large say like more than 5 meter. So, that is another important type of water erosion as far as soil erosion is concerned.

So, next one is a stream channel erosion. So, here now the water say, when the rainfall takes place say in a watershed. So, all the water comes to major stream through small small streams. So, due to the velocity of this flowing water, there will be erosion will takes place. So, that is so called an stream or channel erosion. So, this is the removal of soil from the stream banks soil movement in channel. So, that is called a stream or channel erosion. So that is, what is finally happening, and these stream or channel erosion that will be taking this sediments to the either to reservoirs or to lakes or to the oceans.

So, that way the different types of water erosion, what we have seen like a Interrill Rill erosion, then say Rill erosion, gully erosion, and the say channel erosion. So, now as far as water erosion is concerned, we can measure the the water erosion as soil loss.

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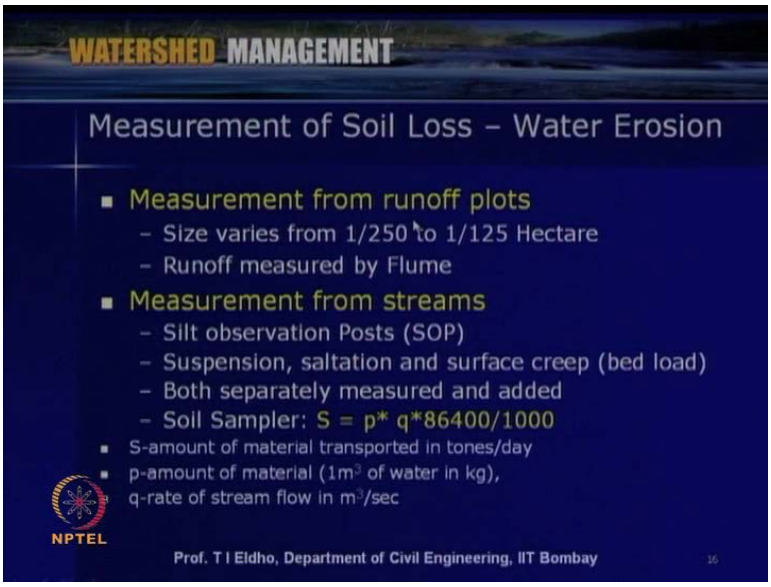

So, a measurement generally we can conduct as far as typical watershed is concerned, we can conduct experiments in a small say runoff plots like 1 1 by 250 to1 by 125 hector small size runoff plots, and then we can collect this the water flowing over. So, that we can collect the sediment. So, the runoff can be measured by Flume, and from that we can identify how much is the soil eroded as far as the water erosion is concerned.

And then in streams measurement can be done using silt observation post. So, this can be say the erosion, say in streams are concerned, it can be due to suspension, salutation, and surface creep like a bed load.

So, suspension, and bed load is concerned both separately measured and added together. Say for example, if you are doing sampling. So, we can take samples, and then identify how much will be the erosion takes place. So, say we can use this equation say for example, S is equal to p into q into 86400 divided by 1000, where S is the amount of material transport in tons per day, p is the amount of material, then q is the rate of stream flow in meter cube per second.

So, like this say, we can do sampling in a channels or rivers, and then from that we can measure how much will be a soil erosion say especially due to the water erosion. So, now, say we have seen as far as water erosion is concerned various factors, various causes, and then various types of water erosion also we have seen.

So, now say if you want to predict, say as far as a watershed is concerned or as far as area is concerned, many times we have to predict how much is the soil erosion taking place for an area or say for example, for a watershed is concerned. The different methodologies are available. So, one of the commonly used equation is called a universal soil loss equation.

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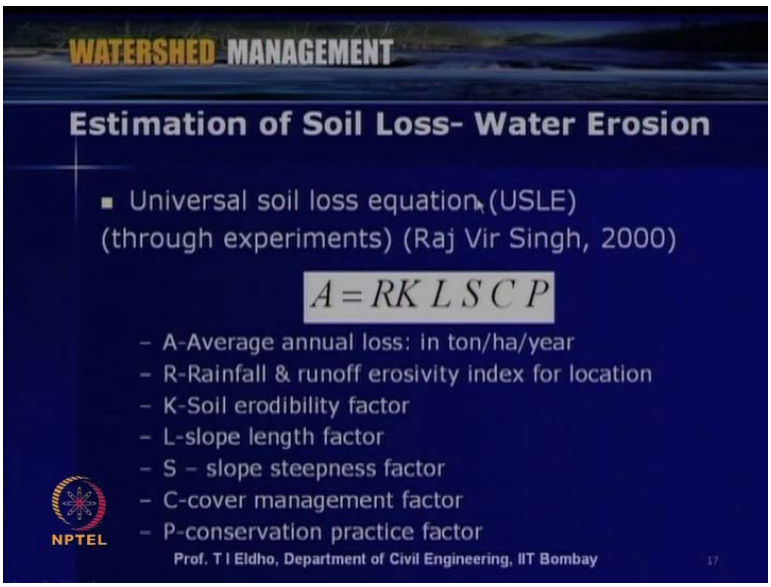

So, out of the many methodologies available, we will be briefly discussing one equation commonly used equation called an universal soil loss equation. So, this equation has been developed in a united states, through a large number of experiments. So, this is reported in various text books say for example, the various relationships here in this lecture is taken from the book of a Raj Veer Singh.

So, the relationship for the average annual loss in ton per hectare per year can be expressed as R into K into L into S into C into P. So, A is equal to R K L S C P. So, this equation is called a universal soil loss equation - USLE. So, this is one of the most commonly used equations as far as estimation of soil loss due to water erosion is concerned. Of course, numbers of modifications are available for this USLE, like modified USLE, revised USLE, etcetera.

But a basic equation is a relationship connecting the average annual loss with respect to the R, which is the rainfall, and runoff Erosivity index for the the geographical location

which we consider. Then K soil Erodibility factor, then L slope length factor, S slope steepness steepness factor, C cover management factor, and P a conservation practice factor. So, various relationships are available for this various factors, and based upon the watershed or based upon the area. We can assign values for each of these parameters, and then we can calculate or we can estimate the average annual soil loss using this universal soil loss equation, as far as water erosion is concerned.

