Digital Elevation Models and Applications
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Lecture - 16
DEMs Based Surface Hydrologic Modelling-2

Hello everyone and welcome to digital elevation models and application course. This is 16th lecture and we will continue where we left earlier, about the surface hydrologic modelling, based on digital elevation model. So, in the previous lecture what we have discussed that how to do this modelling, by first filling the digital elevation model, removing the sinks local pits and other than flow direction, flow accumulation drainage network and stream ordering. These things we have already discussed.

Now, we will proceed in this one, and there are few more derivatives of a surface hydrologic modelling, based on digital elevation model we can derive and the major one is the flow length. As a as you can see that the flow length of an rotary pixel is determined by summing the incremental distance from centre to centre of each pixel, along the flow path from the selected pixel to the outlet pixel.

So, this flow length is calculated, and this is used for various purposes which we will see little later. Flow length can be calculated in two directions; either upstream or downstream distances, or we can also bring some weight, may be along the as a impedance, and this weighted distance can also be included, while calculating upstream or downstream for. And this is calculated for each cell, and a the major use of this flow length output from a surface hydrologic modelling is to calculate the length of longest path flow within a given basin. So, which one would be the longest or in reverse we can say which is the shortest path of a given basin or catchment.

We can calculate. And this measure is often used to calculate the time of concentration of a basin. So, in a flood related studies, this is very important, that what would be the situation of flow of water along particular length or stream or maybe at the outlet. So, this we will see in little detail. And this upstream if we take the example; like flow length upstream option.

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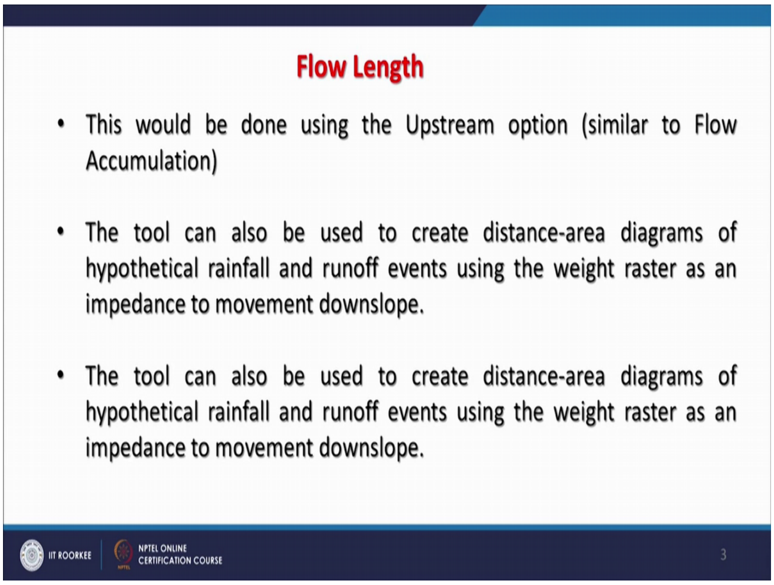

Flow Length

- This would be done using the Upstream option (similar to Flow Accumulation)
- The tool can also be used to create distance-area diagrams of hypothetical rainfall and runoff events using the weight raster as an impedance to movement downslope.
- The tool can also be used to create distance-area diagrams of hypothetical rainfall and runoff events using the weight raster as an impedance to movement downslope.

If we choose, it is just like a flow accumulation which we have already discussed, and this also flow length output can be used to create a distance area diagram and of hypothetical rainfall and runoff events. So, we can stimulate, do some modelling work here, using the weight ah, raster some ah, some raster maybe a soil cover, maybe a land use cover as an impedance to the movement towards the down slope side or downstream side. And this output the flow length can also be used to create distance area diagram of hypothetical rainfall and runoff events, using weight raster.

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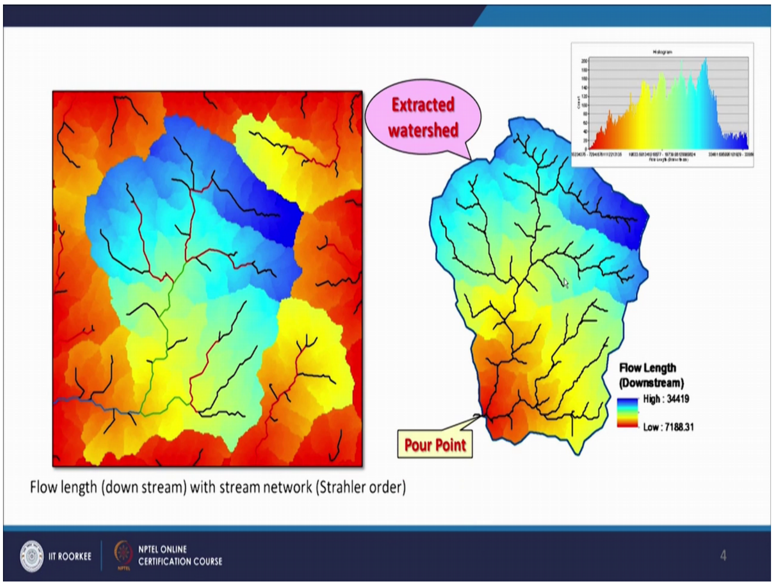

Flow length (down stream) with stream network (Strahler order)

And other thing. Let us say take this example here the same digital elevation model, which we have been using earlier for a surface hydrologic modelling, on which this downstream flow length has been calculated and as you, and top of this stream network, which is a having a strahler order has been overlaid just to depict the different flow lengths, and when we have extracted this one, what we can see here; that a at the outlet the flow length is very little or very less as compared to the flow length at the boundary, especially at the watershed boundary.

So, this is how, because this downstream flow length basically at the outlet, it should be zero, and this is what we will see here this is distribution of flow length in form of histogram, as we can see here that this ah, the highest flow length which is depicted in blue colour are having a some representation here, but the maximum is this light blue colour and so on so forth and that pour point as indicated earlier is here.

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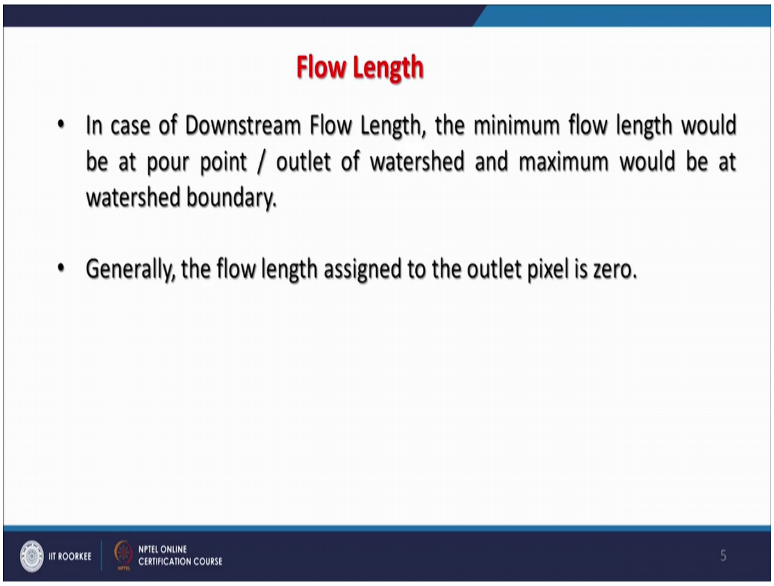

Flow Length

- In case of Downstream Flow Length, the minimum flow length would be at pour point / outlet of watershed and maximum would be at watershed boundary.
- Generally, the flow length assigned to the outlet pixel is zero.

So, in case of downstream flow length as the example we have just seen, the minimum flow length would be at the pour point, or out the outlet of the watershed or catchment and the maximum would be, would be at the watershed boundary, and generally floor length assigned to the outlet pixel is zero. So, theoretical it should be zero at the outlet, and when it rains, in within that basin or catchment, a drop of water ah, you know getting or landing somewhere in the basin, must first travel some distance before reaching the outlet.

