Soil Science and Technology
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Lecture – 42
Universal Soil Loss Equation

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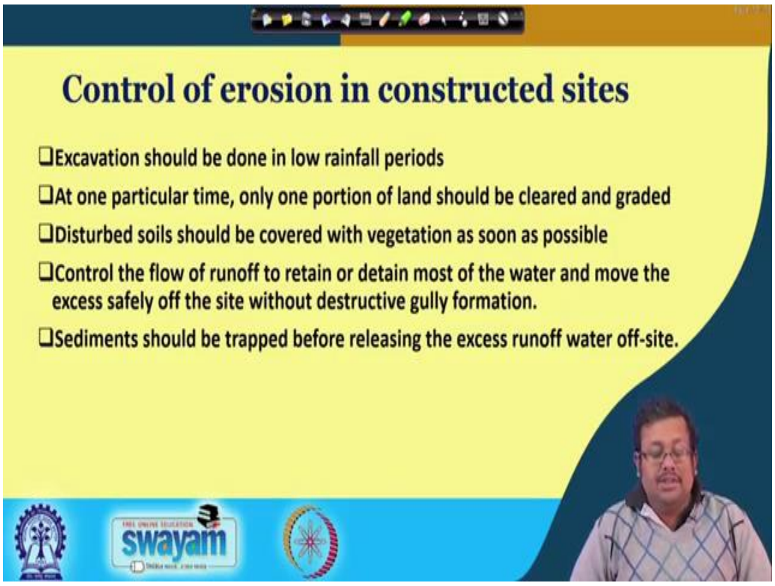

Welcome friends to this lecture of week 9 lecture of Soil Science and Technology. And in this lecture, we trying to finish this soil erosion and land degradation topic, and then we will be starting the universal soil loss equation. So, in the last lecture we are talking about the control of erosion in constructed sites and we talked about 5 different ways to control the erosion soil erosion at the constructed sites.

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So, let us see different types of ways to control this soil erosion in constructed sites, and these practices are generally performed in advanced developed countries and nowadays some of these practices are also started in Indian condition also. So, let us start with covering the exposed soil, you can see here, this instrument is called the hydroseeders which basically sprays a mixture of grass seed, straw, fertilizer, water and sticky polymers which ultimately established vegetation in that difficult to access areas.

So, this is another way to control the soil erosion and covering the exposed soil. These hydroseeders helps in the spraying the mixture of grass seed, straw, fertilizer, water and sticky polymers, and basically, ultimately you can see this established vegetation in the ultimately which develops in the difficulty access areas.

And, you know, erosion control mats are also another way of fighting this, you know, water soil erosion. At the constructed site you can see, these are the erosion control mats which are spreaded, you know, which are spreaded and these are basically these mats are basically made up of jute and these basically holds the soil and seed in place until the vegetation is established.

So, this is also very much important which helps in reducing the movement of soil from one place to another place. So, these hydroseeders and erosion control mats are important ways to fight against the water erosion, and other type of erosion movement of soil particles from one area to another area.

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So, also you can control the stream bank erosion, we know, here this is an example of controlling the stream bank erosion, you can use, you know, hard and soft armors, you know, hard and soft armors will basically use to control the stream bank erosion.

So, these are the rocks and armors which are, you know, present to ultimately lessen the impact of water moving through this water body. And this is another example, this is avoiding of gully erosion you can see here large rocks are used to control the off-site, you know, effects of gully erosion in bare soil. So, these are called rip-rap ultimately and these are grass sods, so ultimately it helps in controlling the, we know, gully erosion in bare soil and so.

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So, these are some of the ways to control the soil erosion and again the trapping the sediments you can see here, we are using the straw in the end of the site to slow down and these are the straws in the end of the site. So, slow down and lets runoff while retaining the sediments, and here you can see this is another trapping sediments.

So, it is a sediment retention pond this is sediment retention pond and the pipe at the upper ends, you know, allows excess water to flow out. So, basically, you can see there is an inflow of water from this place, the water carrying all the sediments. So, it deposited here and ultimately when the water level rises above a certain point, this is the pipe at the, this is a pipe through which the excess water flows, you know, flows down or flows out leaving all the sediments.

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So, these are example of trapping the sediments. So, these are couple of ways to control these the soil erosion ok. So, what are the other means of soil land degradation? Obviously, mass wasting is another means of soil degradation and it is basically the downhill movement of unstable soil along the regolith. And basically it is of 3 types, one is soil creep, second is mud flow and third one is land slide. In case of soil creep, it is basically slow and downward movement of soil curving the trees and mud flows are basically partial liquefaction of soil and their moderately rapid movement due to loss of cohesion and landslides are basically sudden shear failure and causing rapid downhill movement of the soil.

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So, in the next slide you will see the pictures of this 3 different process. The left one shows the soil creep in UK England and this second word shows the mud flow in Colombia. And finally, the third one is land slide; and land slide is very much visible throughout the world and this land slide can also be visible extensively in different hilly areas of India.

