Introduction to Geographic Information Systems
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Lecture - 17
GIS Analysis – 3

Hello everyone. Today we are going to discuss the last part of GIS analysis that is GIS analysis part-3, in which we are going to discuss buffer analysis which is very important analysis or analytical tools which are available in GIS.

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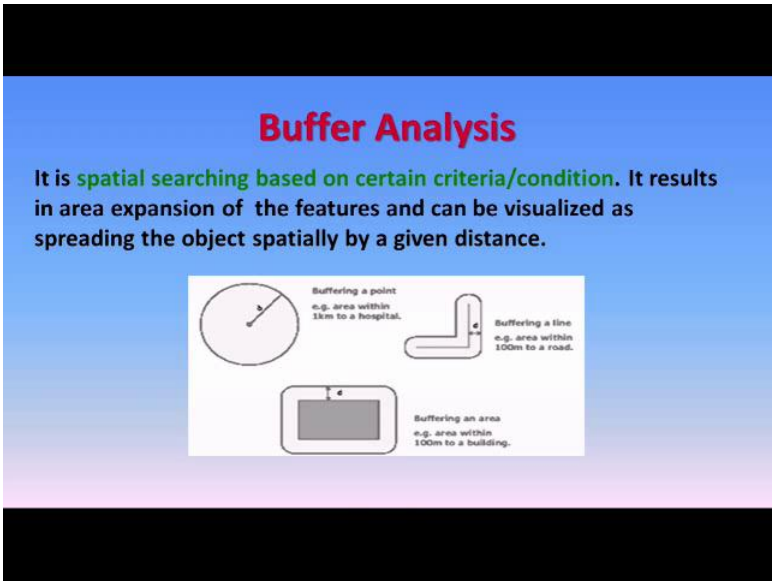

Basically in a buffer analysis you can perform this buffer around any vector feature like a point line or a polygon and this is based on the searching or you did the area that I want to cover this much area, the extend. In case of a point data at good way radius in case of line data in good way width as well as the polygon data. As mentioned here is the spatial searching based on certain criteria or condition and it results in area expansion of the features and can be visualized as spreading the object spatially by a given distance. Now this can be given by the user or any attribute which you want to create to use buffer that is also possible. So, which all these details see one by one. So, these are the examples of a three vector features having buffer generation that d becomes a radius, this is the input which a user will give, this a point data and a circle is created.

We will see little complicated cases two adjacent points are there; that means, you can merge the point here with the line data, also buffering a line you providing the bits and the around that line and buffering can be done. And this thing like in case of point data why buffering requires some time because there might be a point source pollution, might be a factory or thermal power plant and you want to assess what is the affected area.

So, if you have the knowledge or information that how much area is affected you can create a circle or a buffer around that point source. In case of a line feature like a road network or a river if you are having information like how much what would be the extend of the pollution and in case of a suppose a road has to be widen then how much length will come under that buffer when you widen the road that analysis can also be done. Buffer also around a polygon can also be created like around a building or agriculture field or a playground depending on your requirements.

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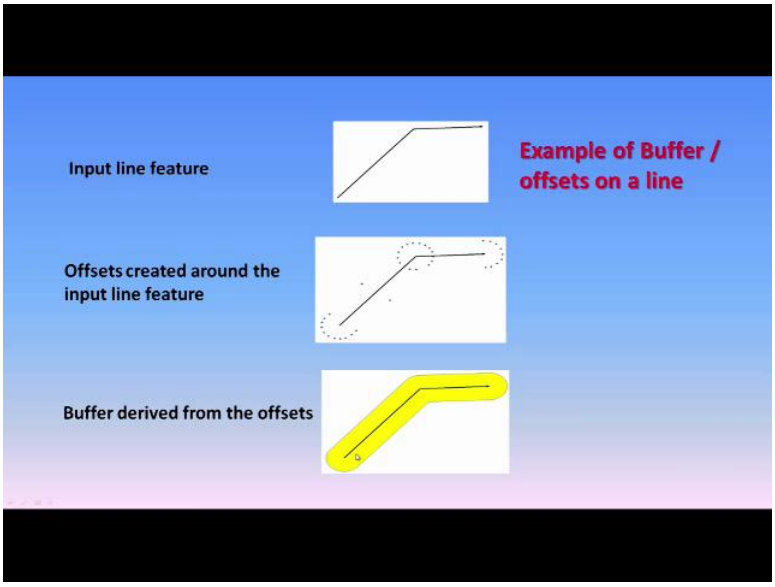

In case of point buffers it is simpler, just a point all along a points a buffer is generated of a given an radius, however if there are two clothes points then overlapping circle will be created and a merged circles will be there. In case of line the concepts starts like here that the input feature here is line, but we are having when we give that offset of the width of the buffer then all along the nodes or the enter nodes circles are created and important note here on the edges. On the edges itself, also the circles are created and this lines are connected and then the buffer is created.

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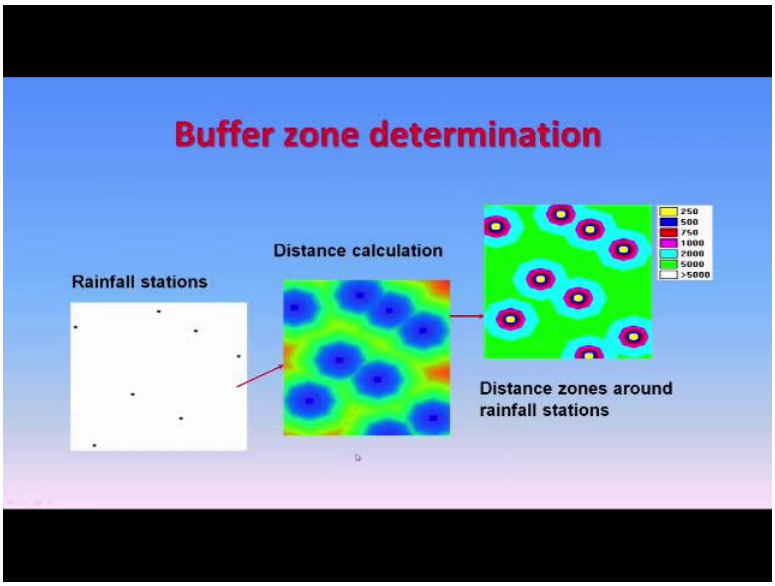

So, here the important point is from everywhere the perpendicular distance could be the same as per the given width as I was mentioning about the point, suppose you having rain fall data you have given some distance that a this much affected information will be there.

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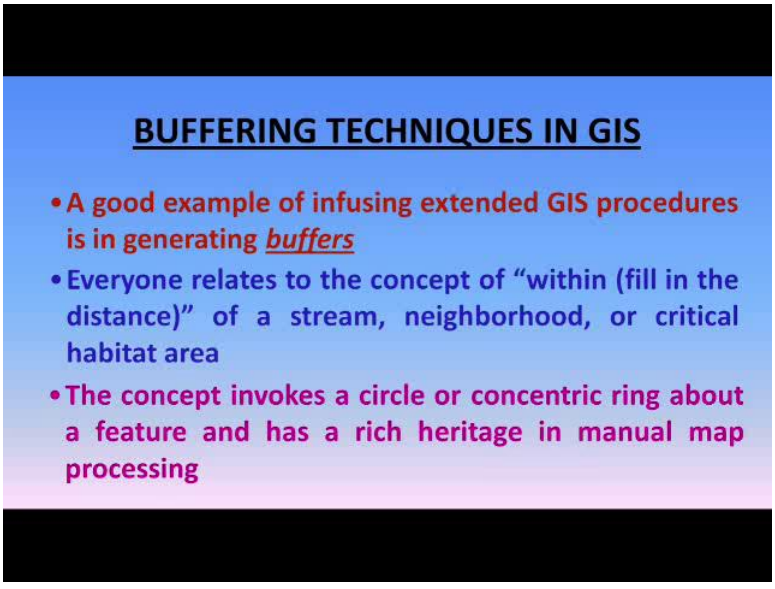

So, you can create here you can see when points where very close then the outer buffers they are merged here like here also. So, buffering techniques in GIS is a good example of infusing extended GIS procedures is in the generating of buffers. Everyone relates to the

concept of within the in the fill distance of a stream neighborhood a critical habitat area or a concept invokes a circle or concentric ring around a feature and has a rich heritage in manual map processing. And there is similarly the division of a simple buffer into uphill and downhill components can be important.