So, that will give us the basically the flow length, and assuming constant flow velocities, because this is modelling. So, some assumption have to be there one assumption is that each drop, has to flow, another assumption here that the flow velocity will be constant ah. So, that a the pixel with the greatest flow length to the outlet represents hydrologically most remote pixel. So, the one which is having highest length that water or that drop is coming from the maximum, must have travelled the maximum length, and the flow length Ah is divided by flow velocity, represents a representative lag time for the basin, and as I have mentioned that this flow length is used in the flood forecasting or flood modelling.

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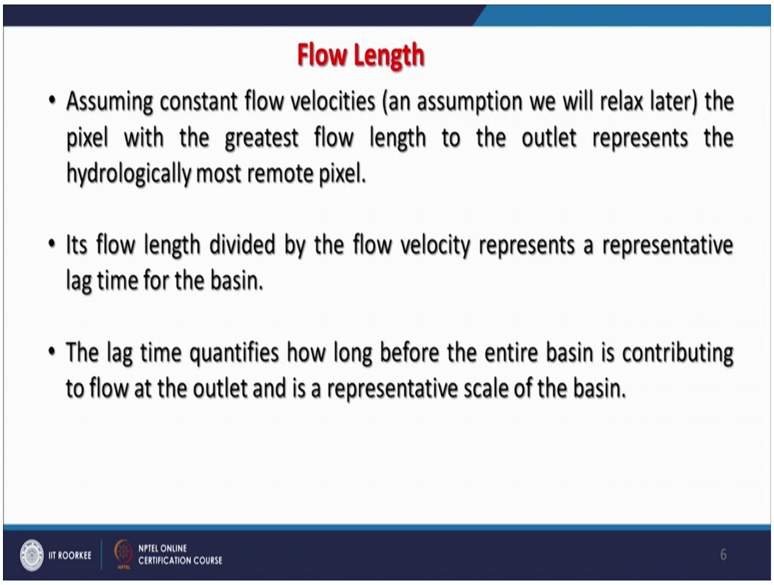

Flow Length

- Assuming constant flow velocities (an assumption we will relax later) the pixel with the greatest flow length to the outlet represents the hydrologically most remote pixel.
- Its flow length divided by the flow velocity represents a representative lag time for the basin.
- The lag time quantifies how long before the entire basin is contributing to flow at the outlet and is a representative scale of the basin.

So, there it can play very important role, and this lag time quantifies how long before the entire basin is contributing to flow at the outlet and is representative scale of the basin.

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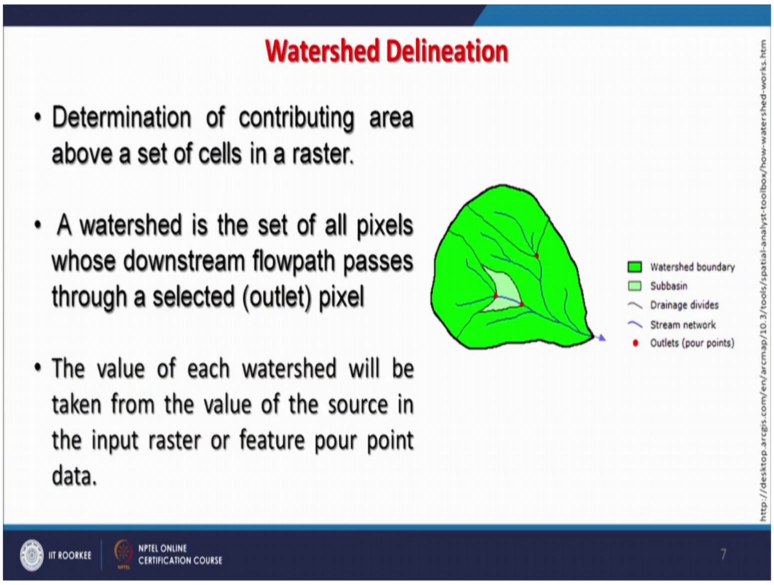

Watershed Delineation

- Determination of contributing area above a set of cells in a raster.
- A watershed is the set of all pixels whose downstream flowpath passes through a selected (outlet) pixel
- The value of each watershed will be taken from the value of the source in the input raster or feature pour point data.

http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/how-watershed-works.htm

Now, the next thing which we can do here, this, in this surface hydrologic modelling is delineation of watershed boundary, and this is a after once the flow accumulation has been calculated or flow length has also been generated, then it becomes very easy to delineate watershed boundary, but basically is watershed boundary is the determining, determination or a delineating the contributing area, above a set of cells in a raster. So, the outlet you decide ah, like this example we have seen earlier, that at the outlet ah. If we, if we take this as a outlet ah, then this becomes the watershed boundary if we take outlet here, that might be a watershed boundary or might go little up. So, basically it is the contributing area to a outlet. In watershed is set to ah, set off all pixels whose downstream ah, flow path passes through a selected outlet pixel.

So, whatever the water will fall within that catchment or watershed has to come out of that outlet. This condition is there and the value of each watershed will be taken from the value of the source in the input raster or digital elevation model or feature pour point data set ah. This is one example o on the same digital elevation model which have been, we have been using in this course.

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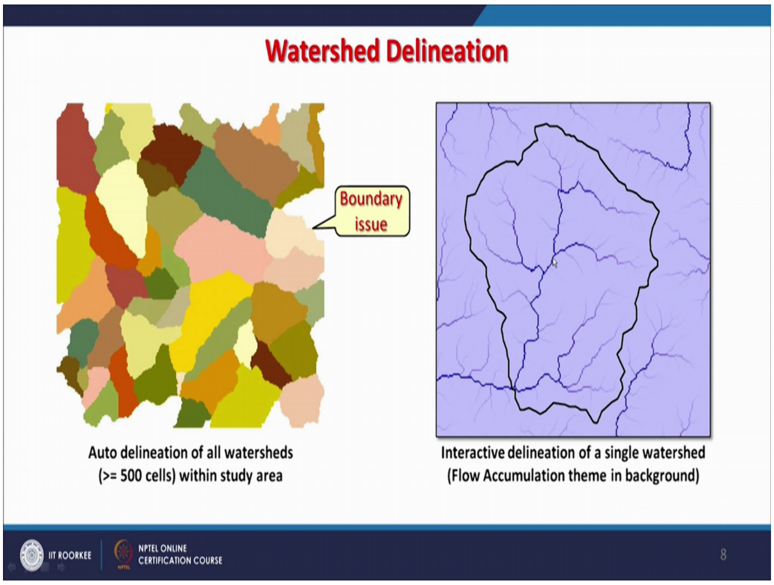

Watershed Delineation

Auto delineation of all watersheds (>= 500 cells) within study area

Interactive delineation of a single watershed (Flow Accumulation theme in background)

And when this is option is automatic delineation of watersheds, delineate all watershed, whose cells are more than or equal to 500 within that watershed and it has delineated. The only problem is that our input digital elevation model had a almost rectangular shape ah. Whereas, at the boundaries, at some places the watershed could not be delineated, because the outlet of say. Particularly say this watershed or this watersheds might be the on the other side or beyond the digital elevation model which we have taken. So, except for boundaries within that study area or within that dm, all those watershed which are having area more than or equal to 500 cells have been delineated automatically.

Of course, there are manual methods are also there, where user decide or you know put a pour point accordingly the watershed will be delineated. And this is a interactive way of delineating watershed boundary; that means, once I click here then automatically it will delineate the watershed at this point, but if I click here or say example here, then it will delineate the watershed above this pour point. So, of course, it has to the theme on which you would be delineating watershed that has to be flow accumulation theme.