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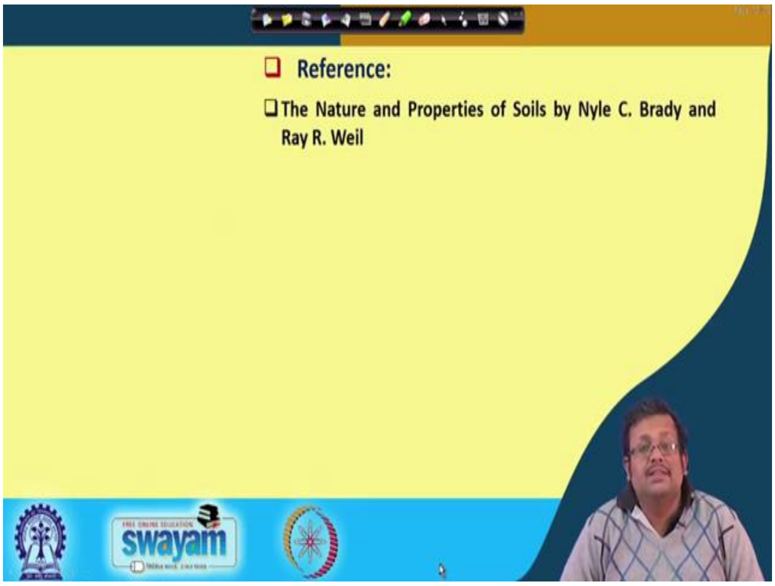

So, guys we have finished this lecture or the finished this topic of soil erosion and land degradation the next topic we will be cover we will be starting is universal soil loss equation.

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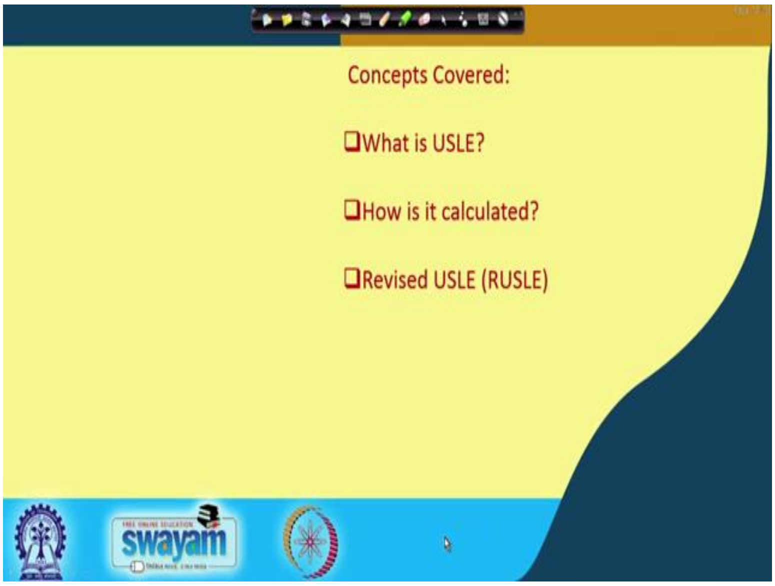

And in the universal soil loss equation we will be covering this concepts, first of all what is universal soil loss equation, and how we calculate this universal soil loss equation and what is the revised universal soil loss equation.

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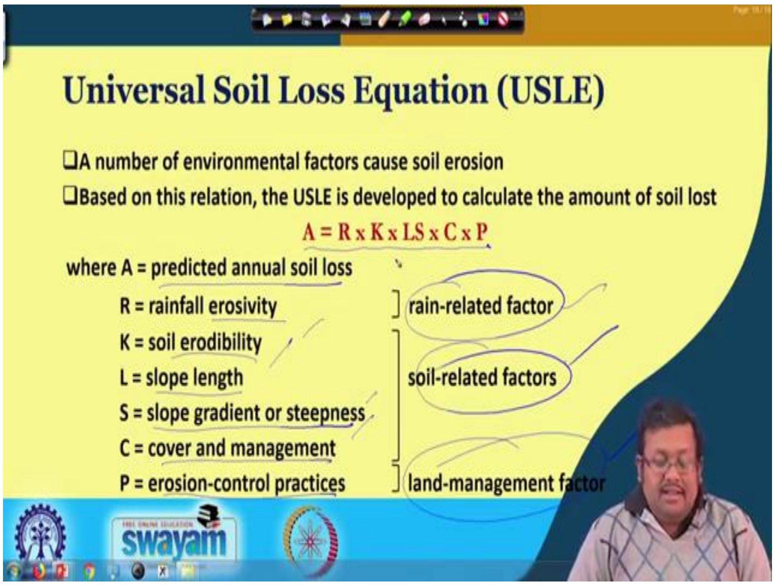

So, let us start with the universal soil loss equation. So, you can see, it is a basically you remember if you unless, you know. Now you have understood that a number of environmental factor causes soil erosion it is not only the water, not only the wind different types of other practices management practices in the field are also important for, you know, soil erosion.

So, based on these relation, these universal soil loss equation is developed to calculate the amount of soil loss and this is basically these A equal to the the equation is A equal to R into K into LS into C into P. Where A is the predicted annual soil loss and, R stands for rainfall erosivity, K stands for soil erodibility and, L stands for slope length, S stands for slope gradient or steepness and C stands for cover and management and P stands for erosion control practices.

So, rainfall erosivity is basically comes under rain related factor whereas, soil erodibility then, slope length then, slope gradient or steepness and cover and management basically comes under soil related factors and these erosion control practices comes under the land management factor. So, you can see here basically, we are considering both rain related factors, soil related factors and land management factors while calculating the annual soil loss in the universal soil loss equation. So, let us see a details, how we can, we know, what are the different factors.