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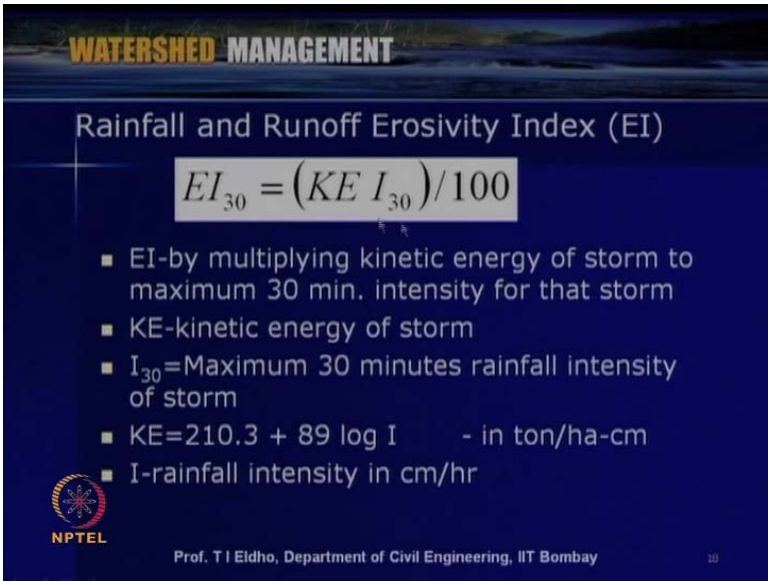

So, now let us see this various parameters like this R K L S C P is concerned various parameters, some relationships as defined in the book of Raj Veer Singh, let us see here. So, first one is a rainfall and runoff Erosivity index. So, that can be expressed as E I 30 is equal to K E into I 30 divided by 100, where E I is the E I is obtained by multiplying kinetic energy of storm and, to maximum 30 minute intensity for that storm. So, where K is the kinetic energy of storm, I 30 is the maximum 30 minutes rainfall intensity of the storm. So, where we can write this kinetic energy of the storm is we can write like this 210.3 plus 89 log I, in say where I is the rainfall intensity in centimeter per hour. So, this using this equation, we can find out the Erosivity index E I.

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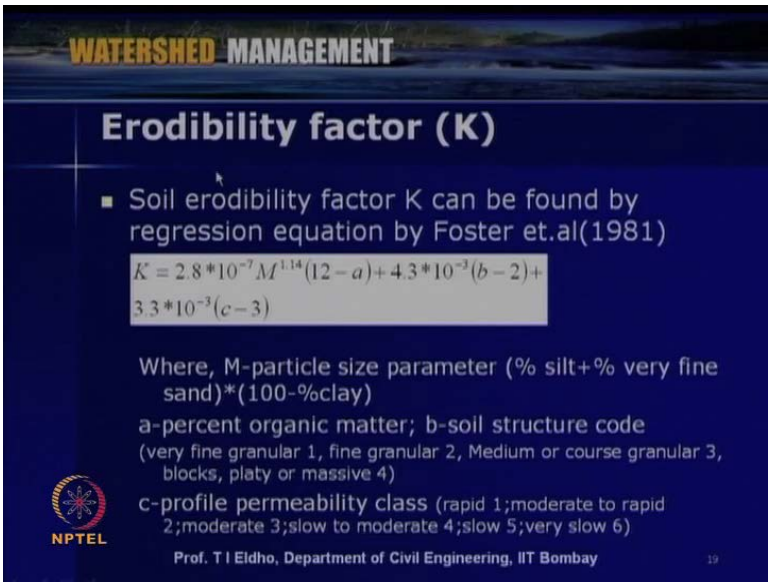

Then Erodibility factor K, it is indicates the soil Erodibility factor K can be found by regression equation as reported by foster, a number of equations are available one of the commonly used equation as reported by foster is written here. K is equal to two 0.8 into 10 to the power minus 7 M to the power 1.1 4 into 12 minus a plus 4.3 into 10 to the power of minus 3 b minus 2 plus 3.3 into 10 to the power minus 3 into c minus 3, where M is the particle size parameter like, percentage silt plus percentage of very fine sands into 100 minus percentage of clay. And then a is percentage organic matter, b is the soil structure code, say like very fine granular it can be one, a fine granular two medium or course granular three, then a blocks (( )) platy or massive it can be four.

And then here c is profile permeability class, like if a rapid profile one moderate to rapid 2, moderate 3, slow it to moderate 4, and slow 5 very slow 6. So, like that we can calculate the Erodibility factor K.

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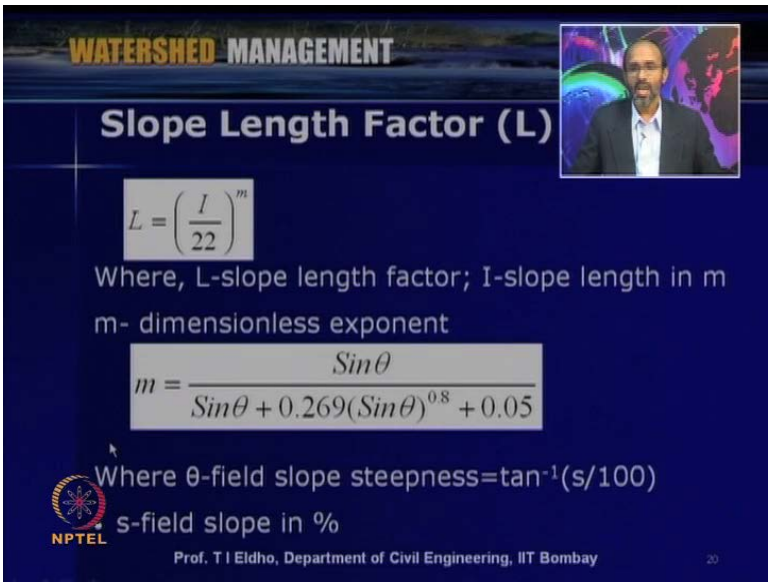

Then another important factor in the USLE is Slope Length Factor L. So, that is defined as L is equal to I by 22 to the power m, where L is the slope length factor, I is the slope length in meter, and m is the m is a dimensionless dimensionless exponent as defined by this equation. m is equal to sin theta divided by sin theta plus 0.269 sin theta to the power 0.8 plus 0.05, where theta is the field slope steepness which is expressed as tan inverse S by 100, where S is the field slope in percentage. So, using this equation, we can find the Slope Length Factor.