So, interactively one can delineate watersheds or automatically using a threshold value as the example given here, that 500 or more cells if falling in one watershed delineated. So, both options are available few more examples are here, just for comparison. This is when the threshold value was kept at 500 cells.

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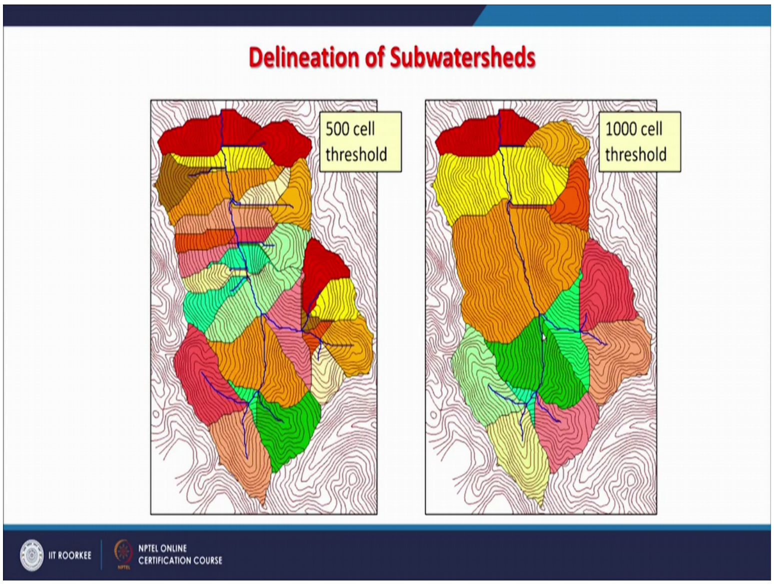

Delineation of Subwatersheds

Ah these number of watershed have been delineated, and when this threshold value was 1000 has been made double, then only few watersheds have been delineated. So, depending on our requirements we can delineate the watershed automatically or some watersheds, within a large watershed that is also possible. So, once we are having this flow accumulation theme available, after a first few steps of surface hydrologic modelling process, then we can get this, these kind of results.

Now, what are the different characteristics also which we can determine through this surface hydrologic modelling of a watershed. So, these are the mainly important characteristics of watershed, are size. We can determine the size; that means, we can measure the area of watershed, we can also measure the perimeter of watershed, we can measure or this ah, the shape of the watershed. So, we can identify the shape of watershed, it is very important ah, the shape plays very important role in flood modelling or in flood analysis, because a circular watershed or a you know a watershed in which all small drains are bringing water at a centre point at one time then there are chances of flooding, but if it is a linear watershed ah, then chances of flooding are very less ah. So, the shape of watershed plays very important role for several such studies, including flood and soil erosion and others ah.

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For various kinds of studies the following watershed characteristics are important

- Important Characteristics
- Size
- Shape
- Physiography
- Climate
- Drainage
- Land use
- Vegetation
- Geology and Soils
- Hydrology
- Hydrogeology
- Socioeconomics

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In physiography also ah, we can know that what is the physiography and this climate inputs can also be brought, because you may be having meteorological or climatic data for a large area, and you want to delineate only for your area using of interest or a particular watershed, using that watershed boundary over a large theme, you can detect those thing, drainage of course, land use from may be from the satellite data, and land use classification can be performed, the vegetation cover can also be identified ah, maybe geology and soils, which is required for soil related studies or in some other ah. Maybe other part other parameter related with hydrology, groundwater hydrology that is hydrogeology, maybe socioeconomics.

So, all these various characteristics of watersheds are useful for various purposes. Some of them can come through surface hydrologic modelling, some of them can come from other sources; like a remote sensing or field surveys or some other thing. The major the characteristic which one can derive automatically area, perimeter, centroid of the watershed.

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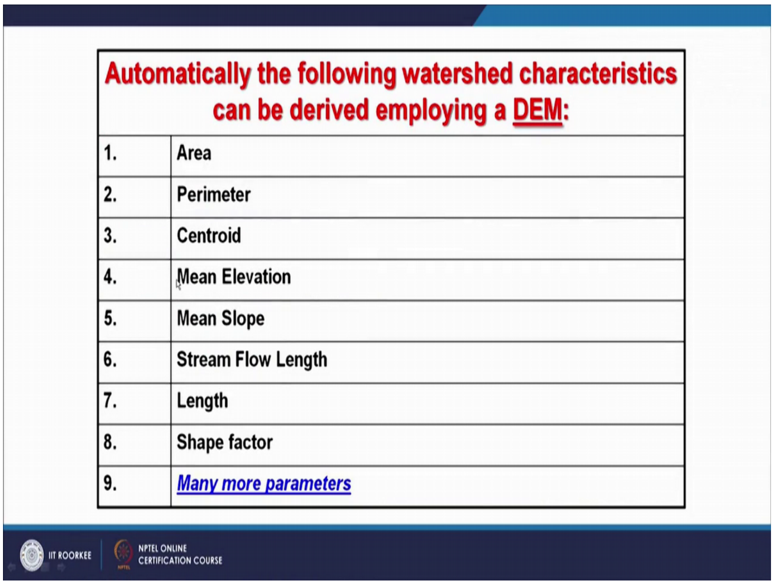

Automatically the following watershed characteristics can be derived employing a DEM:

1.	Area
2.	Perimeter
3.	Centroid
4.	Mean Elevation
5.	Mean Slope
6.	Stream Flow Length
7.	Length
8.	Shape factor
9.	*Many more parameters*

Mean elevation, the mean slope, stream flow length ah, mainly downstream flow length, and then length total length of streams present within one watershed and shape factor and many more parameters can also be identified, based on the surface hydrologic modelling analysis.

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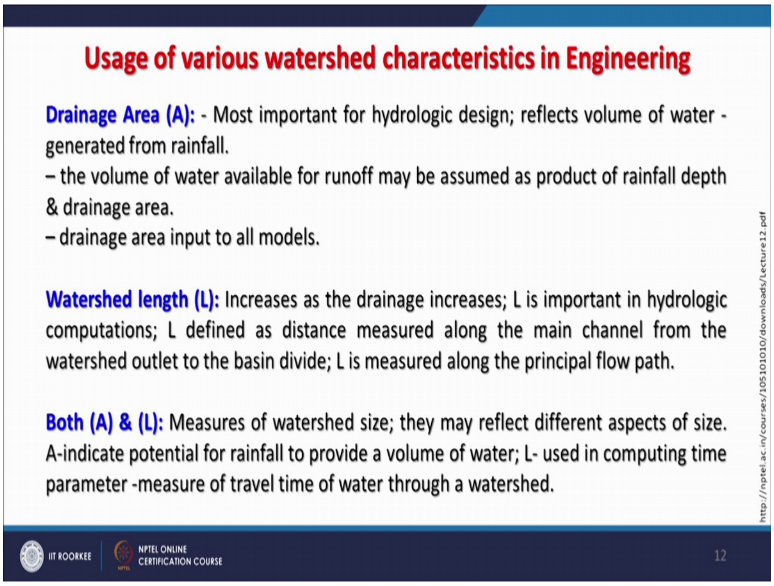

Usage of various watershed characteristics in Engineering

Drainage Area (A): - Most important for hydrologic design; reflects volume of water - generated from rainfall.
– the volume of water available for runoff may be assumed as product of rainfall depth & drainage area.
– drainage area input to all models.

Watershed length (L): Increases as the drainage increases; L is important in hydrologic computations; L defined as distance measured along the main channel from the watershed outlet to the basin divide; L is measured along the principal flow path.

Both (A) & (L): Measures of watershed size; they may reflect different aspects of size. A-indicate potential for rainfall to provide a volume of water; L- used in computing time parameter -measure of travel time of water through a watershed.

http://nptel.ac.in/courses/105101010/downloads/Lecture12.pdf

Where are the, what are the, where. What are the applications of different these watershed characteristics; like area, which is important for hydraulic design, which reflects the volume of water generated from a rainfall; that means, if a area of a watershed is very small, then we know that the contribution which will come in form of rainwater would be little less, but if it is very large.