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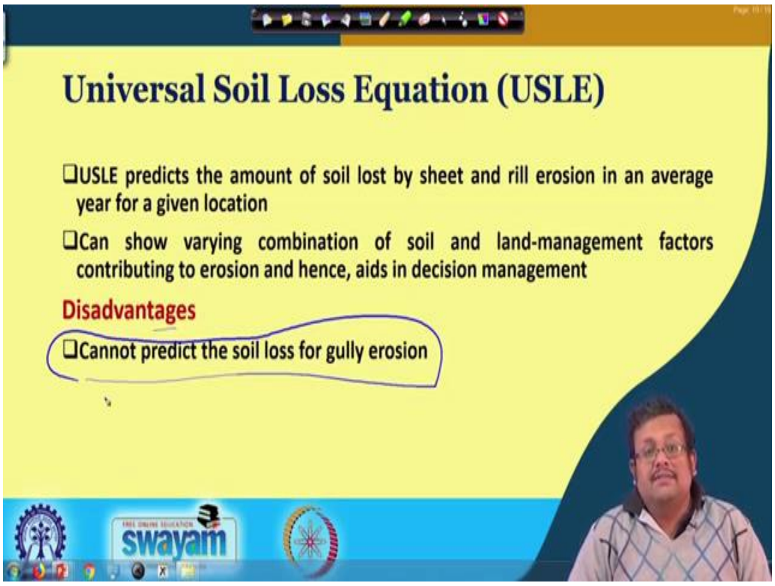

So, this universal soil loss equation basically predicts the amount of soil loss by sheet and rill erosion in an average year for a given location. So, that is fine. So, this we use this universal soil loss equation to predict the amount of soil loss through, you know, by sheet and rill erosion we know about the sheet erosion, we know about the rill erosion remember the sheet erosion when there is a sheet of soil being lost as a result of water activity, and it basically occurs at the higher slope and higher position of the, you know, of a slope land and ultimately the rill erosion is the creation of small channels through which water moves the soil sediments.

And this universal soil loss equation is helpful for calculating the about of soil loss by sheet and rill erosion in an average year for a given location and it can show varying combination of soil land management factors contributing to erosion. And hence, aids in decision management as we have seen it is considering both soil factors and their land management factors as well as rainfall factors for calculating the total soil lost. And the final and the also there is a disadvantage and the disadvantage is basically, it cannot predict the soil loss for gully erosion. So, this is the disadvantage of universal soil loss equation.

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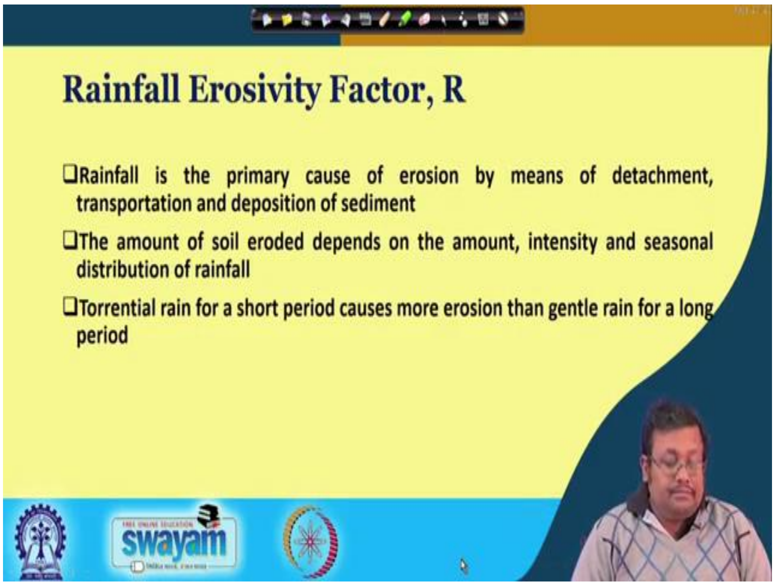

So, let us go ahead and see individual factors in this R K L S P. So, let us start with the rainfall erosivity factor. So, rainfall erosivity factor or R is, you know, is an important factor for calculating the soil loss. So, remember that rainfall is a primary cause of erosion by means of detachment, transportation and deposition of the sediment. And the amount of soil eroded depends on the amount, intensity and seasonal distribution of the rainfall. Obviously, when there will be torrential rain for a short period of, you know, time that will cause more erosion than gentle rain for a long period.

So, you can see not only the amount, but also the intensity is also very important for creating the soil erosion and also seasonal distribution of rainfall if it is evenly see, you know; obviously, the soil erosion will be different when they are concentrated at a particular season or they are evenly distributed throughout the year.

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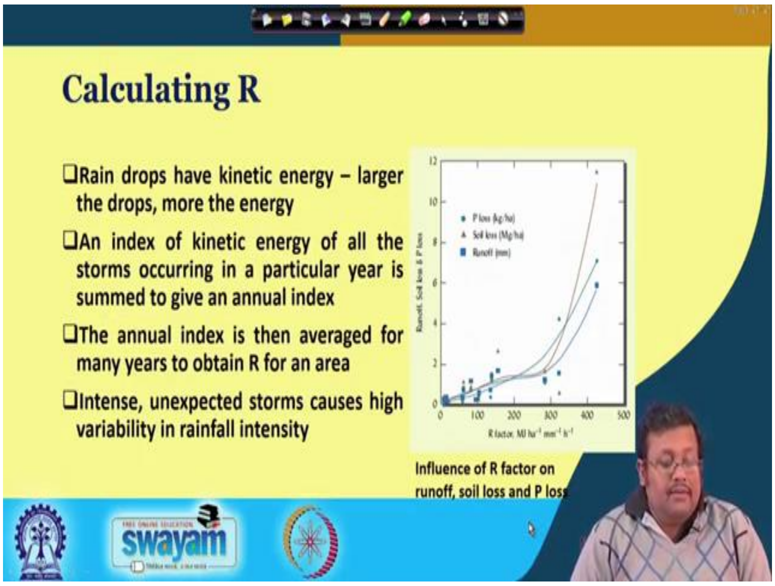

So, we have covered the R. now how to calculate the R. So, rain drops have obviously, rain drops have kinetic energy and obviously, larger the drops means more the energy. So, it is an index of kinetic energy of all the storms occurring in a particular year is summed to give an annual index of R. So, the annual index is then averaged for many years to obtain R for an area and intense unexpected storm causes high variability in rainfall intensity. So, that is how R is basically calculated.