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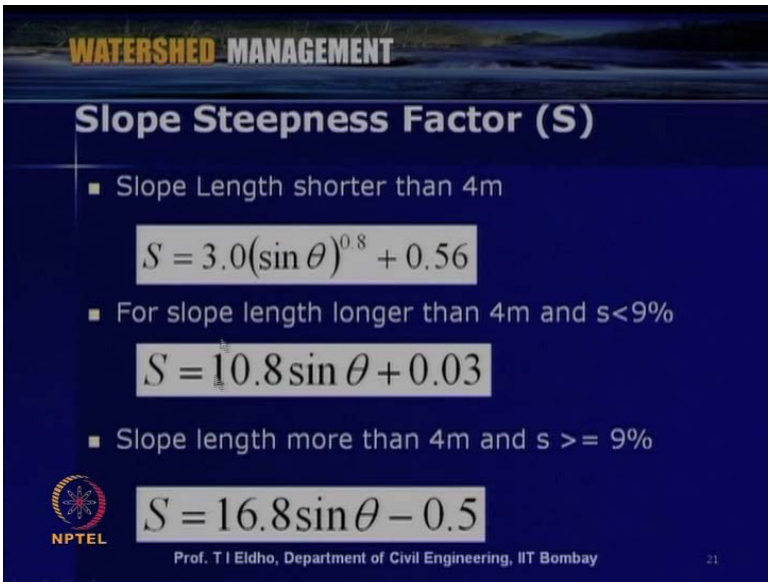

Then another factor is Slope Steepness Factor S. So, that is is say defined by various equation for various conditions like this. Slope length shorter than 4 meter equation is S is equal to 3 into sin theta to the power 0.8 plus 0.56. Then for slope length longer than 4 meter, and the percentage slope say field slope less than 9 percent, S is equal to 10.8 sin theta plus 0.0 3. And slope length more than 4 meter, and S is greater than equal to 9 percent; S is equal to 16.8 sin theta minus a 0.5. So, this give the Slope Steepness Factor.

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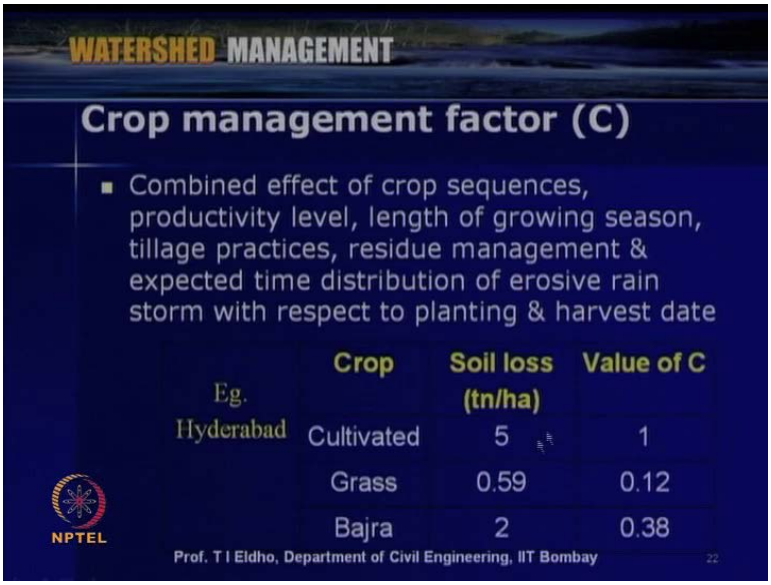

Then another important factor in the USLE equation is universal soil loss equation is Crop management factor C. So, that is it is combined effect of crop sequences, productivity level, length of growing season, tillage practices, residue managements, and expected time distribution of Erosive rain storm with respect to planning, planting, and harvest data with respect to planting, and harvest data.

So, this depends upon the locality say for example, say various textbooks gives this (( )) crop management factor that depends upon the locality, and the type of crop say for example, Hyderabad region. They crop for cultivated soil loss can be 10 per hector, it is 5 ton pen hector, and value of C is 1 for the grass region it can be soil loss can be 0.59, and value of C will be point 0.12, Bajra soil loss can be 2 ton per hector, and and the value of C can be 0.38.

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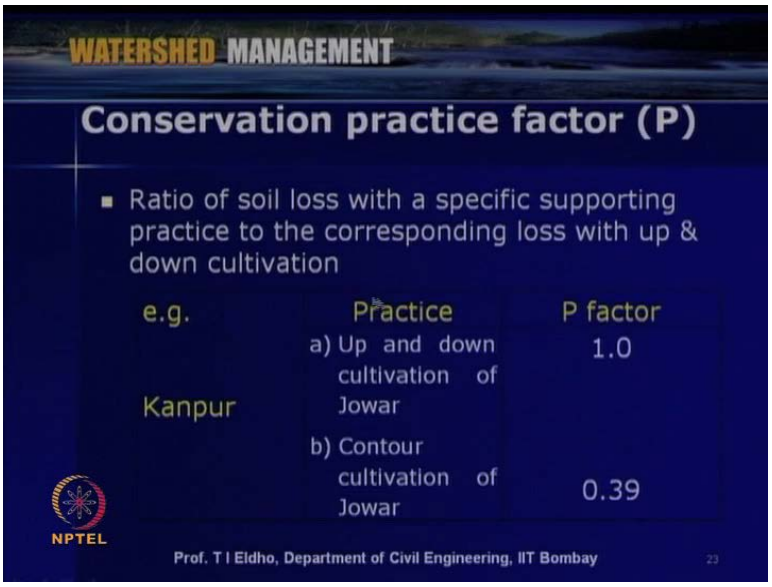

So, then another factor is Conservation Practice factor p, the USLE equation it is the ratio of soil loss with a specific supporting practice to the corresponding loss with up and down cultivation. So, this up be also depends upon the (( )) the geographical location, and the what kind of practice we adopt say for example, up and down cultivation of Jowar. The P factor is equal to one, then contour cultivation of Jowar it can be 0.39. So, this depends upon the practice, and the geographical location.

So, like this using the USLE which is one of the commonly used equation, we can estimate the water erosion, the soil erosion due to water. We can calculate for a given watershed. So, as I mentioned the modified USLE revised USLE different versions of this equations are available in literature. So, one of this equation, we can utilize to estimate how much will be the soil erosion taking place due to water within a watershed. So now, we will discuss the other importants type of erosion. So, one one is water erosion, second one is the wind erosion.