So, area influence is in that way ah. It influence the basically the volume of water which will come through a outlet of a water shed. So, that is important ah. Second is a that a watershed length. Length also plays, because decides the shape factor also. So, increases as drainage increases ah, and L or length can be denoted as L is important in hydrologic computations ah. The watershed length defines as distance measured along the main channel from the watershed outlet to the basin and divide, at the; that means, up to the watershed boundary, and watershed length is measured along the principal flow part.

So, the mainstream within a watershed which can be identified easily can be measured, or in this one ah. When we are doing this analysis on GIS platform this can be measured automatically. Both area and watershed length ah, both can be used together. So, this measures of watershed size. This may reflect a different aspects of size, a indicates potential for rainfall to provide a volume of water; that is the area and watershed length is computing time parameter and measure of travel time of water through a watershed.

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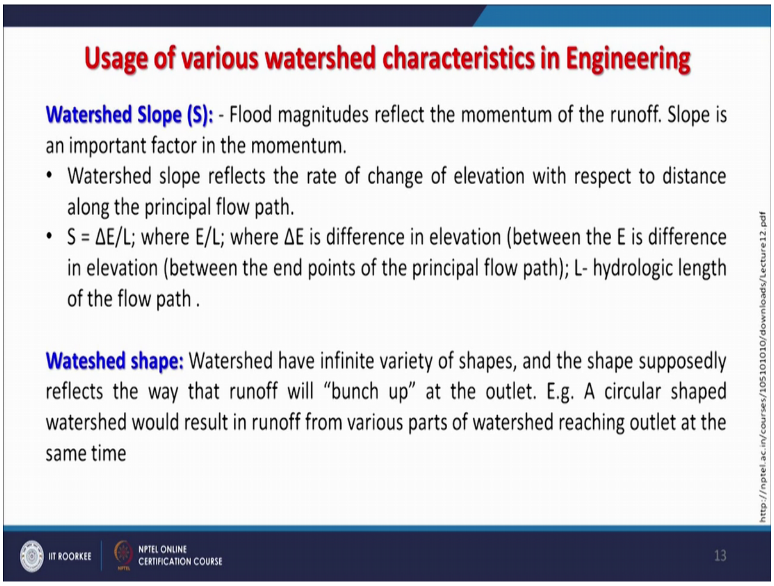

Usage of various watershed characteristics in Engineering

Watershed Slope (S): - Flood magnitudes reflect the momentum of the runoff. Slope is an important factor in the momentum.

- Watershed slope reflects the rate of change of elevation with respect to distance along the principal flow path.
- $S = \Delta E/L$; where E/L; where ΔE is difference in elevation (between the E is difference in elevation (between the end points of the principal flow path); L- hydrologic length of the flow path .

Wateshed shape: Watershed have infinite variety of shapes, and the shape supposedly reflects the way that runoff will “bunch up” at the outlet. E.g. A circular shaped watershed would result in runoff from various parts of watershed reaching outlet at the same time

http://nptel.ac.in/courses/105101010/downloads/Lecture12.pdf

So, another factor which as I have already indicated or characteristics which one can derive, is water slope; that is flood magnitude reflects the momentum of run of slope, as important factor in the momentum here. And watershed slope reflect the rate of change of elevation, as we know very well, and this can be determined like this ah. You can use the elevation divided by flow length, and watershed shape plays very important role, that a watershed have a infinite varieties of shapes, all kinds of shapes and sizes of watersheds are there ah. Important thing is that one watersheds ends another starts, and this is a kind of global phenomenon or globally coverage thing is there, except when we reached to the coastal areas, then things ends there.

And the watershed shape reflects the way that runoff will bunch up at the outlet that how it will reach and what time it would reach. So, I give the example a circular shaped watershed would result in runoff from various part of watershed reaching outlet at the same time, and may cause flooding. Whereas, compared to circular a linear watershed of, maybe of the same size; of course, different shape may not cause flooding, even the rainfall remains same in both shaped watersheds. So, this is that is the importance of watershed shape. Now channel length also indicates various hydrological characteristics of a watershed, and it is used for hydrological computations. ah.

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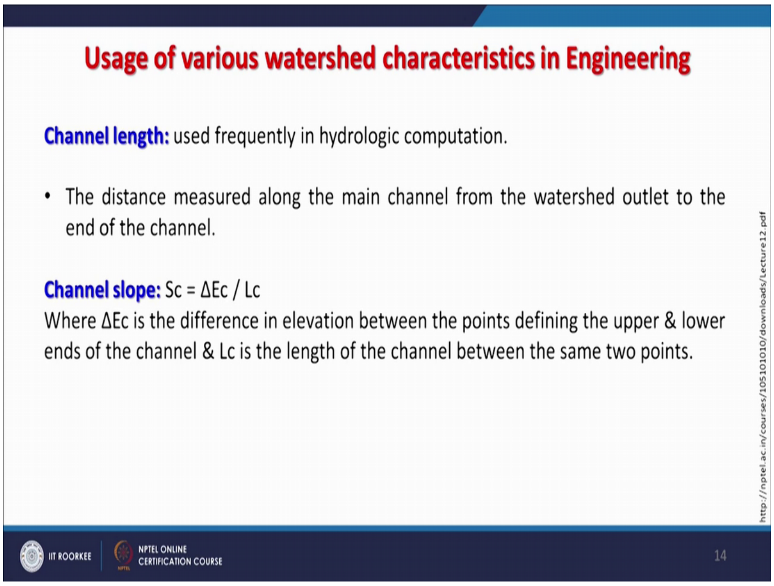

Usage of various watershed characteristics in Engineering

Channel length: used frequently in hydrologic computation.

- The distance measured along the main channel from the watershed outlet to the end of the channel.

Channel slope: Sc = ΔEc / Lc
Where ΔEc is the difference in elevation between the points defining the upper & lower ends of the channel & Lc is the length of the channel between the same two points.

The distance measured, this channel length; that is the distance measured along the main channel from the watershed outlet to the end of the channel or almost near watershed boundary. Channel slope is also important ah, which is it can be determined like this channel slope S c equal to delta E c oblique L c, where delta E c is the difference in the elevation between the points defining the upper and lower ends of the channel, and L c is the length of channel between the same two points.

So, channel slope is important for a some a hydrologic computations ah. One more a output one can take for this surface hydrologic modelling; that is raindrop stimulation or sorted path root ah. This is important in especially in pollution studies, if we know the point source pollution, from where the pollution is coming, then we can exactly track that what would be the flow path of a that pollution.

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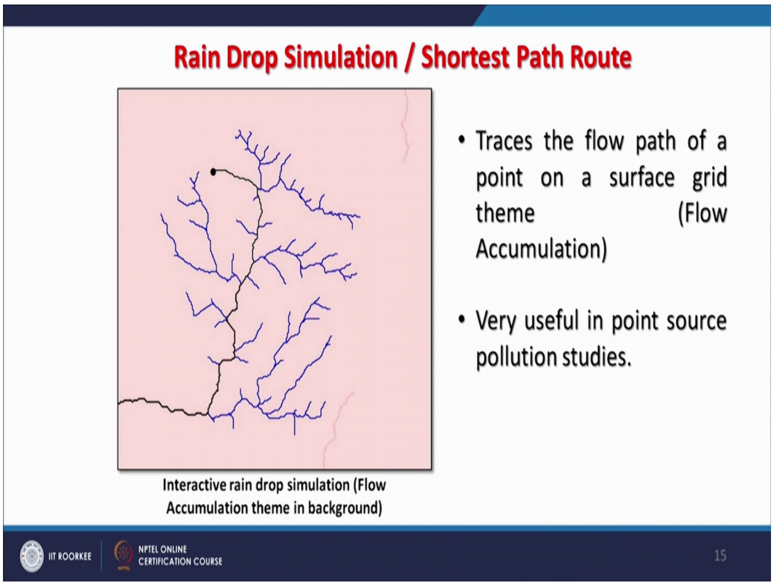

Rain Drop Simulation / Shortest Path Route

- Traces the flow path of a point on a surface grid theme (Flow Accumulation)
- Very useful in point source pollution studies.