So, you can see the, this shows the influence of R factor or runoff soil loss and P loss. So, as you can see in the x axis the R factor is given and R factor is quietly, you know, increasing in this direction. And in the y axis, runoff is basically shown. So, as R factor is continuously increasing the runoff is getting increased not only the runoff is getting increased, but also simultaneously soil loss is increasing and also phosphate loss in kg per hectare is also increase, increasing; because in case of runoff the soil moves from one area to another area including the nutrient. So, you can see with the increase of runoff, R factor obviously, the runoff of soil and phosphorous, you know, soil, and as, you know, runoff, soil loss and phosphate loss also increases simultaneously.

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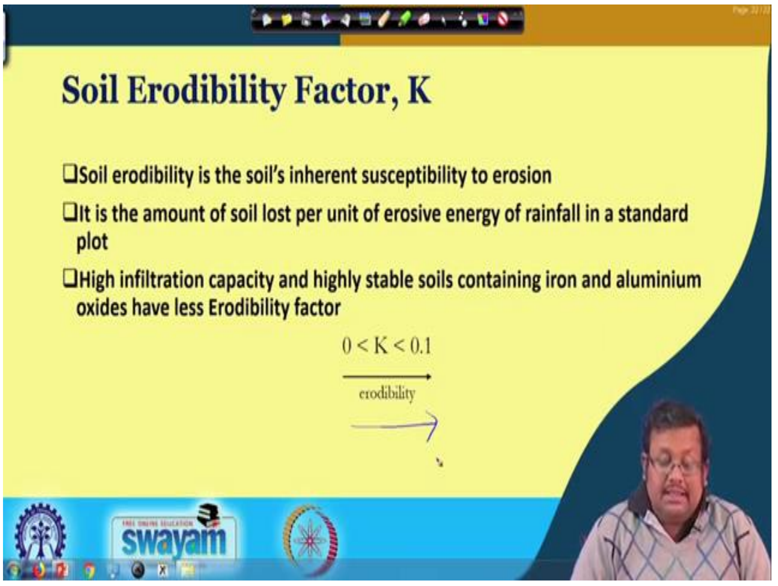

So, the second factor is soil erodibility factor or K factor, and soil erodibility is the soil inherent susceptibility to erosion. Remember that, it is the amount of soil lost per unit of erosive energy of rainfall in a standard plot and high infiltration capacity and high stable and highly stable soil containing iron and aluminium oxide have less erodibility factor. So; obviously, this erodibility factor varies from 0 to 0.1. And this erodibility increases we know when in these direction; obviously, the erodibility increases in this direction. So, when it is 0; obviously, less erodibility and when there is 0.1 it shows the greater erodibility and this is the soil erodibility factor.

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Now, how, we know, soil erodibility factors also depends on several, you know, several aspects. For example, there are several factors which increases K or less resistant to erosion or factors reducing K are also there. So, let us first discuss what are the different factors which increases K the value of K; that means, increases the erodibility. For example, high silt and low sand, sorry, high silt and sand content. The second is expansive clay, third is presence of impervious soil layers, fourth one is blocky and platy and massive soil structure. So, high silt and sand content; obviously, the water holding capacity will be less.

And obviously, the detachment will be much more pronounced in this case of silt and sand content because there is no cohesive force or there is no attachment or formation of aggregates due to the absence of clay or, you know, organic matter. Now the presence of expansive plays the presence of expansive clays like 2 is to 1 montmorillonite is an example for less resistant erosion.

Because whenever they dries they creates a creates, we know, different types of large cracks and as a result there is always a chances of erosion. Then presence of impervious soil layers and this blocky, platy massive soil structure it helps, you know, it, it basically hinders the movement of water into the soil and as a result there is the excess of water goes for runoff goes through runoff and ultimately, we know, eroding away the soil.

So; obviously, when there is a blocky, platy or massive soil structure there will be less water movement and the water will be moved away through runoff and creating more soil erosion. And factors there are several factors which reduces the K and ultimately increases resistances to erosion are soil or high organic matter; obviously, when there is a high organic matter that will increase the infiltration of water into the soil and as a result of that, there will be less amount of runoff.

Then is non expansive clay, you know, expansive expansive clay and like, you know, kaolinite is an example of non expansive clays which helps in reducing the soil erodibility. And finally, the strong granular structure; obviously, they help in more water movement it is and as a result there is a less erodibility of soil.

So, these are different factors which are responsible for either increasing or decreasing the soil erodibility.

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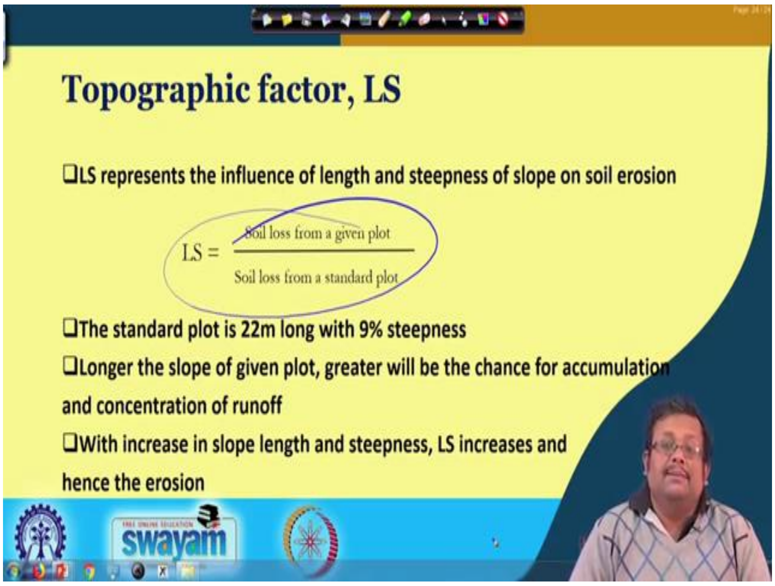

Let us see the topographic factor, the topographic factor is basically denoted by L and S, and LS represents the influence of length and steepness of the slope on soil erosion. Obviously, you can see the LS can be calculated by using this formula, where soil loss from a given plot over soil loss from a standard plot, and the standard plot is obviously, 22 metre 22 metre long with a 9 percent of steepness. And longer the slope of given plot, greater will be the chance for accumulation and concentration of runoff and with increase if the slope length and steepness LS increases and hence the erosion.