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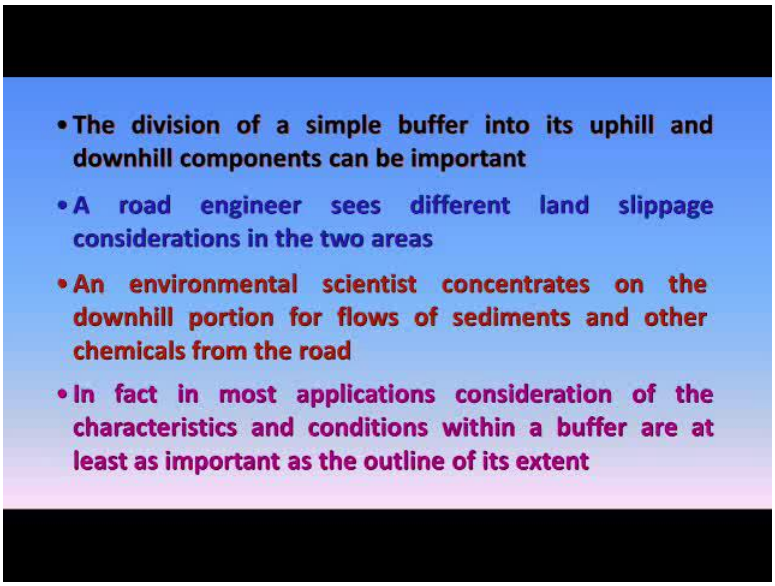

So, you know if a road is going towards a hill or coming down then other factors will also come (Refer Time: 05:16) another thing. Those things also are involved instead of having a simple buffer you can create some complicated buffer, but that kind of information is required before you do the buffer. Like road engineer sees different land slippage considerations in the two areas an environmental scientist concentrates on the downhill portion for flow of sediments and other chemicals from the road and in fact, in most applications consideration of characteristics and conditions within buffer are at least as important then outline of the extent. So, as you know how buffer works you can have a fixed distance and that buffer you give a value and this much buffer in mapping units the value will come and then buffer is created.

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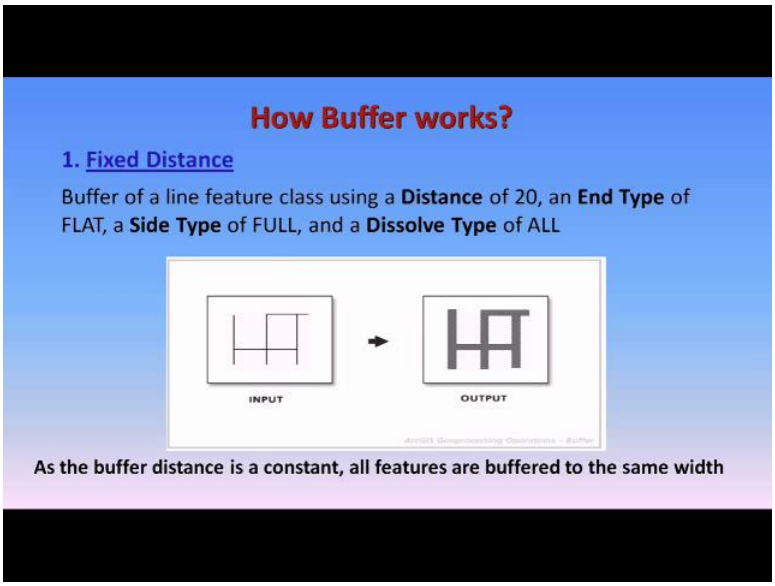

And there is example is here along a line how the buffer is created through a fixed distance and a buffer or a constant distance buffer.

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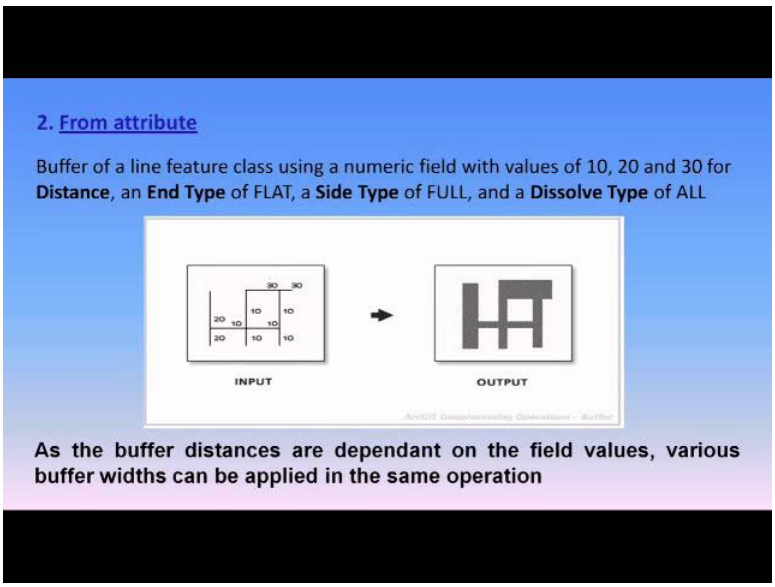

Buffer can also be created using a attributes like here buffer lines and you use the attributes which is available in your spatial data or attribute table and you say that along these line I want you know the buffer of a 10 unit with along this line I want buffer of 30 units accordingly the output can be created. So, buffer as distances are dependent on the

field values this field values are attribute values and various buffer width can be applied in the same operation.

So, these kinds of things are useful for certain application. Now what are the applications of buffers? Buffers can be used to understand the erosion phenomenon all along a river or any other natural causes or natural reason may be the landslides earthquakes how much area got affected and so on so forth.

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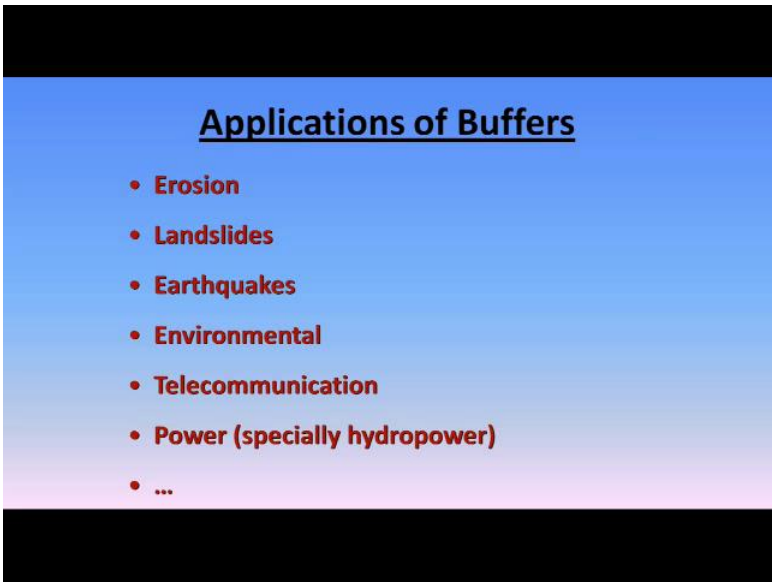

Environmental like in case of pollution may be noise pollution, air pollution, point source pollution. In telecommunication because nowadays lot of mobile towers are coming and the operators of these mobile towers would like to know how much area one single tower will cover. So, they do not want the gap for the communication and therefore, the buffers are generated and one know that you leave one tower go directly into another tower.

So, these are the point data and the point buffers can be created and having if there is overlap then you not lose the connectivity. So, telecommunication companies are also employing buffer techniques of GIS to find out the gaps in their coverage and in power generation especially in hydropower also the buffering can be very useful. And these is not ending, this is not exhausted so will be more applications which are coming now. Another analysis which we can do using digital elevation model and some certain input we have to provide and that analysis is called visible area and viewshed analysis.