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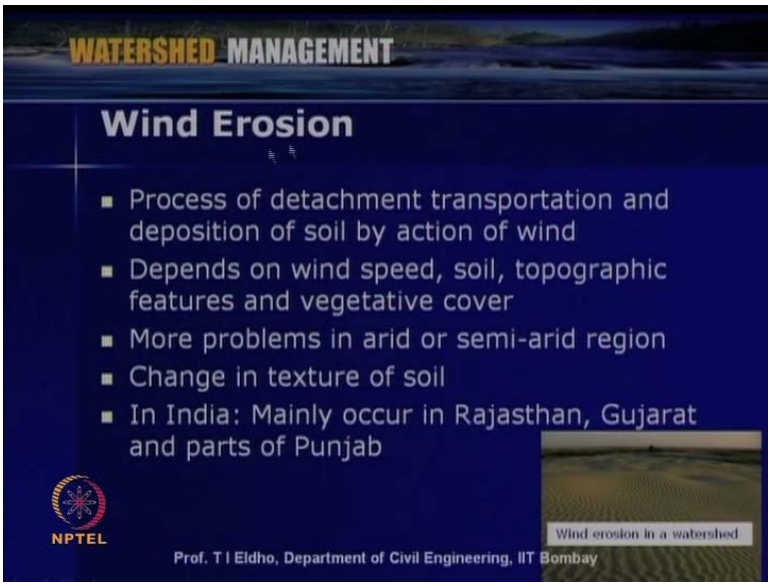

So, here let us discuss about the wind Erosion. So, wind erosion. So, it is a process of detachment transportation, and deposition of soil by action of wind.

So, in some of the areas, where the wind velocity is very high; the soil will be soil particle will detached, and then it will be transported, and when the wind velocity comes down, it will be deposited. So, you can see that say for example, in areas like Rajasthan desert areas, but the desert areas arid and semi arid regions, you can see that them are the wind velocity is higher, this sand will be taken by wind, and that it will be transported and then it will be deposited by action of the wind.

So, as (( )) it depends on the wind speed, the soil type Topographic features, and the Vegetative cover. So, if there is a good Vegetative cover, then the the it will be wind erosion will be reduced. So, as we can see that this major issue will be there in especially in arid, and or a semi arid region. So, this also depends upon especially especially depending upon what kind of soil, and a texture of soil. So, say for example, in India say this kinds of major wind erosion takes place in Rajasthan, Gujarat, and some parts of Punjab.

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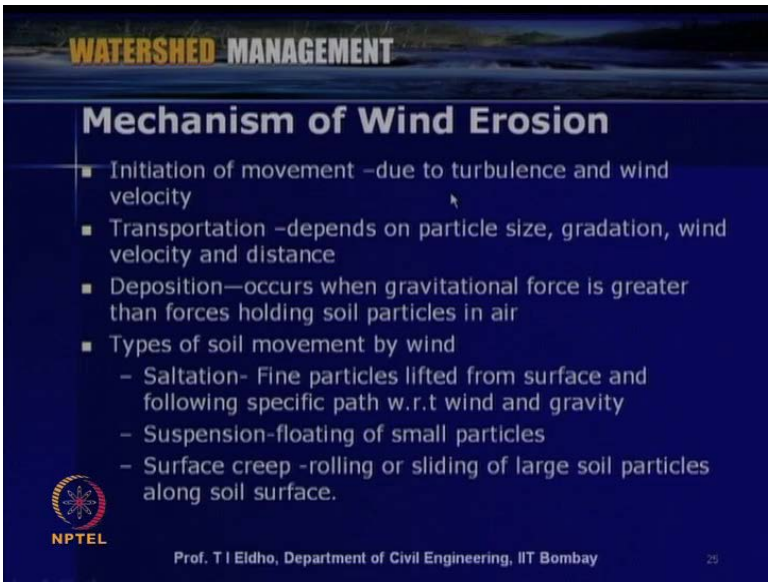

So, now let us look into the Mechanism of wind erosion, as far as wind erosion is concerned, the wind erosion first there is initiation of movement. So, this is due to turbulence, and a wind velocity. So, the when when the wind hit on the soil - the loose soil. So, due to the velocity, and then that the bit shear stress changes, and then the turbans. So, it will be transported.

So, next Mechanism initiation of movement, then next one is transportation. So, this depends on the particle size. So, if the soil particle is fine, then you can see that the transportation rate will be higher than gradation wind velocity, and the distance. Then third Mechanism is deposition. So, deposition occurs when gravitational forces is greater than forces holding soil particles in air. So, when the especially, when the wind velocity comes down, you can see that deposition takes place.

So, as far as types of soil movement by wind is concerned, here the various types are listed - first one is a saltation; saltation means fine particles lifted from surface, and following specific path with respect to winds, and gravity. Then second one is, suspension. So, this suspension means floating of small particles in the air media with respect to the wind, then surface creep. That means, rolling or sliding of large soil particle along soil surface. So, as we have seen for the water erosion. So, as far as wind erosion is also concerned, we can estimate the wind erosion by using various equation available in literature.

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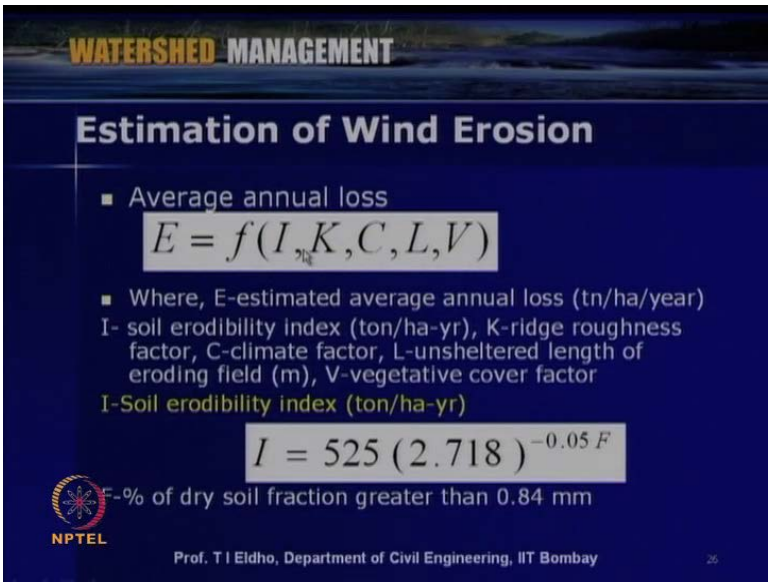

So, this wind erosion is concerned the average annual loss, we can generally represent as a function of E is equal to as a function of I, K, C, L, V; where E is the estimated average annual loss ton per hector per year, then I is the soil erodilibility erodilibility index, K is the ridge roughness factor, C is the climate factor, L is the unsheltered length of eroding field, then V is the Vegetative cover factor. So, say for example, I which is the soil Erodibility index, say some equations are available in literature. So, like I is equal to 525 into 2.718 to the power minus 0.05 F, where F is the percentage of dry soil fraction greater than 0. 84 mm.