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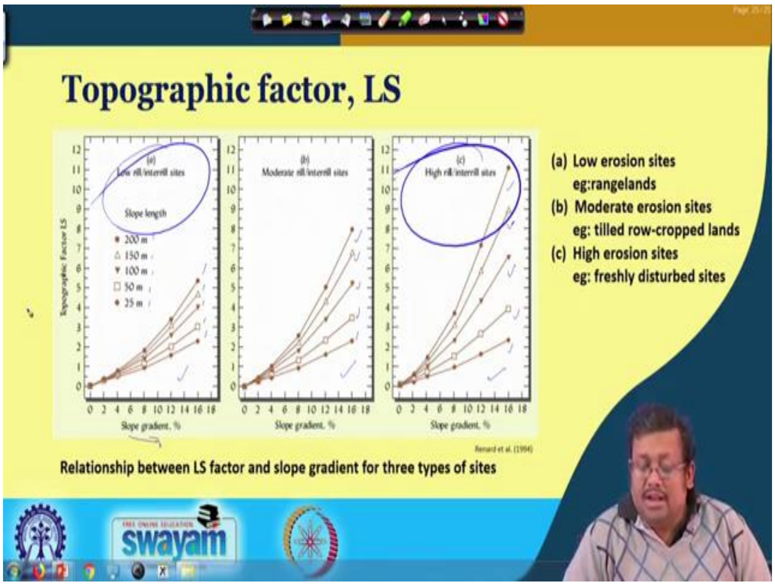

So; obviously, when the increase in the slope length the L factor increases and also when there increase in the steepness, that is S factor, these LS increases and ultimately increasing the soil loss or soil erosion. So, let us see the relationship between LS factor and slope gradient for 3 types of sites. You can see here, there are 3 types of site, one is low erosion sites, that is rangeland and the second one is the moderate erosion site that is tilled row cropped lands. And finally, there is a high erosion lands that is a freshly disturbed sites.

So, in all these cases you can see here, as we increase the slope gradient; obviously, at the slope length these are basically slope length 25 metre, 50 metre, 100 metre, 150 metre, 200 metre. For all this cases with the increases of the slope gradient, you know, the topographic factor LS is continuously increasing, because, we know, both the slope gradient is increasing as well as the slope length that is L is also increasing. So, ultimately the topography factors is also increasing in all this 3 condition.

So, for example, it is a 25 metre slope length then, 50 metre then, 100 metre, then 150 metre. So, and then, 200 metres. So, it is quite expected. Similarly, here you can see it is for 25 metre then 50 metre then, 100 metre then, 150 metre and 200 metre. And in case of freshly disturbed soil; obviously, we will have the same trend where is the 25 metre then, 50 metre then, 100 metre then, 150 metre and 200 metre.

However, you will see that the slope is quite high in case of high rill and interrill sites as compared to low rill and or interrill sites or in other words a high erosion sites the erosion or the LS factor will show the steeper increase as compared to the low erosion sites or rangelands.

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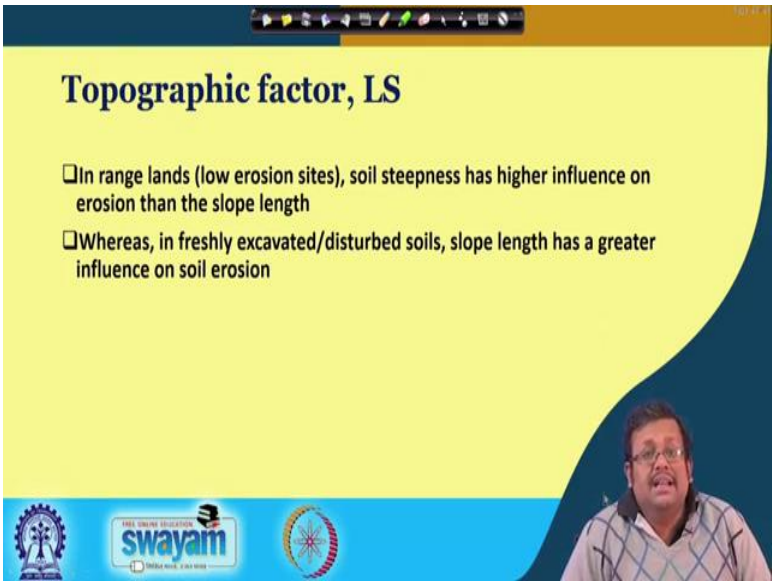

So, remember that in range lands or low erosion sites, soil steepness has high influence on erosion than the slope length and. So, that is why, we know, whereas, freshly excavated disturbed length slope length has a greater influence on soil erosion. So, that was quite, we know, quite, you know, evident from this 2 different plots for example, in this case slope gradient is more important here the slope length is more important.