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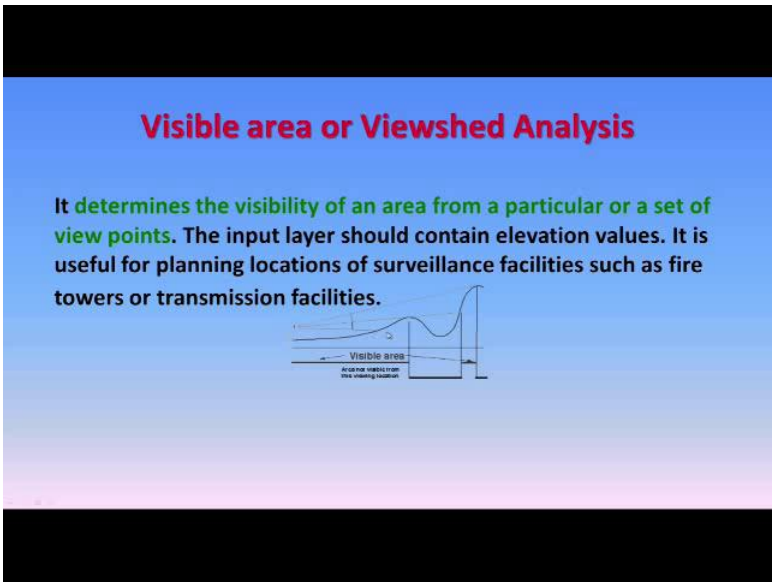

In which you are having basically a (Refer time: 08:42) which is given here and the input you provide a offset and then you would like to know that how much of this slope would be visible from this point and how much of the slope will not visible at your point. And application of such analysis might be when somebody is a going for construction of certain things and then they would like to know that a after that tower comes then what would be the visible or viewshed from that tower. Especially it is useful in a forest management, it is also useful in case of a laying you know a power lines or power towers for long distances, if it is power lines are going through (Refer time: 09:42) train and there in then one would like to know that a were this a mountain or hill rocks will create the problem and where exactly the tower should come and node. So, for that also viewshed analysis can be done.

Basically the viewshed as I have explained here that it determines the visibility of an area from a particular or set of viewpoints, you can have one point, you can have multiple points and the input layer should contain the elevation values. The main input here is a digital elevation model and they it is a useful for planning location of surveillance facilities such as fire towers, transmission facilities, also in nowadays and like a somebody is a developing a resort or a hotel in a mountain or a hill station they would like to know after when the hostel is constructed, how much what kind of visibility or viewshed they will have from a top of the hotel or third floor of the hotel or fourth floor windows of the hotel. Because you know that this involves the cost and they get in

returns because if from window the view is nice they can have higher prices for such rooms.

This kind of analysis is now being done even in the hotel management especially during the planning stage. So, it has got wide useful as. Now on this analytical operation, the last one which you I would like to discuss which has got many sub operations and that is the connectivity operations.

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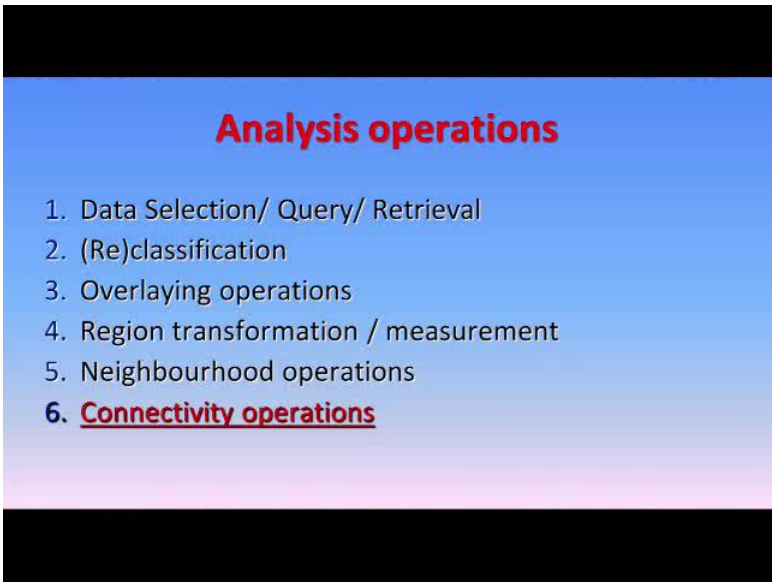

So, what are the connectivity operations; we will see.

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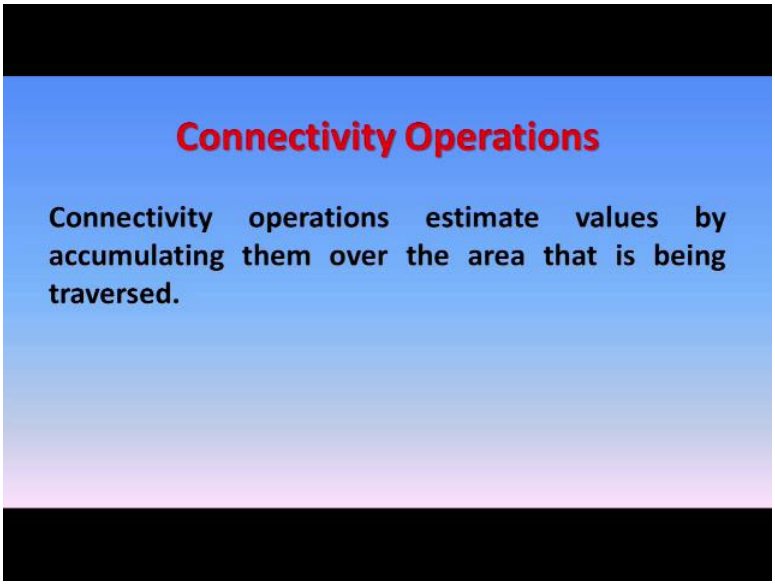

That connectivity operation that estimates value by accumulating them over the area that is being traversed, in the best example can be given that if in hilly terrain or in a (Refer time: 11:47) terrain more you walk lesser you will walk; that means, you are accumulating the tiredness. So, say in first hour you walk 5 kilometers, but in next hour you may not walk 5 kilometers, you may walk just 4 kilometer and in third hour you may walk just 3 kilometer or 2 kilometer because the tiredness is getting accumulated.

Similarly in natural phenomenon also like in sediment transport or in pollution spreading or other thing and these thing are might may not be accumulating, but it is a spread, but the concept wise it is same that the connectivity operation estimate value by accumulating them over the time, over the area that is being traversed. And to calculate this connectivity function there are certain inputs which are required the first one is specify the manure in which the spatial elements are interconnected because this is Connectivity function and therefore, the interconnection are very much.

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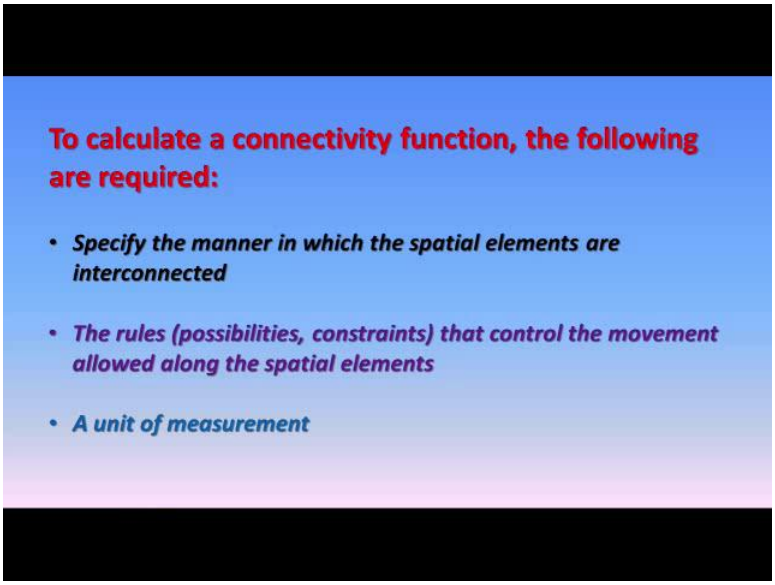

Second is the rule, what are the rules or constraints you have to provide the possibility that control the movement allowed along the spatial elements and third one is a unit of measurement. So, before you go for connectivity from the sense these three inputs must be ready and then you can drive nice results. So, connectivity functions can be grouped into various categories.

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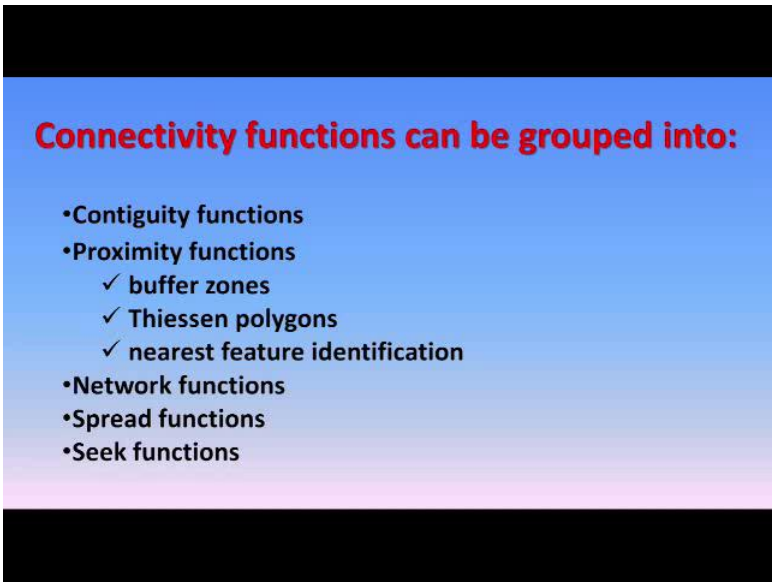

One is contiguity function, proximity function in which buffer which we have discussed Thiessen polygon we have also discussed during interpolation techniques and nearest future identification is also possible. Then next functions in the connectivity function are the network functions, then a spread function and then seek function.