Interactive rain drop simulation (Flow Accumulation theme in background)

So, for example, here ah, if a rain is single rain drop ah, drop is here, then this is the path which is shown through the black line, a black drainage will follow, till the end of this digital elevation model or till the end of the, or at the outlet. So, this can be done very interactively. The requirement is that, the flow accumulation theme should be in the background, wherever I will click this will trace the path, and this path is going to be always the shortest route. So, the this rain drop simulation or shortest path, this traces the flow path of a point on a surface grid theme, and the theme is flow accumulation. Very useful in point source pollution studies as I have already mentioned.

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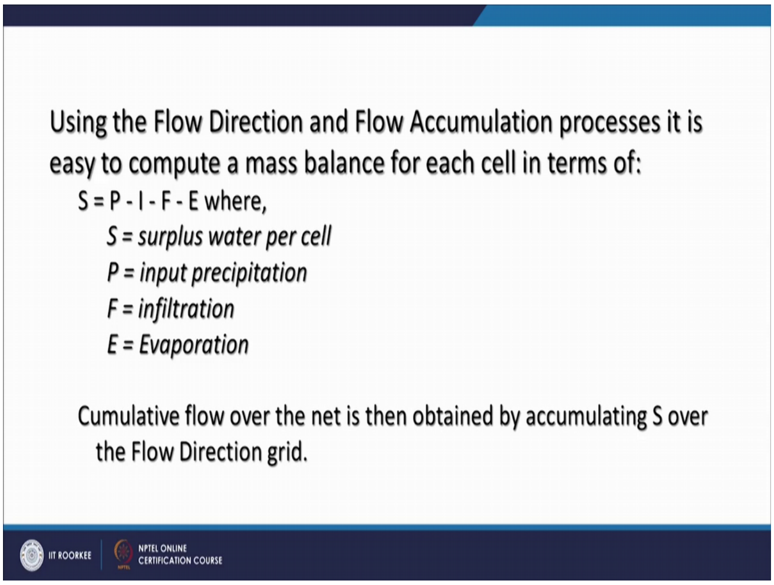

Using the Flow Direction and Flow Accumulation processes it is easy to compute a mass balance for each cell in terms of:

S = P - I - F - E where,

S = surplus water per cell
P = input precipitation
F = infiltration
E = Evaporation

Cumulative flow over the net is then obtained by accumulating S over the Flow Direction grid.

Now, using flow direction theme. Which we have generated in very early stage of surface hydrologic modelling and flow accumulation/ these processes. It is easy to compute a mass balance for each cell in terms of ah; that is S equal to P minus I minus F minus E, where S is surplus water per cell, P is the input precipitation and then infiltration F some water has to go downward. So, that is counted, and some water may go outward; that means, say may be in form loss in form of evaporation or evapotranspiration. So, when these things are there then we can calculate the surplus water per cell and that will decide basically the runoff. So, cumulative flow over the net is then obtain by accumulating S; that is the surplus water per cell over the flow direction grid, and this way we can calculate surplus water ah. Now, their, they are predictive equations or another way to use the map overlay here, for runoff related studies that water available for.

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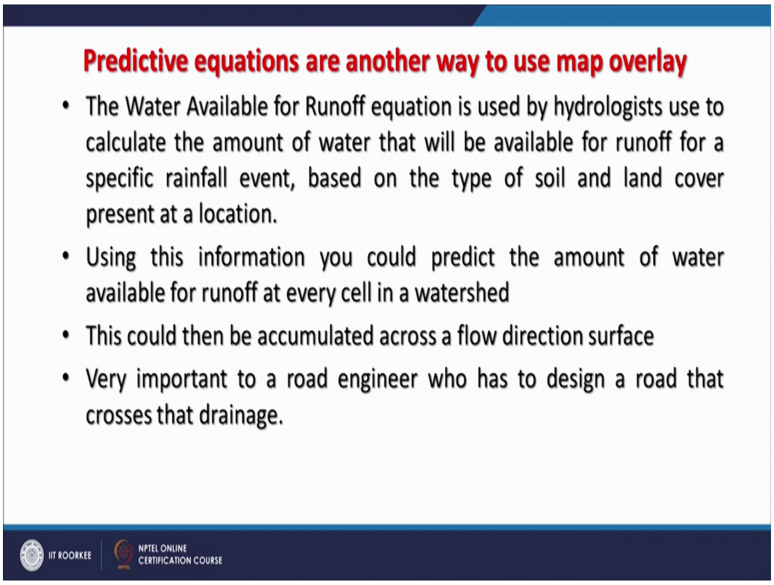

Predictive equations are another way to use map overlay

- The Water Available for Runoff equation is used by hydrologists use to calculate the amount of water that will be available for runoff for a specific rainfall event, based on the type of soil and land cover present at a location.
- Using this information you could predict the amount of water available for runoff at every cell in a watershed
- This could then be accumulated across a flow direction surface
- Very important to a road engineer who has to design a road that crosses that drainage.

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Runoff equation is used by hydrologist ah, to use calculate the amount of water that will be available for runoff for a specific rainfall event, and based on the type of soil and land cover present at a location. So, while these informations can be incorporated in into GIS, along with your surface hydrologic modelling and this runoff equation can be solved. So, using the information you could predict the amount of water available for runoff at every cell in a watershed.

Not only at the out outlet, but outlet of the watershed, but for every cell it can be calculated and this could be then accumulated across a flow direction surface, and this is very important for road engineers, who would like to know that how much water will come at a crosses that drainage or at culvert it will, if it is designed. So, because if a culvert, if they put a culvert that is too small there could be a problem. So, they would like to know that the, how much runoff they are going to expect at particular location. And a this is the flow chart for runoff calculations ah.

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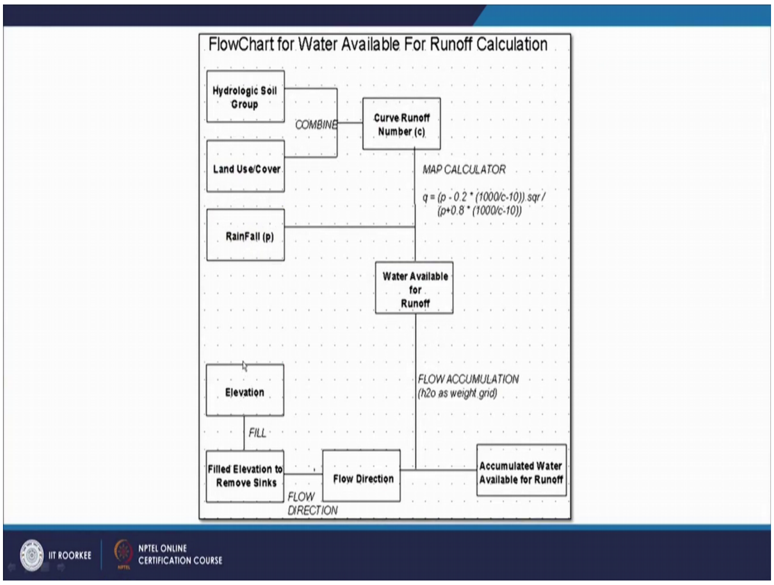

FlowChart for Water Available For Runoff Calculation

Hydrologic Soil Group

Land Use/Cover

COMBINE

Curve Runoff Number (c)

MAP CALCULATOR

q = (p - 0.2 * (1000/c-10)).sqr / (p+0.8 * (1000/c-10))

RainFall (p)

Water Available for Runoff

FLOW ACCUMULATION (h2o as weight grid)

Elevation

FILL

Filled Elevation to Remove Sinks

FLOW DIRECTION

Flow Direction

Accumulated Water Available for Runoff

Some of the parameters will come through surface hydrologic modelling, some will come from other sources like for example, here of course, our digital elevation model, fill DEM then we get the filled elevation, sink one flow direction and flow accumulation available, and then we finally, also include the soil information, land use land cover information precipitation information in form of rainfall. We combine this one, this becomes the runoff curve number and then whatever the water available for runoff that can be calculated at this stage, this comes for. And finally, accumulated water available for runoff at a particular location or for each cell can be calculated by this way. So, this becomes very important. So, some of the parameters for a runoff calculations can come through surface hydrologic modelling. So, there therefore, the surface hydrologic modelling based on DEM digital elevation models, play very important role for calculating surface runoff.