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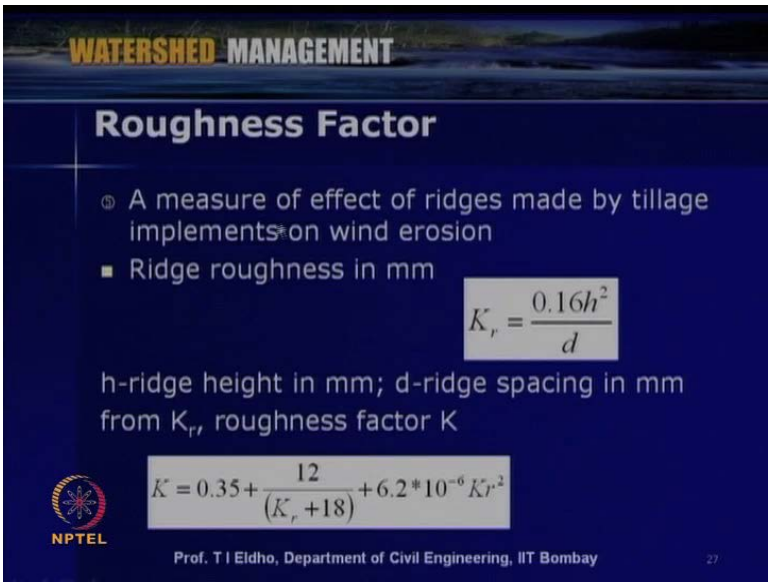

So, like that various relationships are available in literature. And then, say the other factor like roughness factor. So, it is a measure of effect of ridges made by tillage implements on wind erosion. So, ridge roughness, we can express as 0.16 x square by d, where h is the ridge height in mm, d is the ridge spacing in mm. Then an say K say K r we can obtained from the first we can calculate K r, and using this we can find out the roughness factor K. So, K K is equal to 0.35 plus 12 by K r plus 18 plus 6.2 into 10 to the power minus 6 into K r square. So, first we can calculate K r from which we can find the roughness factor K.

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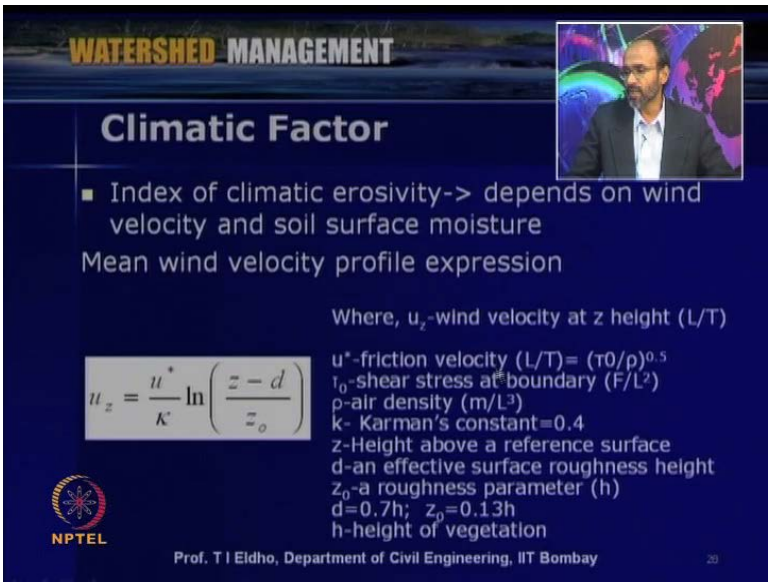

And then another important factor as far as wind erosion is concerned, it is climate factor- climatic Factor. So, this is an Index of a climatic Erosivity. So, this depends upon wind velocity, and soil surface moisture moisture. So, this depends upon the mean wind velocity profile. So, how the velocity varies from there as far as depthwise variation is concerned. So, if u is that is a wind velocity at z height, it can be mentioned as U z is equal to u star by kappa natural log z minus d by z 0, where u star is the friction velocity, and then tau 0 is the shear stress. So, this friction velocity we can write square root tau 0 by rho, and rho is the air density. Then kappa is the Karman's constant, z is the height above reference surface, d is the an effective surface reference height, z 0 a roughness parameter.

So, depending upon the location we can say define d is equal to 0.7 h, z is 0 is equal to 0. 13 h, where h is the if Vegetation is there, h is a height of Vegetation.

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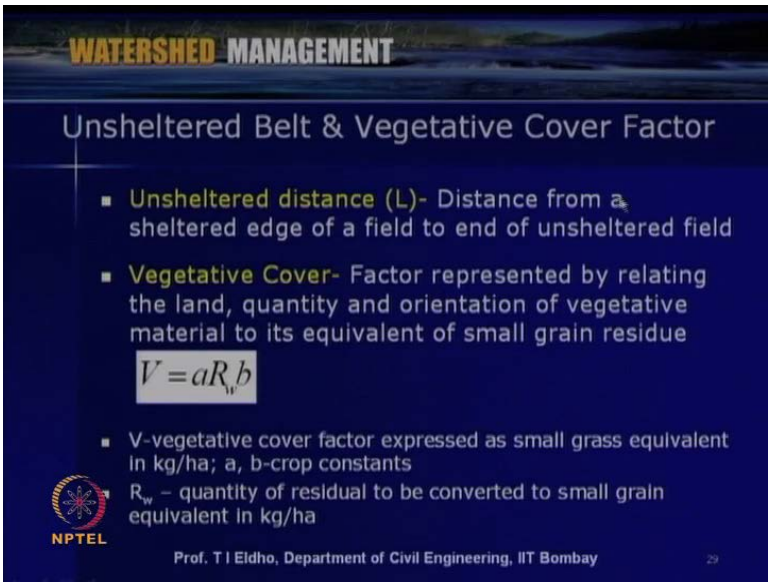

So, then another important factor in wind erosion is Unsheltered Belt, and Vegetative Cover Factor. So, unsheltered distance we can identify it is a distance from a sheltered edge of a field to end of unsheltered field. Then a we can identify this a Vegetative cover as a factor represented by relating the land, quantity, and orientation of Vegetative material to its equivalent of small grains residue as given by V is equal to a into R w into b, where v is the Vegetative cover factor expressed as small grass equivalent. Then a, and b are crop constants, and R w is a quantity of residual to be converted to small grain equivalent.