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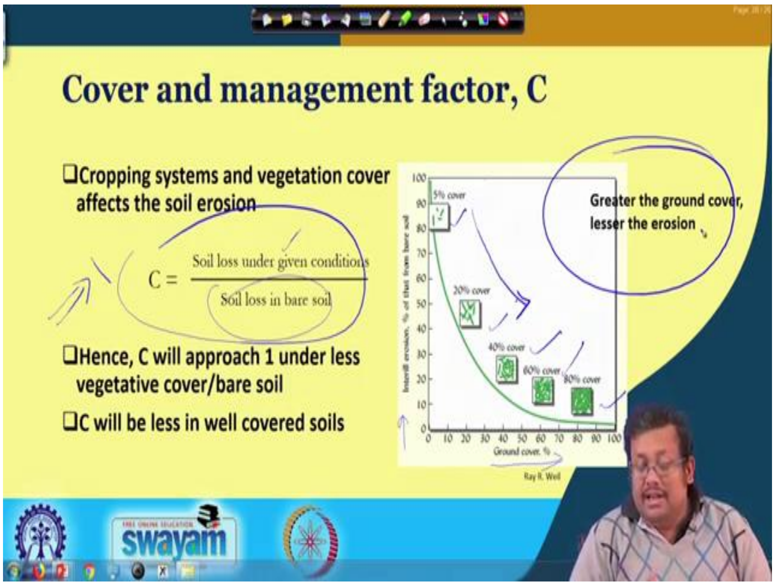

So, the another factor is C factor. So, C is basically cover and management factor which basically shows, you know, cropping, you know, how much, you know, what is the percentage of soil cover is present. So, you can see cropping system and vegetative cover affects the soil erosion. And this C is basically calculated from this formula, where C equal to soil loss under given condition over soil loss in bare soil. And you can see here, C will approach 1 under less vegetative cover or bare soil. So; obviously, it will it will tends to 1 when there is both soil loss and bare soil in both these 2 condition and C will be less in case of covered soil.

So, you can see here the relation between the ground cover percentage and erosion. So; obviously, the erosion continuously decreases or exponentially decreases when the increase there is an increase in ground cover as we can see where is a 5 percent cover then, 20 percent cover then, 40 percent cover then, 60 percent cover and, 80 percent cover. So, ultimately the idea of showing this graph is to convey this message that greater the ground cover, lesser is the erosion. So, as the ground cover increases; obviously, there will be lesser erosion.

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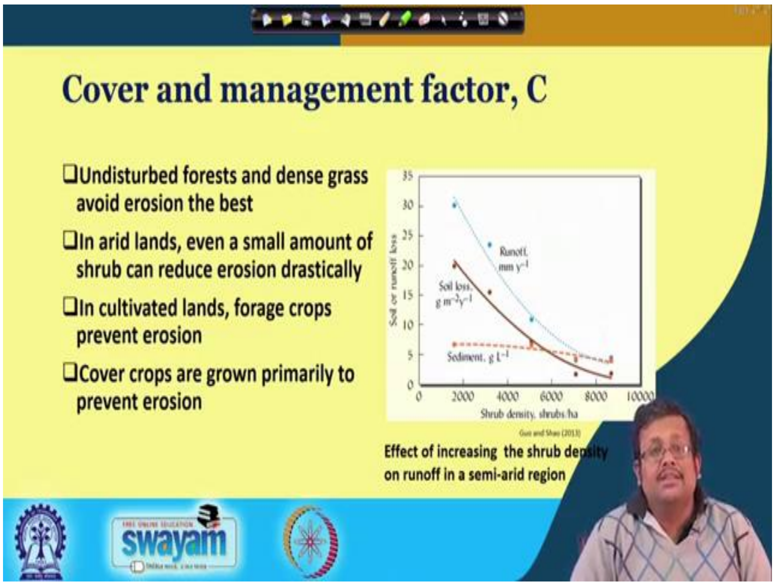

So, also remember that undisturbed forest and dense grass avoid, you know you know, they avoid erosion at the best obviously, undisturbed forest.

So, you will see less amount of runoff with that with those areas which are covered with forest as well as dense grass. And in arid lands even a small amount of shrub can reduce erosion drastically, because in arid lands most of the soil are, you know, are susceptible to erosion high amount of erosion, because there is very; very low amount of soil organic matter ultimately, you know, exposing all the soils to the erosive action of either rainfall or wind either water or wind.

So, in arid lands even a small amount of shrubs that can help in, you know, erosion reducing the erosion dramatically with drastically, because they will help in attaching more soil particles and, you know, resisting the their movement through runoff. And in cultivated lands, forage crops can prevent erosion and finally, cover crops are grown primarily to prevent the erosions

So, you can see this is an effect of increasing the shrub density on runoff in a semi arid region. So, in the X axis basically it is a shrub density, and per hectare and; obviously, soil in y axis this is soil and runoff. So, you can see here as the shrub density increases; obviously, the soil loss is decreased exponentially, runoff also decreased exponentially and also sediment also decreases so obviously, the increasing a shrub density has a greater impact it reducing the soil loss or runoff and sediment and, ultimately preventing the soil erosion.

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So, you can see gully erosion in a bare soil; obviously, in the left picture you can see, you know, this is a gully; gully erosion is a, sorry, this is a gully erosion in a bare soil and water is muddy as it carries the soil and here you can see clear water channel in a grass covered soil. This is a another strategy to reduce the surface runoff because, we know, we call it grass channels or grassed water ways and this grassed water ways ultimately helps in removing, ultimately helps in preventing the movement of water, sorry, movement of, movement of soil particles along with the runoff water.

So, these are an effective management practice for reducing the soil loss through water erosion.