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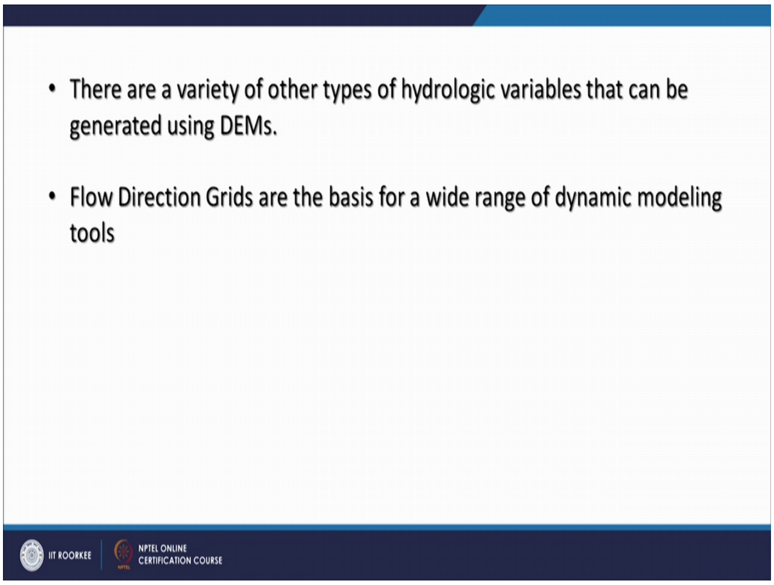

- There are a variety of other types of hydrologic variables that can be generated using DEMs.
- Flow Direction Grids are the basis for a wide range of dynamic modeling tools

There are other variety of types of hydrologic variables that can also be generated using surface hydrologic modelling over a DEM, like a flow direction grids basis for a wide range of dynamic modelling tools ah, can be used.

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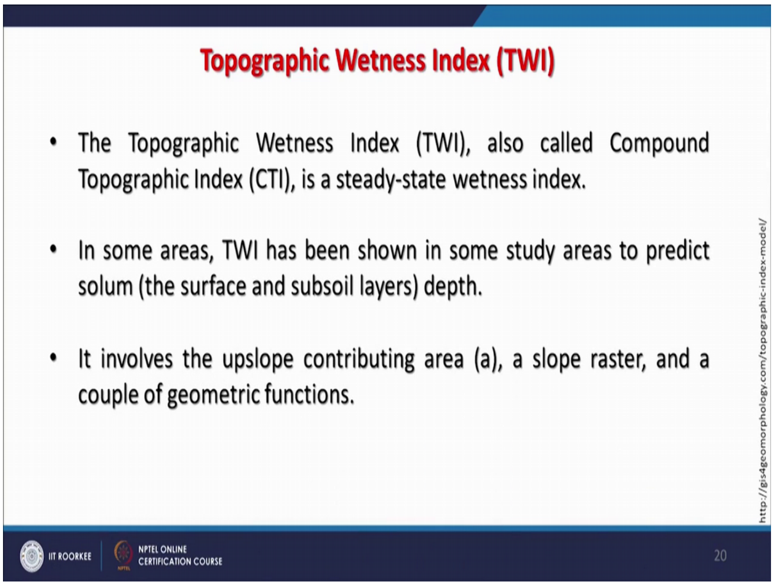

Topographic Wetness Index (TWI)

- The Topographic Wetness Index (TWI), also called Compound Topographic Index (CTI), is a steady-state wetness index.
- In some areas, TWI has been shown in some study areas to predict solum (the surface and subsoil layers) depth.
- It involves the upslope contributing area (a), a slope raster, and a couple of geometric functions.

http://gis4geomorphology.com/topographic-index-model/

Now, I am going to discuss three indices here; one index, one index we have already discussed earlier, in earlier discussions. Now the topographic positioning index that is the index which we have already discussed. Now three indices which we are going to discuss, among them the first one is topographic wetness index ah, which basically we calculate topographic index which provides us the steady state wetness index of the soil. And in some areas this TWI that is the topographic wetness index has been shown in some study areas to predict solum that the surface and subsoil layers depth. So, for that purpose this wetness ah. This wetness index also plays very important role again in case of flood studies, in case of soil erosion studies or maybe in agricultural studies.

So, it involves the upslope contributing area ah, which can be calculated in surface hydrology modelling, a slope raster that is the slope map of a DEM and a couple of other geometric functions are used while calculating topographic wetness index, and this is one example on the same digital elevation model which we have been using in this course.

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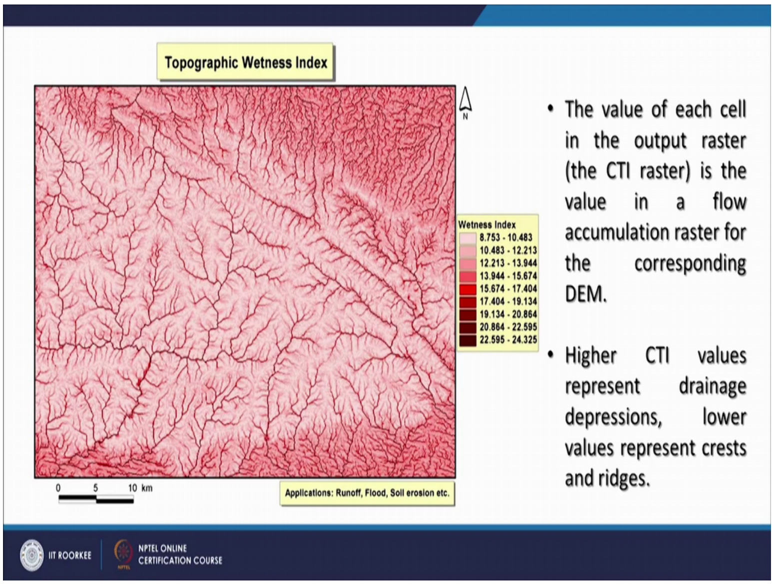

Topographic Wetness Index

- The value of each cell in the output raster (the CTI raster) is the value in a flow accumulation raster for the corresponding DEM.
- Higher CTI values represent drainage depressions, lower values represent crests and ridges.

Applications: Runoff, Flood, Soil erosion etc.

Ah when it was calculated, we get these different values they, the maximum important point here to note that the maximum wetness would be of course, where the drainage lines are there, as you can see the values are very high and wherever these ridge lines are there means watershed boundaries the wetness index is less, because this is as name implies this is topographic wetness index, based on topography as expected that the values will have more wetness and ridges will have less wetness.

So, the value of each cell in the output raster ah, is the value in a flow accumulation raster for a corresponding DEM. So, this value of a TPI TWI and the highest CTI or a TWI ah, values represent drainage depressions and lower values represent the crest or ridges. So, this is very important from that point of view. And what are the applications of this as I have already mentioned that in surface runoff calculations, also in flood studies and in soil erosion and other kind of studies, this topographic wetness index can be used.