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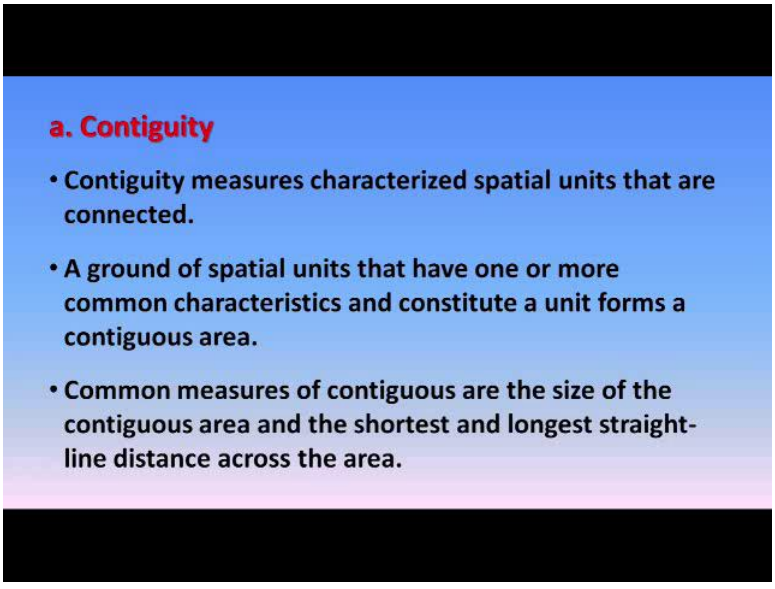

So, these function we will discuss one by one. So, first take contiguity function. In contiguity measures characterized spatial units that are connected. Everywhere this is connected thing will come, a ground of spatial units that have one or more common

characteristics and constitute a unit forms a contiguous area and a then common measures and a then common measures of contiguous are the size of the contiguous area and the shortest and longest straight line distance across the area.

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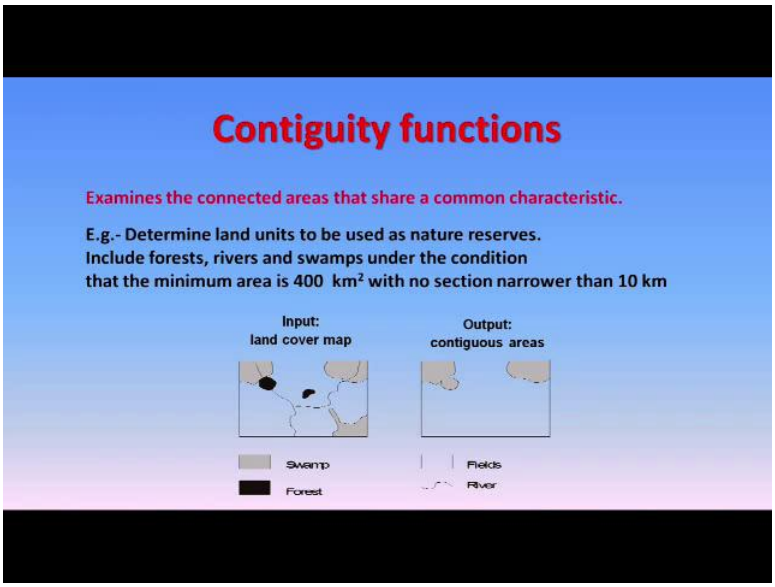

We will see some examples here also in contiguity function like here we are having one input map is here which is a land cover map or land use map. And there certain features which is present like forest is here and then swamp area is there. Now what we can put in an contiguity function we can put certain conditions and then input that what we are looking that determine land units to be used has a nature result this should include forest and river network is also be there which should include forest, include rivers and swamps under the condition that the minimum area should be more than 400 square kilometer and no section narrower than 10 kilometer.

So, these are the constraint and these are the input through a land cover map. Once you use the contiguity function and then put all these constraint an input you get this area. And here these are the areas that these areas are including forest, are including swamp, and minimum area having 400 square kilometer and no section narrower than 10 kilometer. So, likewise you can get output from that. So, depending on your requirements you will choose appropriate tool bring the input, bring the constraint and then perform the analysis. Now next function of connectivity function is a proximity function.

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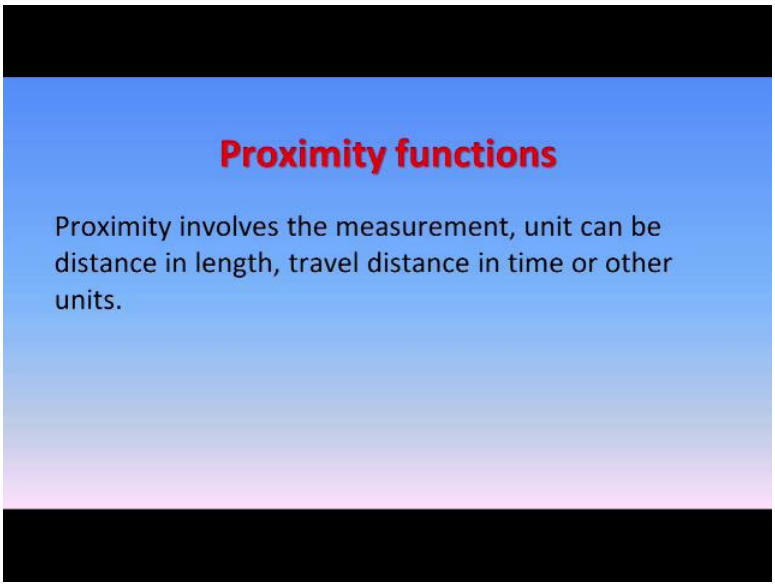

That proximity involves the measurement unit can be distance in length, travel distance in time or other units.

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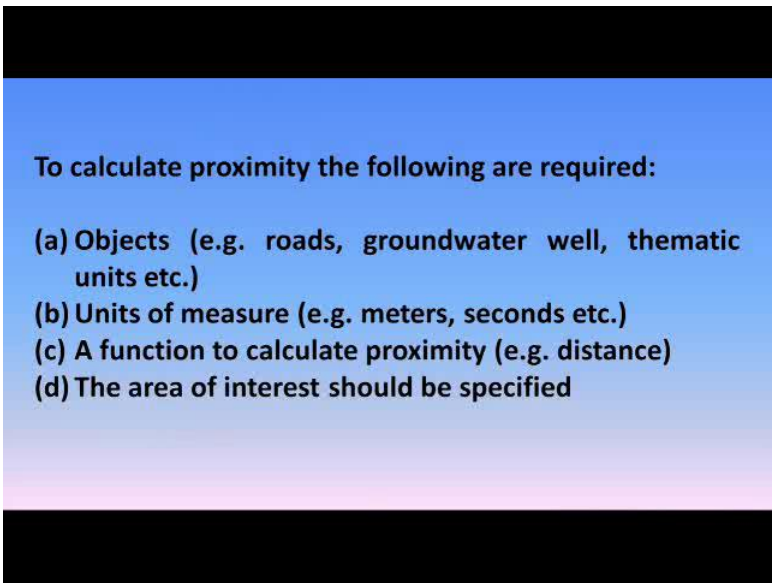

And to calculate this again like in contiguity function again here also you require certain input what are the inputs that objects. Input may be a map of roads road network may be a groundwater well may be a thematic units, and units of measurements that whether this you want results in meters or seconds or whatever because time may be involve here. A function to calculate proximity how this proximity will be calculated for example may be

a distance and then the area of interest should be specified whether you want to perform on entire input map or in a small part of input map.