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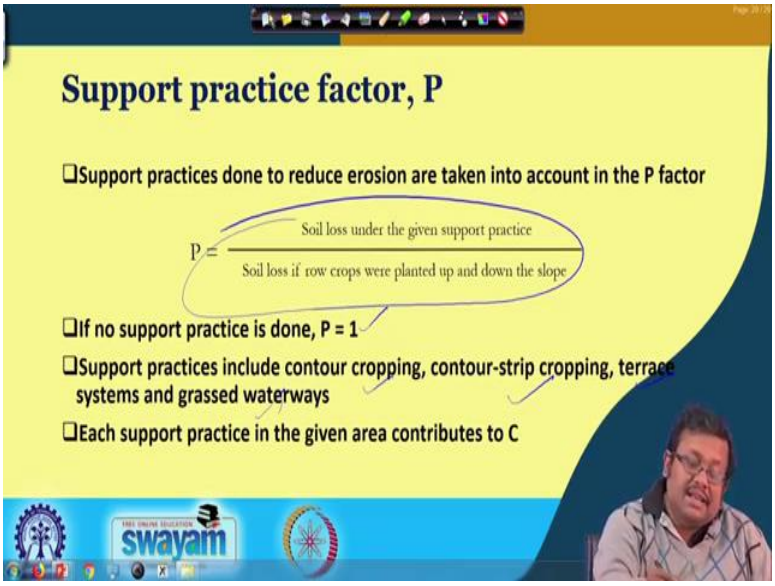

So, let us go ahead and see, what is the P factor or support practice factor? So, support practice are done to reduce the erosion and also taken into account in the P factor. So, P factor basically calculates by using this equation where P equal to soil loss under given support practice over the soil loss if row crops were planted up and down the slope.

So, if there is no support practice is the; obviously, the P factor will be 1, and if the support practice in, you know, is there, this support practice generally include contour cropping, contour strip cropping, terracing and, you know, terrace systems as well as grassed water ways. So, you know about the contour cropping, I showed you in the last lecture and then contour strip cropping then terracing I have already showed you in the last lecture. And; obviously, I have shown you just the grassed water ways, and each support practice in the given area contributes to this C factor also.

So, these are the important factors which are responsible for calculating the universal soil loss equation.

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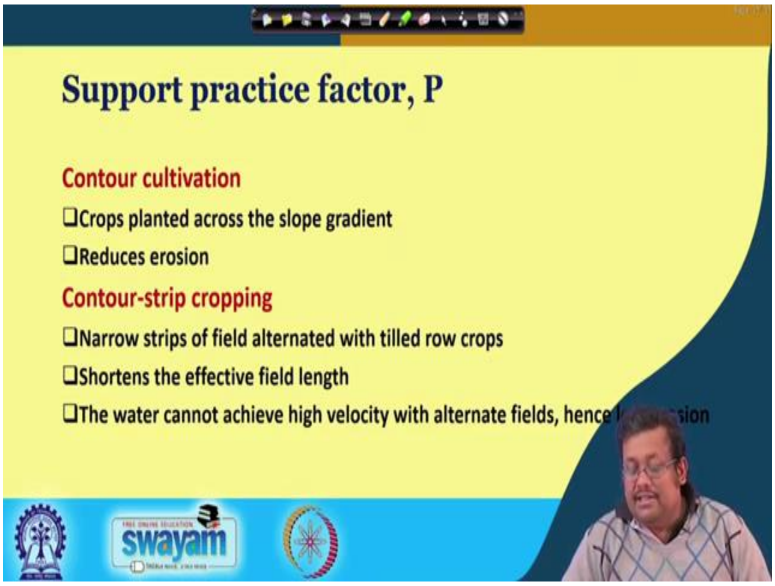

So; obviously, the contour cultivation; obviously, crops are planted across the slope gradient to reduce the erosion. And in the contour strip croppings, narrow strips of field alternate with tilled row crops and it basically shortage the effective field length and the water cannot achieve high velocity with alternate fields hence less erosion. So, these are the, features of contour cultivation as well as contour strip cropping.

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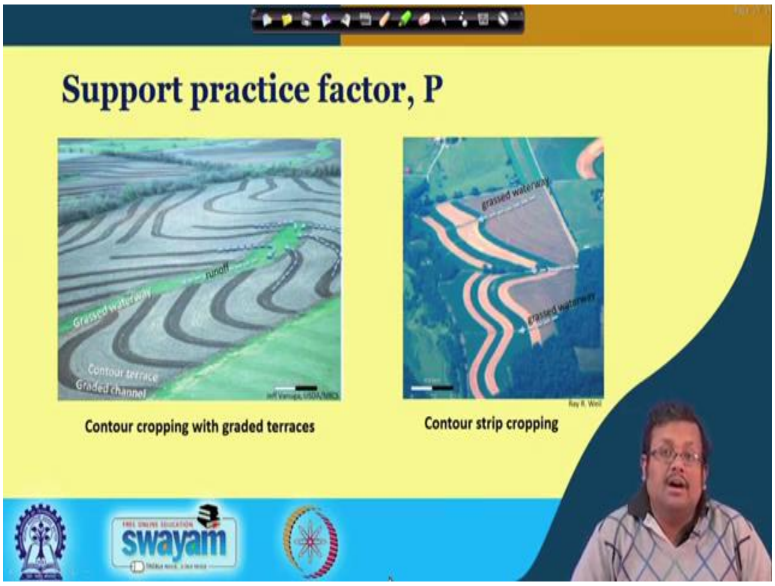

So, these are the pictures of contour cropping with graded terraces you can see here graded terraces.

So, it is the grassed water way and. So, this is the grassed water way and runoff is moving here, and these are the contour terrace and graded channels. And; obviously, this is an example of contour strip cropping; obviously, the grassed water ways these are the grassed water ways and both these practices are very; very helpful for reducing the soil loss through erosion by water agents.