So, like this various parameters can be determined, and then we can calculate the wind erosion. So, two important erosions; one is the water erosion, and another one is a wind erosion. So, we have seen various relationships to estimate the soil loss, soil erosion due to the water and the wind.

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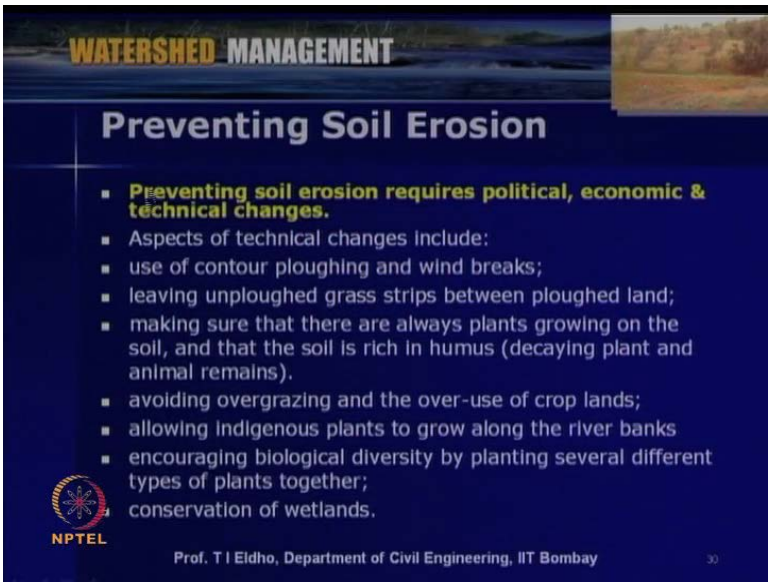

So, now let us see how we can prevent the soil erosion. So, some of the important points are listed in this slide. So, to prevent soil erosion. So, that requires say it is a, it requires political economic and a technical changes changes. So, they of course, the things what is to be done in the field is. So, the technical intervention, but say lot of say money is required for this, so that the economic reasons, and then political will power and then say how the administrative administrators can go for various soil erosion prevention.

So, which way we can implement it. So, accordingly it can be political political, economic, and technical changes. So, as far as technical changes are concerned. So, we can various measures are listed here, like use of contour ploughing and wind breaks; then leaving unploughed grass strips between ploughed land. Then making sure that, there are always plants growing on the soil, and that soil is rich in humus like decaying plant and animal remains. So, that erosion will be reduced.

Then avoiding overgrazing, and over use of crop lands, then allowing indigenous plants to grow along the river banks. So, that soil erosion will be reduced, then encouraging biological diversity by planting several different types of plants together. So, the advantage that if at different levels the plants are growing. So, that the effect of water erosion or soil erosion will be reduced, and then conservation of wetlands. So, these are some of the measures, which we can be adopted us to prevent soil erosion either the water erosion is concerned or the wind erosion is concerned.

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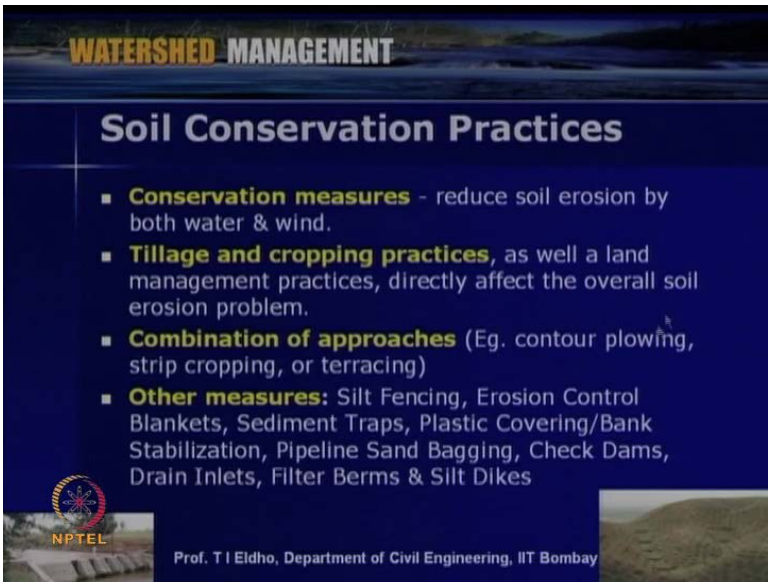

So, now a say final topic in this lecture, so let us looking to the various Soil Conservation Practices. So, the conservation practices, these are the measures to reduce soil erosion say by the major factors of water, and wind. So, what kind of measures we can adopt. So, various measures are possible. So, some of the important measures are listed here, like a Tillage and cropping practices as well as land management practices. So, this directly affects the overall soil erosion problem.

So, this is a direct intervention as in a watershed or in an area. So, the cropping pattern say according to the cropping pattern, the erosion can be have been found to be erosion has been found to be reduced.

Then Combination of approaches like a contour ploughing, then strip cropping, terracing etcetera. Then other measures like a silt fencing, erosion control blankets, sediment traps, plastic covering bank stabilization, pipe line sand bagging, check dams, drain inlets, filter berms, silt dikes, etcetera. So, there are… So, many measures available available as for soil conservation practices are concerned.

So, like check dam or contour bunding are say like a say how we can go for blankets or sediment traps. So, like that various measures can be introduced to reduce the soil erosion. So, that soil conservation conservation practices, depending upon the area depending upon the conditions available as for the concerned watershed. And of course,

the resources available we can go for say particular practice, which is suitable for that particular area.