Also maybe in mountain regions for landslide studies, for accurate prediction landslide hazard zonation, the this topographic wetness index can also be used, because landslides are also influenced by the soil motion. Now the another index which we can calculate using a digital elevation model, which is another derivative of digital elevation model, is a sediment transport index, and this sediment transport index is basically is the movement of sediment, typically due to combination of gravity acting on the sediment and or the movement of fluid in which the sediment is entrained.

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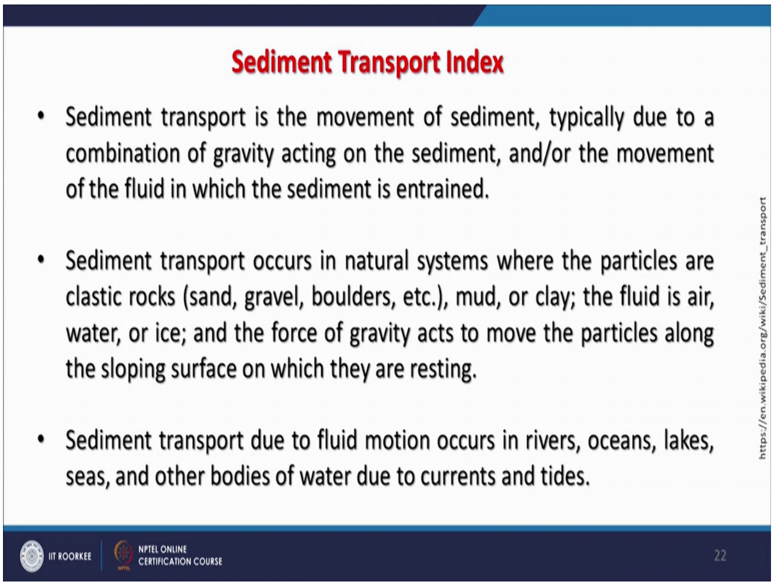

Sediment Transport Index

- Sediment transport is the movement of sediment, typically due to a combination of gravity acting on the sediment, and/or the movement of the fluid in which the sediment is entrained.
- Sediment transport occurs in natural systems where the particles are clastic rocks (sand, gravel, boulders, etc.), mud, or clay; the fluid is air, water, or ice; and the force of gravity acts to move the particles along the sloping surface on which they are resting.
- Sediment transport due to fluid motion occurs in rivers, oceans, lakes, seas, and other bodies of water due to currents and tides.

https://en.wikipedia.org/wiki/Sediment_transport

So, this a ah, this is calculated the sediment transport as we know will occur through a natural system or drainage systems, where the particles are clastic rocks may be sand gravels boulders etcetera, mud and clay, fluid is air, water or ice, but in a, normally in the case which we are going to discuss related with drainage systems and other is water, and the force of gravity acts to move the particles along the sloping surface on which they are residing. So, the sediment transport due to fluid motion, in our case is water motion occurs in river, oceans, lakes, seas and other bodies of water due to current and tides. Generally in the example which we have taken does not include the coastal areas or sea part. So, it is only hilly region, but this sediment transport index calculation has been done on the digital elevation model, and this is again the output of sediment transport index is again very useful in soil erosion studies.

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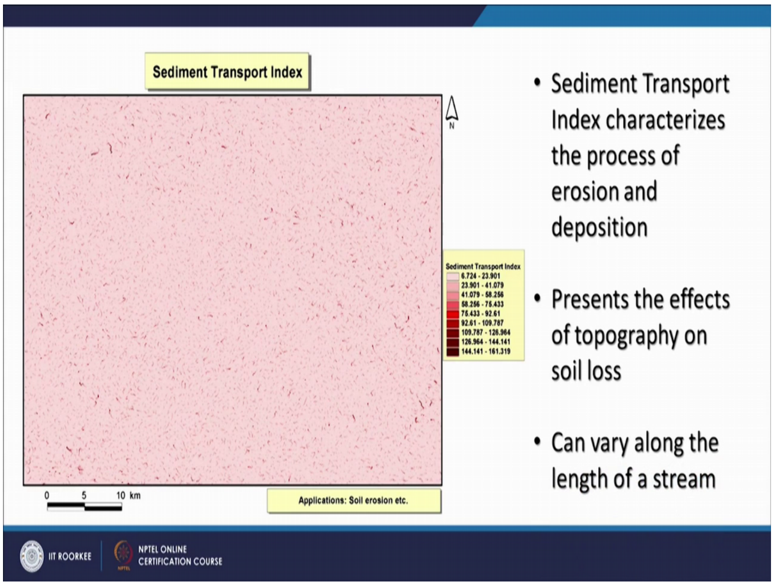

- Sediment Transport Index characterizes the process of erosion and deposition
- Presents the effects of topography on soil loss
- Can vary along the length of a stream

So, as you can see that at places it is having very high value, and mainly maybe on the where the sharpest curvements and other things are there, where we may have the very high values, because again the input is main input is here is the digital elevation model or terrain. So, it is influenced by the topography or ruggedness of the topography, this sediment transport index.

So, this characterizes the process of erosion and deposition. So, in those studies related by the erosion sediment transport, this can be used and this sediment transport index also presents the effects of topography on soil loss. So, in soil loss modelling or a such a erosional, soil erosional studies can be used, can vary along the length of a stream and this sediment transport index can vary along a drainage particular drainage line. This sediment transport is important in sedimentary geology, in geomorphology civil engineering and environmental engineer, and this knowledge of sediment transport is a most often used to determine whether erosion or deposition will occur.

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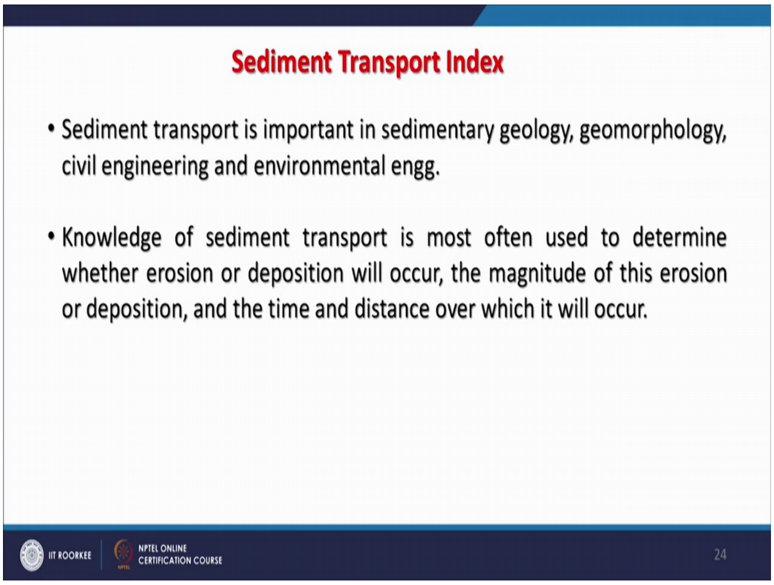

Sediment Transport Index

- Sediment transport is important in sedimentary geology, geomorphology, civil engineering and environmental engg.
- Knowledge of sediment transport is most often used to determine whether erosion or deposition will occur, the magnitude of this erosion or deposition, and the time and distance over which it will occur.

And the magnitude of this erosion or deposition, and the time and distance over which it will occur. So, it is very important to know along a drainage system or a stream that where deposition will occur, where erosion will occur and accordingly the civil structures can be located. So, that is why sediment transport index is variable. And the last index here which we are going to discuss, which again can come based on a digital elevation model analysis is a stream power index, as name implies that is the rate of energy of flowing water is expended in the ah, on the bed and the banks of a channel.