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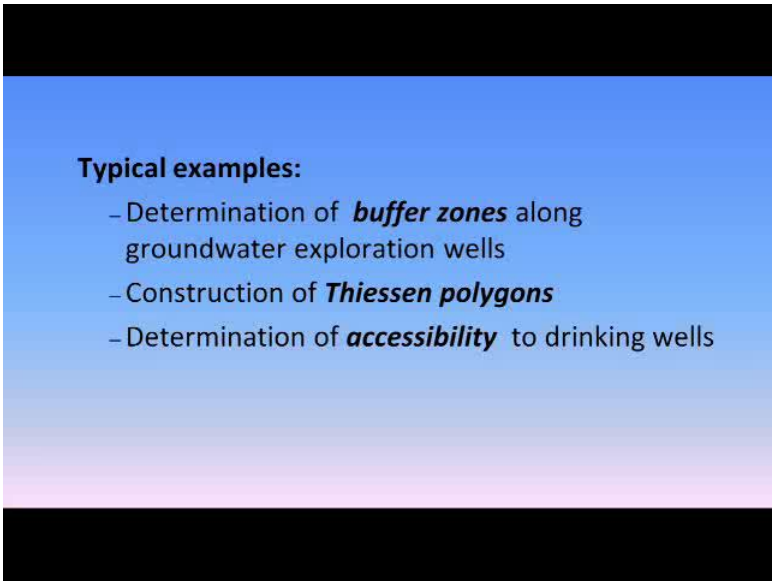

So, when you go for that like examples are determination of buffer zones along with groundwater exploration wells construction of thiessen polygon and all along in this rainfall hill stations or determination of accessibility to drinking wells. So, these are rain fall in the proximity analysis.

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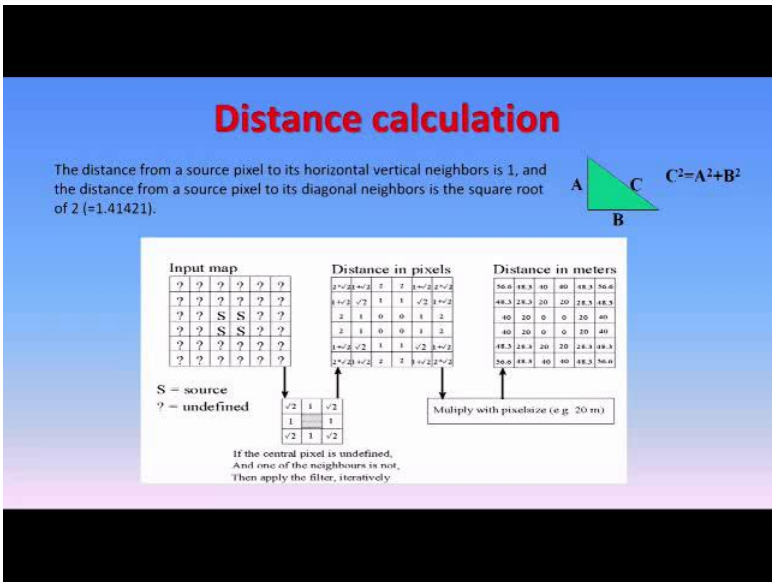

And this is how the distance is calculated because distance is as you can recall here that a function to calculate distance and calculate proximity that is distance. So, this example here is that this is the input map, where as the s stands for source and that a question mark is for undefined where we will calculate the distance and again it is a based on rowing window which we have discussed in earlier part of GIS analysis. That, here for center pixel the values have to be calculated and these are the weights which have been assigned.

If the central pixel is undefined and one of the neighbors is known then apply the filter iteratively and one by one throughout this thing it is applied and the center you get this one. So, distance is in meter because this is the source. So, that is why distance here is coming zero. As you go away from the source the distance increases when you go diagonally accordingly the diagonally the distance has been calculated you go up and down or east west the distance is calculated.

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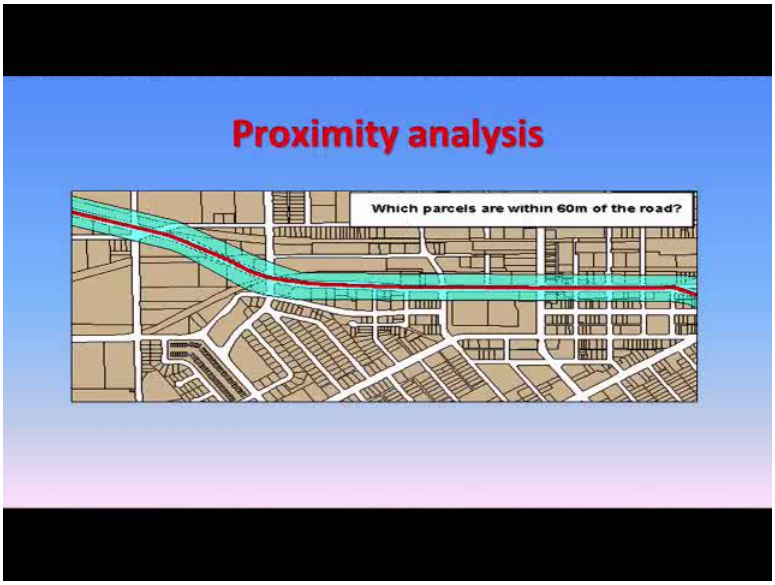

So, this is how the distance are calculated in proximity analysis that is a function and the function which is involves here in proximity analysis like a buffer is one of the example that initially the road was a single line or double line now it has been decided to make it four line. So, there will be few inputs one is that how much width is required for four line that input has to come and then the road existing road network is there and then land

records also which are also called parcels land records through revenue department that to come that map.

Now, once the buffer has been created all along its existing road. Now you exactly you know whose land and how much of their land will go under the road accordingly, then permissions and compensation another things can be provided. Similar example I can give that you know like a there is a mineralization zone or along a line or a linear fashion. Now if you want to if the government is decided to give on the lease. So, they want to know that if mining is done then how much area has to given for the lease. So, along the mineralization a buffer is created depending about the you know the requirements for the mining and whose land will go in that lease can be determine if you are having revenue records and once that is there, now exactly you know to whom the money has to be given how much and so on so forth.

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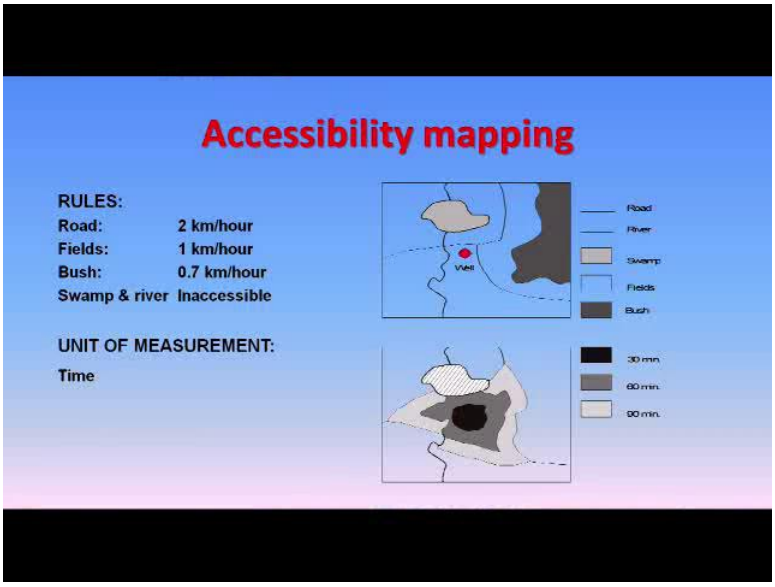

So, it has got really good applications there is also a proximity analysis can also be used for accessibility mapping and here, there is a water well for which the water has to fetched and there is a road network, there is a bushy area, the agriculture fields are there and swamp is there and river is also there. So, this is a typical end use scenario. Now there in accessibility or either proximity analysis there are certain rules that the speed along the road is going to be two kilometer per hour, where is a speed along the field is

going to be one kilometer per hour and if one has to walk through the bush area then it is a 0.7 kilometer per hour.

And also the condition have been declared a along the swamp and river a no walking is possible so these are inaccessible area and of course, unit of measurement here is time once these are the constraint and input map is available then this is the map which has been created which tells that within this the black area this is within 30 minutes the water well can be reached.

One can reach to this water well within 30 minutes if he is present within this black area or this black polygon. Whereas in grey polygon this is 60 minutes and then it is 90 minutes. Since this is a swamp area and we have said the condition the swamp is an accessible and therefore, this has been excluded in the analysis. So, depending on your requirements and once the rules the constraints are available one can do all different varieties of analysis using these functions. Now another connectivity function is the network function.

Remember that initial the development of GIS or invention of GIS is started for network therefore, and GIS is extensively used till today for network related things and the initially the software where also very powerful mainly for network analysis, but now the same time they are also having equally strength for our study data analysis.