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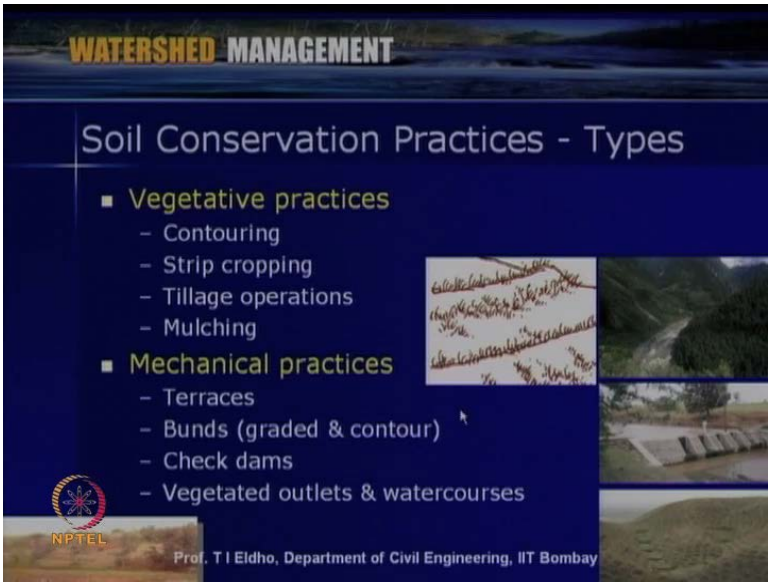

So, some of the soil Conservation Practice Types are listed here. So, mainly two types - one is the Vegetative Practices. So, that can be like a contouring. So, like that to be converse we can (( )) we can plant various types of Vegetation, then Strip cropping, then a tillage operations, merging. So, these are some of the Vegetative type of practices which we can adopt.

And then a next one is Mechanical practices. So, the Mechanical practices what can be done for soil conservation is construction on Terraces, Bunds like graded or and contour. Then like check dams, then a Vegetated outlets, and water courses. So, that the whatever soil is eroded that will be either hold there, and that the soil erosion problem will be reduced. So, like that as far as soil conservation practices are concerned; it can be Vegetative practices or the Mechanical practices. So, before closing today's lecture. So, let us have a look what is the Indian scenario as far as soil erosion is concerned.

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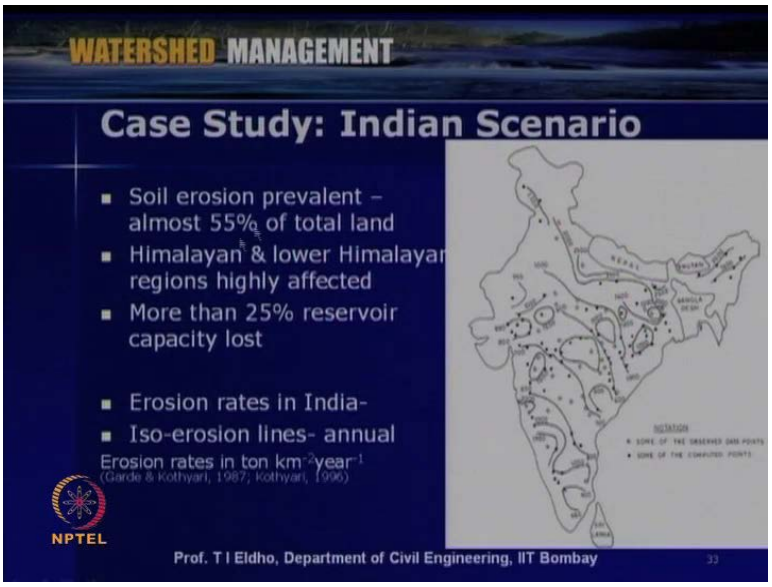

So, here say in this slide, the the the soil erosion rates in India is shown in terms of ISO erosion lines. So, soil erosion is a big problem in India. So, actually in the 1960s, and 1970s, and 1980s government of India implemented many programs to reduce the soil erosion problems, as in terms of soil conservation. So, almost 55 percent of total land is affected; especially Himalayan, and lower Himalayan regions highly affected by soil erosion. And say in say as far as major reservoirs are concerned more than 25 percent of the reservoir capacity as lost due to the sedimentation problems, and the soil erosion problems.

So, here this figure the shows ISO erosion lines. So, this the unit is a the erosion rates in ton per square kilometer per year. So, you can see that here say example here in 1000, here it is 1500, and this is a the Himalayan regions it is much higher.

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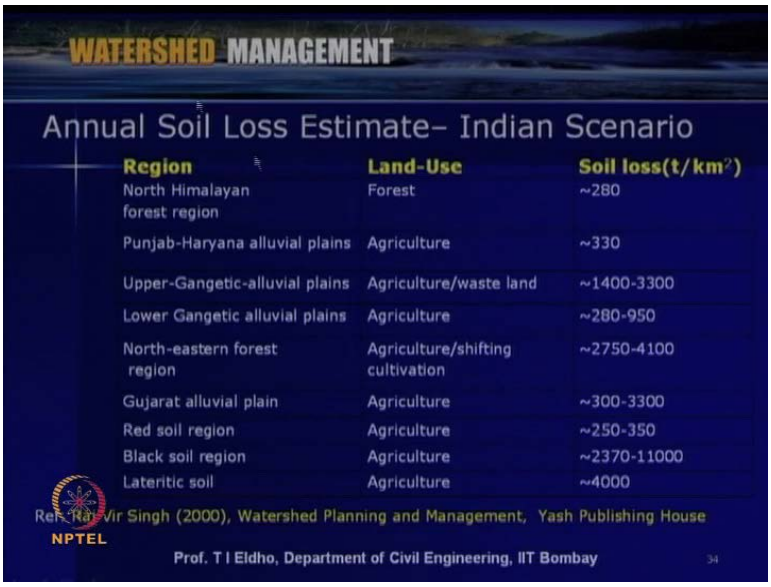

So, the next table shows for various Regions depending upon the land use, the soil loss in ton per square kilometers is listed, like a northern Himalaya, then a forest region, then Punjab, Haryana alluvial.

So, the here you can see that, where alluvial plane or the red soil region say alluvial plane, and then a black soil region the depending upon the land use especially in agricultural region, the soil loss is much much higher. So, this table is taken from Raj Veer Singh watershed planning, and management.

So, this is the scenario as far as India is concerned. So, in India the soil erosion is a major problem, soil conservation practices say say already going on in many locations. And now, soil conservation practice are part of the watershed management practices. So, some of the important references used in today's lectures, lecture is listed here.