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So, grassed water ways let us talk about more in, let us talk more about the grassed water ways. So, grassed water ways, you know, contour strips are augmented by grassed water ways you can see here in the left picture this is a, we know, there is no grassed water way; however, in the right picture there is a grassed water way and you can see the difference in mud flow in these two conditions. And these, we know, grassed water ways consist of permanent sods established in shallow channels as we can see here and they carry water from the field without creating the gullies. So, they are very; very helpful for preventing the gully erosion.

Because they help in reducing or restricting the movement of runoff which carries away soil particles and ultimately creates the gully erosion.

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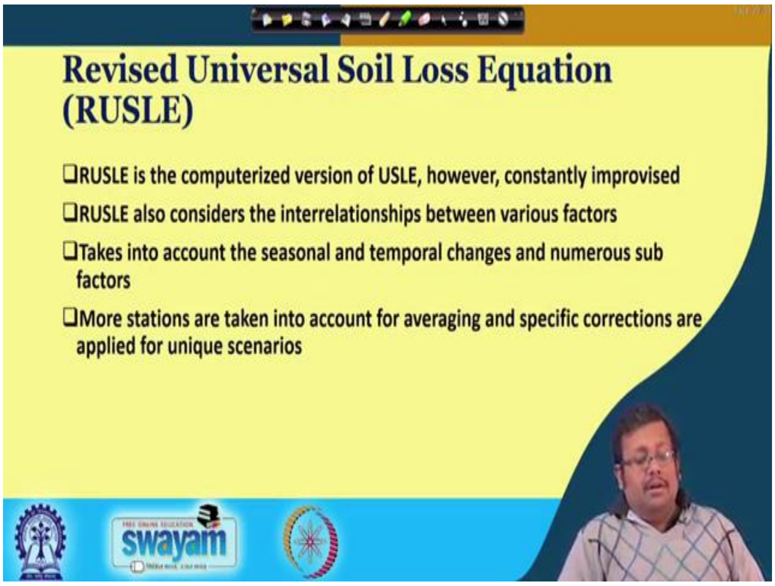

So, there is a another Universal Soil Loss Equation, we call it revised universal soil loss equation or RUS RUSLE or this RUSLE or RUSLE is the computerized version of universal soil loss equation, however, constantly, you know improvised. And these revised universal soil loss equation also considers the interrelationship between various factors and it takes into account the seasonal and temporal changes and numerous sub factors. And; obviously, more stations are taken into account for averaging and specific corrections are applied for unique scenarios.

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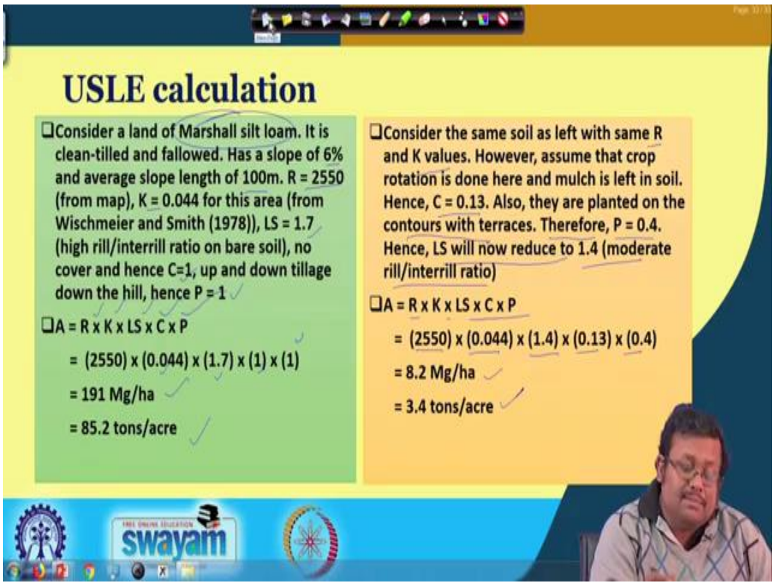

So, let us see the universal soil loss calculation and subsequently the revised universal soil loss equation calculation. So, if we consider a land of Marshall silt loam. So, it is a particular soil, soil series and it is clean tilled and fallowed. It has a slope of 6 percent and average slope length of 100 metre. R is 2550 from map we can already, we have already got it. And K is 0.044 for this area from Wischmeier and Smith scale, and LS factor is 1.7 high rill or interrill ratio on bare soil, and low cover and hence C is 1 and upper down tillage down, up and down tillage, down the hill and this P equal to 1.

So, we will all know the factors. So, basically we will be putting all these values in this universal soil loss equation. So, you can see R values we have put 2550, K stands for 0.044, LS stands for 1.7, C stands for 1, and P at, P is basically 1. So, we are ultimately getting 191 mega gram per hector or 85.2 tons per acre

So, let us consider the same thing with the revised universal soil loss equation. So, the, let us consider the same soil as left with the same R and K values. However, assume let us assume that the crop rotation is done here and mulch is left into the soil. Hence C values will change from 1 to 0.13. Also, they are planted on the contours with terraces. So, this also being take, you know, we are taking also taking this into account. So, therefore, P is basically right now 0.4 instead of 1.

So, LS will now reduce to 1.4 that is moderate rill to interrill ratio. So, ultimately using the same equation R K L S C and P, we will be getting this 2550 multiplied by 0.044, then 1.4 then, 0.13 into 0.4. So, we are getting 8.2 mega gram per hectare. So, ultimately it is 3.4 tons per acre. So, you can see that using the revised universal soil loss equation, we take into account different aspects or different, you know, we we can take into account different management practices or modification in the management practices.

And you can see the ultimately the quantified amount is different in both universal soil loss equation and revised universal soil loss equation. So, guys we have finished this lecture and let us wrap up here, we know, I hope that you have learned something new in this lecture and in the next lecture, we will be starting discussion about the conservation tillage and till then good bye and let us meet in the next lecture of week 9.

Thank you.