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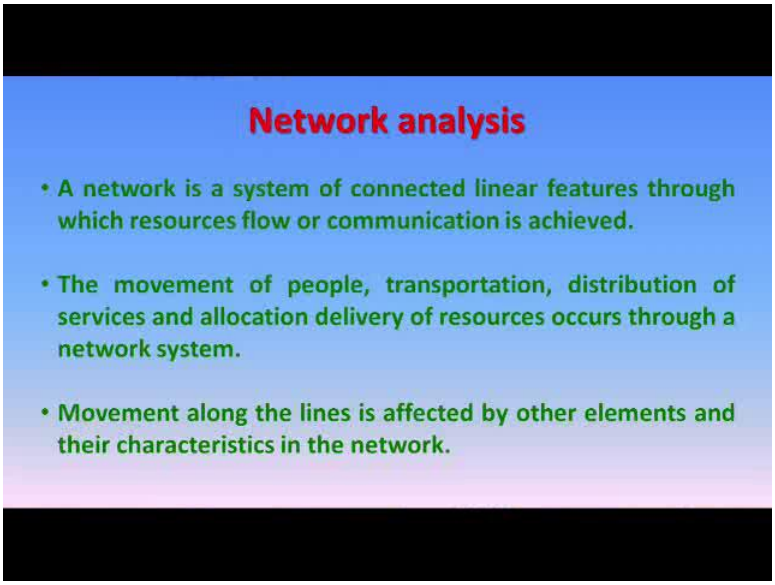

So, in network systems which are connected linear features through which resources flow or communication is achieved. Resources flow that might be a natural river system, so resources might be water, resources might be sediment, or may be pollutants and then also communication may be is a road network or a power grade or a sewerage network and so on so forth.

So, this is an also the resource might be movement of people transportation, distribution services, allocation delivery of resources occurs through a network system and the movement along the lines is affected by other elements and their characteristics in the network. If resources have to move through a road network then one need to know whether is a two way or a single way or single line or two lines. These kinds of constraints on information are very much required and then of course, traffic condition red light zones crossings and flyovers that all kind of information will be required to achieve a very good network analysis. Let us see what are the other details which we will be required.

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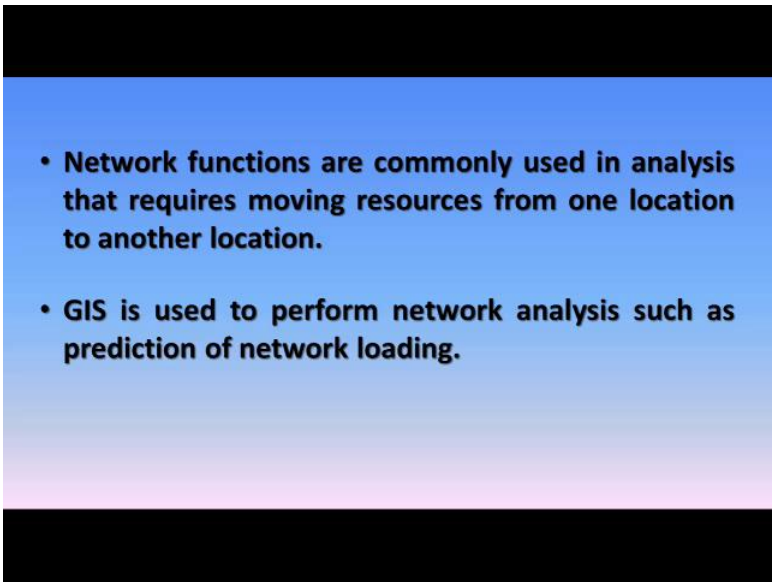

The network functions are commonly used in analysis that requires moving resources from one location to another and GIS is used to perform network analysis such as prediction of networking loading.

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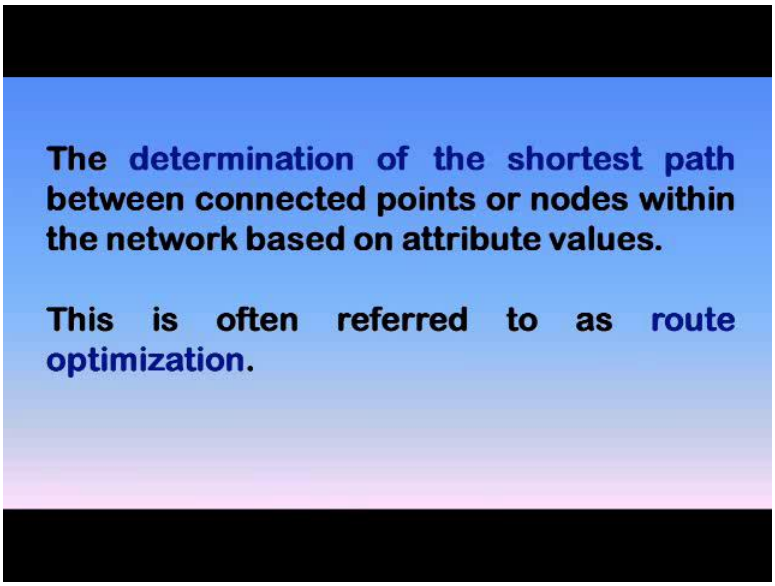

And this is basically the determination of shortest path between connected points or nodes within the network based on attributes values and this is often referred as a route optimization. This is nowadays being used extensively a by even (Refer time: 24:34) of a taxi operators may be other transport systems may be by the emergencies services like fire brigade or ambulances may be by police.

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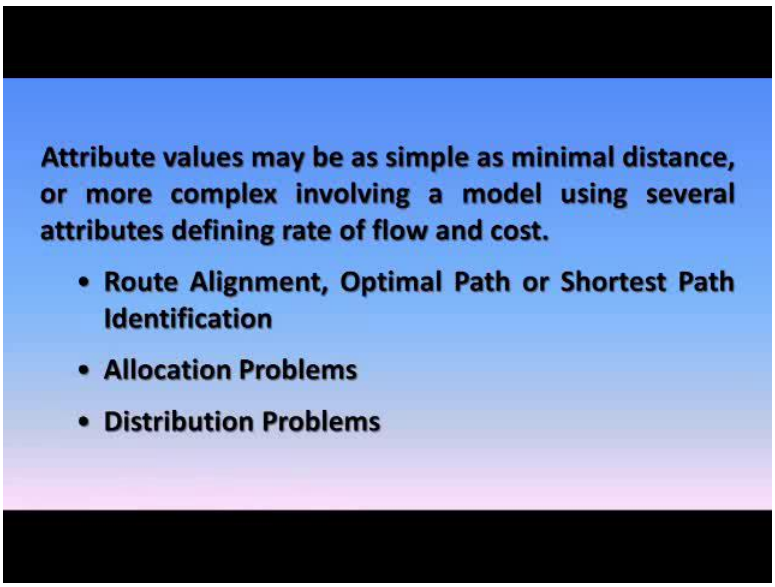

So, attributes values may be a simple as minimal distance or more complex involving a model using several attributes defining rate of flow and cost we will see very shortly the

examples and they are like route alignment, optimal path, shortest path, identification, allocation problems and then distribution problems are there. So, in network analysis the facility management based on network analysis.

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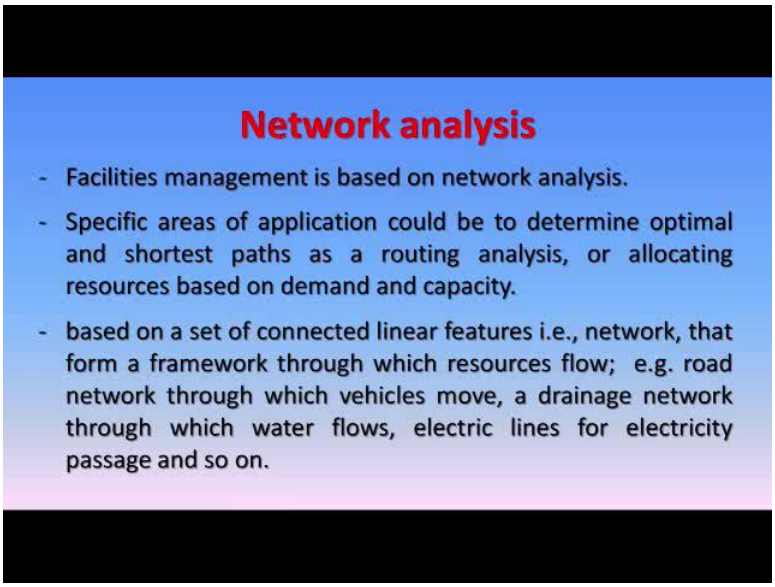

And specific areas of application could be determine optimal and shortest paths as a routing analysis or allocation resources and based on set of connected linear features because for network analysis the input is, there has to be one network. Whether is a road network or a stream network river network or may be network of an electricity telephone lines (Refer time: 25:44) lines all kinds of network that one network at least or may be two depending on the analysis would be required as one of the inputs.