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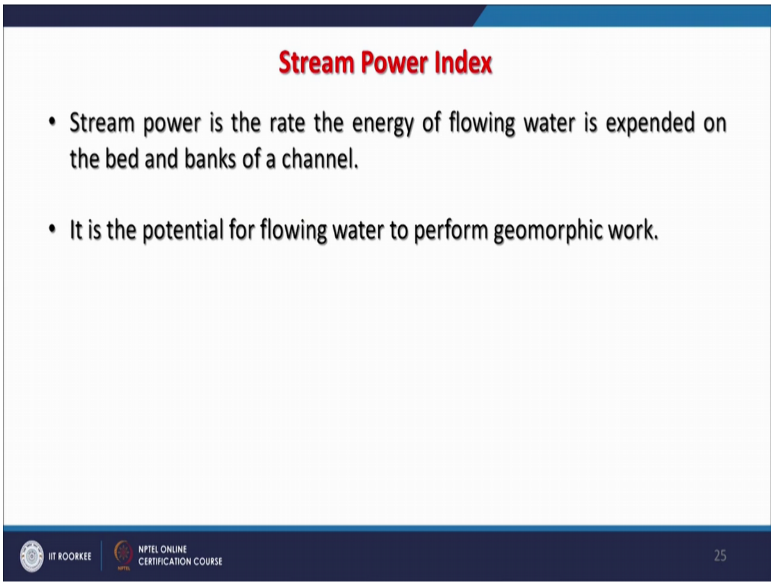

Stream Power Index

- Stream power is the rate the energy of flowing water is expended on the bed and banks of a channel.
- It is the potential for flowing water to perform geomorphic work.

So, how much basically, how much power, stream will have and a it is the potential of flow water to perform geomorphic work. Basically again it come back again to the erosion and deposition, depositional processes and a stream power can be calculated.

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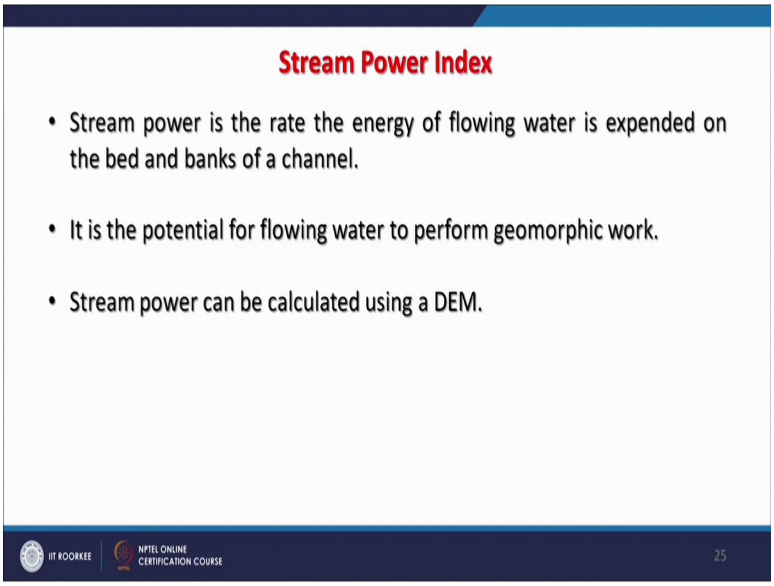

Stream Power Index

- Stream power is the rate the energy of flowing water is expended on the bed and banks of a channel.
- It is the potential for flowing water to perform geomorphic work.
- Stream power can be calculated using a DEM.

Again the input is digital elevation model. So, stream power index can be used to describe potential flow erosion and related landscape processes, especially a fluvial processes are discussed here ah; that is stream power or index or that S I is equal to the C A multiplied by G.

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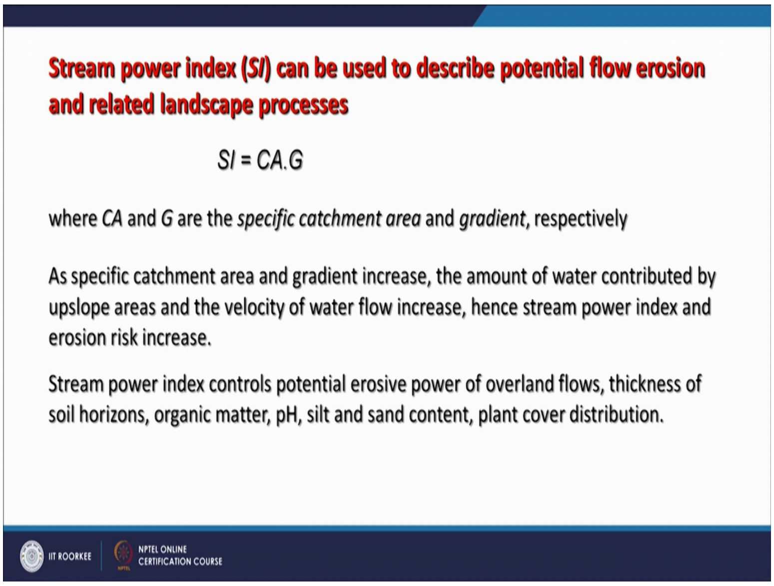

Stream power index (*SI*) can be used to describe potential flow erosion and related landscape processes

$$SI = CA.G$$

where *CA* and *G* are the *specific catchment area* and *gradient*, respectively

As specific catchment area and gradient increase, the amount of water contributed by upslope areas and the velocity of water flow increase, hence stream power index and erosion risk increase.

Stream power index controls potential erosive power of overland flows, thickness of soil horizons, organic matter, pH, silt and sand content, plant cover distribution.

So, C A and G are the specific catchment area and G is the gradient respectively. As specific catchment area and gradient increase, the amount of water contributed by upslope areas and the velocity of water flow will also increase. Hence therefore, there will be a stream power index and erosion risk increases.

So, if a there is a high velocity and the upslope areas are contributing more, then there are chances of more erosion. Whereas, if stream power index can control the potential erosive power of overland flows, thickness of soil horizon, organic matter ah, P H silt sand content, plant cover distributions etcetera. So, they will influence, basically the stream power index ah. Example here is.

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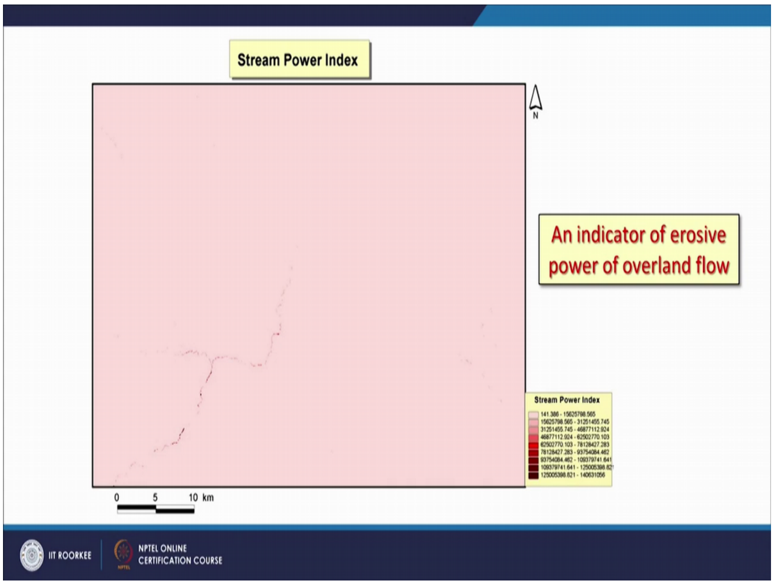

Stream Power Index

An indicator of erosive power of overland flow

Stream power index as you can see that along a major drainage, it is shown high values. In rest of the areas in this particular example, they are almost having the low ah, low stream power index, only along the major lines we expect to have a high steam power values. And this is again indicator of erosive power of overland flow. So, this brings to the end of surface hydrologic modelling, and in these two lectures we have discussed different outputs and how they can be used for various kinds of studies related with hydrology or civil engineering.

Thank you very much.