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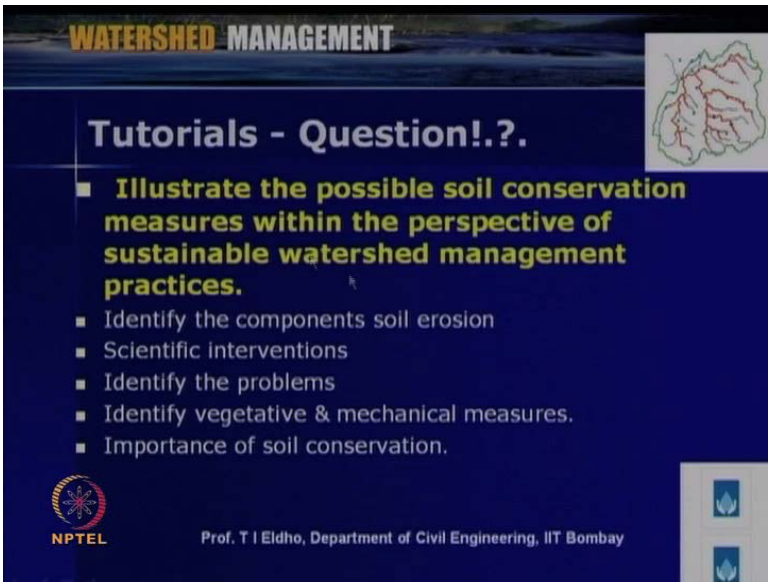

So, before closing today's lecture. So, some one Tutorial Question. So, Illustrate the possible soil conservation measures within the perspective of sustainable watershed management practices. So, you can identify the components of soil erosion, scientific interventions, identify the problems, identify the Vegetative Mechanical measures, importance of soil conservation.

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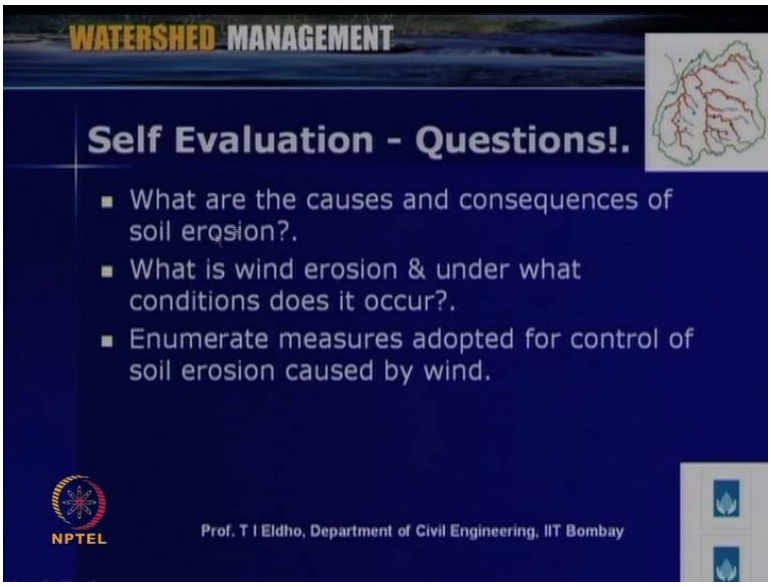

And few Self Evaluation Questions: Like what are the causes, and consequences of soil erosion. What is wind erosion, and under what conditions does it occur. Enumerate measures adopted for control of soil erosion caused by wind.

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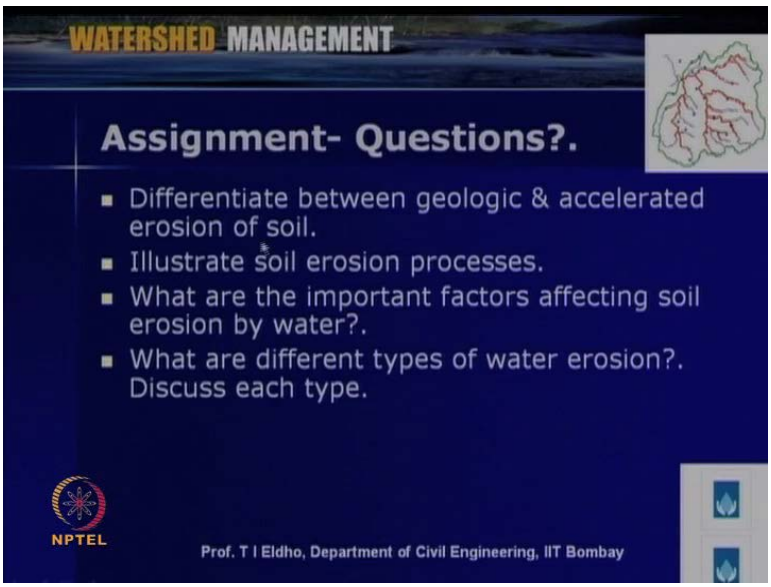

Then a few Assignment Questions: Differentiate between geological, and accelerated erosion of soil, illustrate soil erosion processes; what are the important factors affecting soil erosion by water. What are the different types of water erosion discuss each type.

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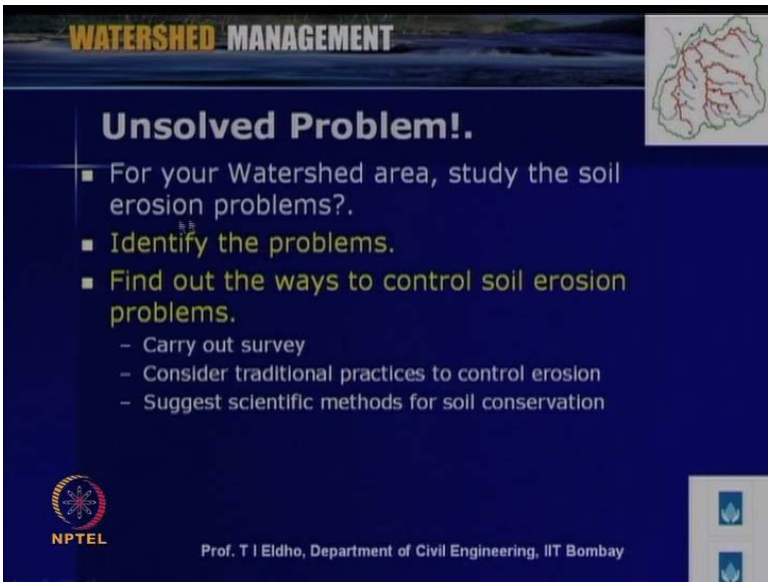

So, finally, one Unsolved Problem, as usual say or your watershed study the soil problems; identify the problems. Find out the ways to control the a soil erosion problems. So, you can carry out a survey, and then consider traditional practices to control the soil erosion, and you can suggest scientific methods for soil conservation in your watershed.

So, with this this lecture on soil conservation is over. So, we will discuss further the other aspects of say water watershed management practices in the a next lecture, thank you very much.