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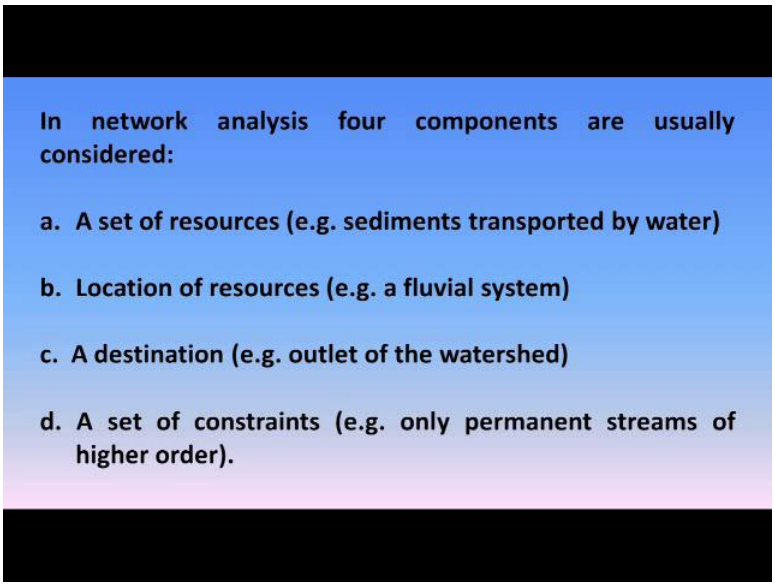

So, in the network analysis four components are usually considered, the inputs. The first one is a set of resources for example, sediments transported by the water along a natural fluvial system or river network location of resources a fluvial system for example, a destination that is the outlet of the watershed. And then fourth are the rule constraints, condition a set of constraint for example, in this case only permanent streams of higher order.

You know that in stream ordering there are a different ordering system exists. So, when stream basically stuck that we consider as first order, then two streams meets generally in one scheme we consider second order in so on so forth. So, higher order means that we are going for not first order, second order, may be 5 6 order streams here. So, this are the four inputs a set of resources a network, location of resources from where the resource will start moving, a destination where it will come out and then how it will move the set of constraint have to be provided.

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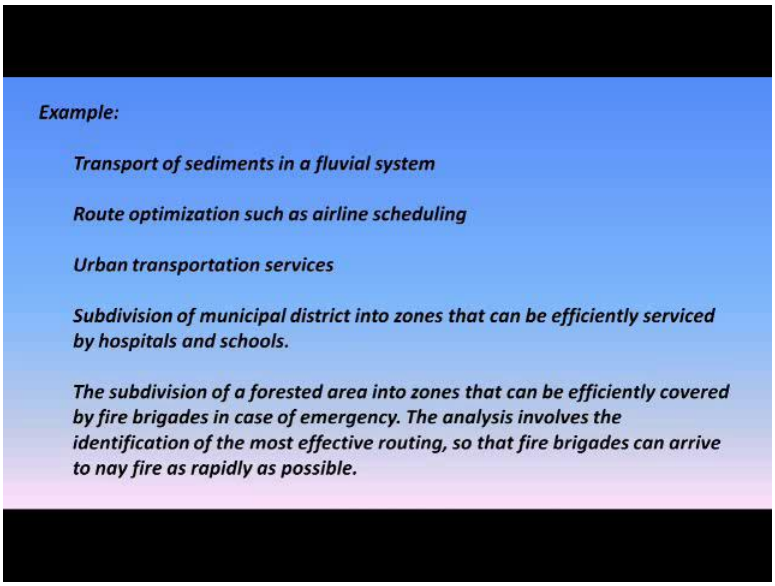

Now, examples are transport of sediments in a fluvial system and route optimization such as airline scheduling may be urban transportation services and subdivision of municipal district into zones that can be serviced by hospitals and schools emergency services and subdivision of a forested into zones that can be effectively covered by fire brigades in case of emergency. These are the things which are very much required in case of forest fire and another thing. So, this will definitely help, network analysis will help to manage forest fire whenever they occur.

Now, another function the second last function is the spread function. The spread function, name implies that the spread function evaluate phenomena that spread dilute or accumulate with distance.

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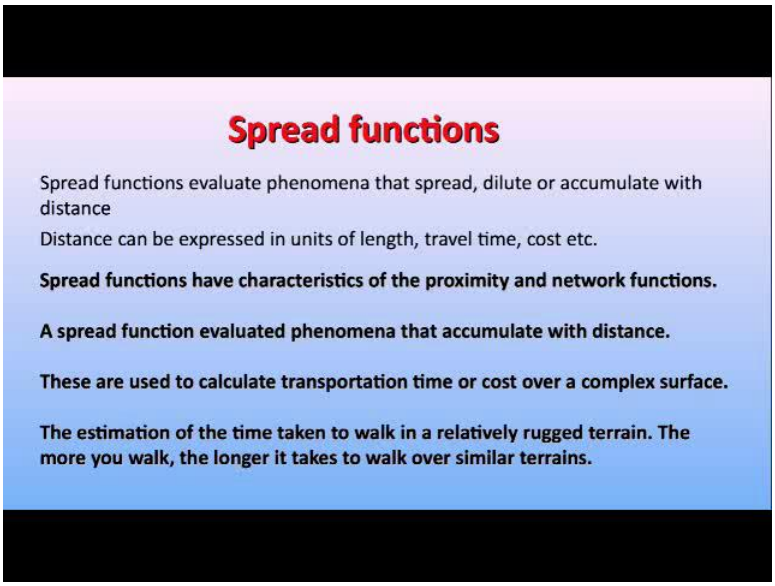

And distance can expressed in units of length, travel, time, cost and the spread functions have characteristics of mix of proximity and network functions. And a spread function evaluated phenomena that accumulate with distance and these are used to calculate transportation time or cost over a complex surface and the estimation of the time taken to walk in a relatively rugged terrain. As earlier mentioned that more you walk and longer it takes to walk over similar terrain; that means, when you walk on a terrain after some time you accumulate the tiredness and therefore, you would walk less.

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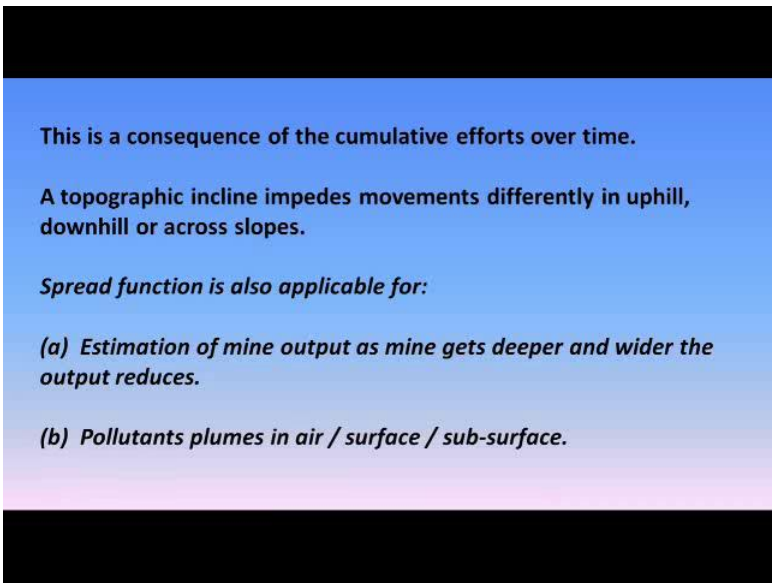

So, this is considered in a spread function, spread function can also be used in case of flooding, spread function also be used in case of a simulation of reserve wire another things that example we will see soon. And these is a consequence of accumulative efforts over the time spread function and a topographic incline impedes movement differently in uphill downhill or across slopes when you go for real type of analysis and it has the terrain is undulating then you can also add this impediment here.

And the spread function also applicable for estimation of mine output has you know that the mine whether it is open cast mine or underground mine the mine get deeper the output reduces. So, if you want to maintain the output or if you want the constant output then you have to bring more resources to keep the constant output because the distance and cost is accommodating and therefore, you have to bring resources in order to have a constant output.

Similarly the pollution plumes in air surface and sub surface this is a spread function, but in an opposite sense opposite sense because a pollution plumps will it spread in air and the concentration reduces it does not accumulate, but it does it same would be it is a fluid then it will flow on the surface or may be in underground condition. So, those things also are estimated that how much time would take reach the pollutant at that particular distance whether it is air or surface or in sub surface condition and what would be the concentration has well. But before that you require if somebody is estimating this pollutant movement in such surface condition then lots of other input would require that what is the conductivity of rocks which are present in such surface and what are the structures are there and so on so forth.

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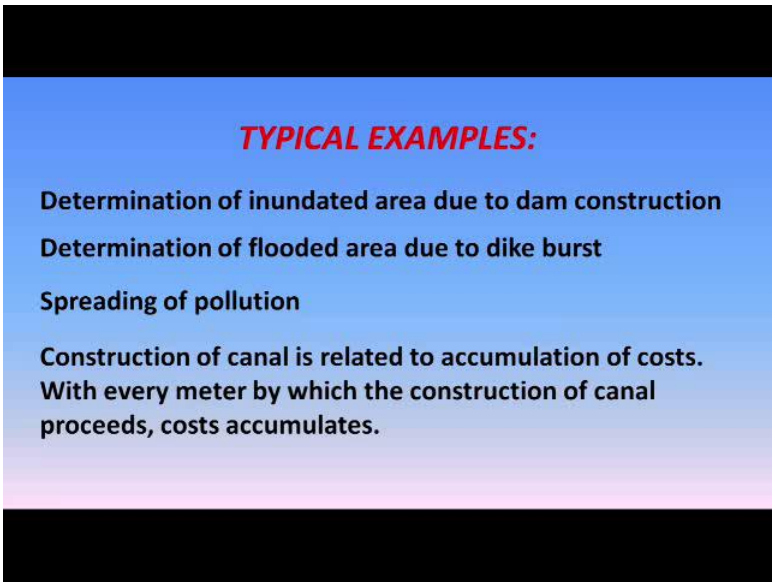

Now, this typical example of a spread functions as I also mentioned that determination of a inundated area due to a dam construction or a reserve wire construction. Determination of a flooded area due to dike burst sometime in order to protect a flooding sometimes embedment or dikes are constructed, but when lot of water comes sometime this dikes may break. So, you want to predict that what would happen if a dike breaks like along a cross river such a embedment is been created some times we here that due to flooding is dikes are breaks and the new areas are got (Refer time: 32:09), but using GIS we can predict we can see what will happen.

The spreading of pollution is also an example and also during a planning or construction of canal which is relatively which is related to accumulation of costs with every meter by which the construction of canal proceeds cost accumulates because the length is increasing, and once the length is increasing more resources would be required that in more cost. Let us see the example of a spread function for in reserve wire simulation or dam simulation in the big round you have a digital elevation model in your GIS software.

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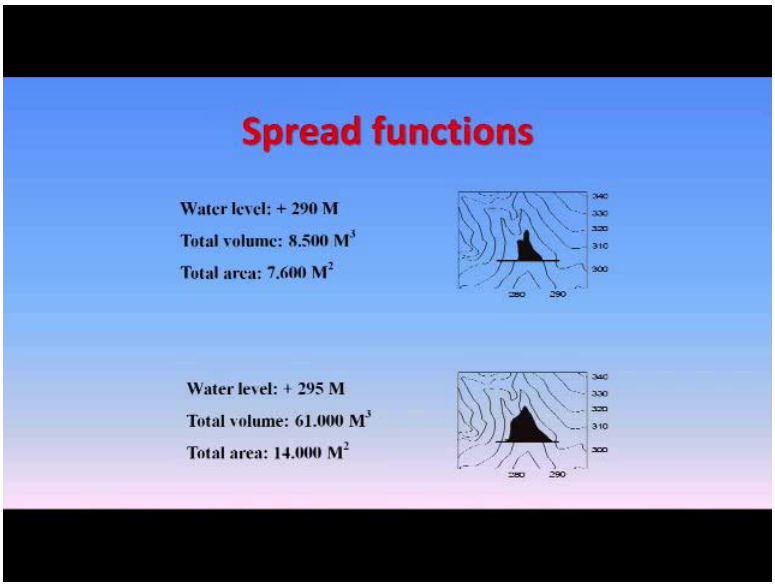

You can create a dam access by giving a height of a dam or the water level and then you want to see that how much area will emendate in the upper stream. Like in this example this is the digital elevation model shown here in form of (Refer Time: 33:10). Water level is plus 290 meters; that means, above the ground and here is along this dam access and once you go for this spread function or some other tools which are available like profile extractor you can also use cut and fill tool especially the fill tool and a this will estimate that how much volume of water will we stored about in upper stream from once if this reserve wire comes or come in existence.

And a total area which will get emendated in a upper stream area that can be, but suppose you are looking for more volume of water that too can be simulated that I want more volume of water so you have to raise the height of this dam. So, instead of these 290 meters if I raise by 5 more meter that it becomes 295 then more in area is emendated and a then you are having a higher volume of water which is available in the upper stream area and of course, larger area will get in updated.

Nothing is being done on the ground here; no cost is involved except on your GIS platform you are doing simulations. If you are not happy with this even this volume you can change the location of this reserve wire or dam access, you can go little downstream then start stimulating again and once you achieved the required volume then you finalize. Another thing is in this particular example this dam simulation is shown, this dam access

is to be straight need not to be. You can have even you know curved shape or having you know some angle between two sections of a polyline and there to also a dam simulation can be done.

And also you can rotate once you have drawn a line for dam access you want to change the orientation of that once or shift that one all this things are possible once you have decided now it is final location, this is nothing you assign the height then stimulate the inundation. So, it is very very useful and not only for a planning or a planning stage or flexibility stage of a reserve wire, but also these things are useful in case of ground water recharge because you can assess that how much existing reserve wire is providing ground water recharge which you may access through the growth of hesitation. So, if in that area a similar size of reserve wire comes you know really a reserve wire is coming that this much area because you have already got the knowledge from existing reserve wire, this much area will be benefited from the ground water recharge.

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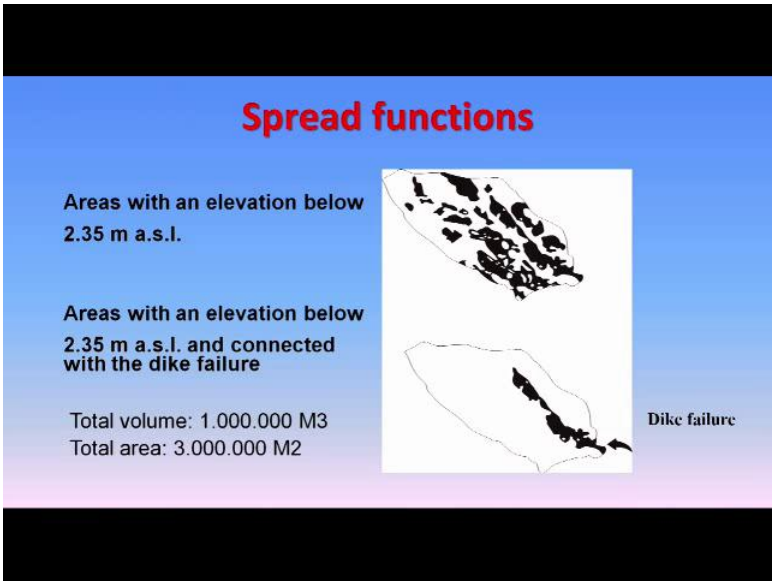

So, a spread function especially a dam simulation or reserve wire simulation is very very useful for many applications. This is the example for dikes, this is the you know that the area is means elevate this is the typical example of a part of Bangladesh and there you are having a you know that the very lake ground label of ground or length part is just a few meters higher than the sea. If a dike fails then this is the scenario which you are going to have. Rather than spreading everywhere may not be true, once you have decided

since for this dike failure there like in case of reserve wire you have to have a reserve wire similar in case of dike failure that feature will come as input. Once that information is there you can simulate and you would know before really anything happen that what would you the volume of water will be there and how much area will get affected this is m power 3 and m power 2.

Now, the last function in this a connectivity analysis is the seek function. This is another very very useful function which you can use along with digital elevation model and some concepts some other modeling tools like surface (Refer time: 37:41) modeling which I will discuss soon. So, seek function determine optimum path ways using one or more specified decision rules and the process is repeated till one or more decision rules becomes inapplicable. And the typical examples or determination of path of water flow highway planning, we will be seeing the first little detail that input here is the digital elevation model shown here as in confirm contours when we go for surface of hydrologic modeling we can drive automatic flow path that how the water will flow.

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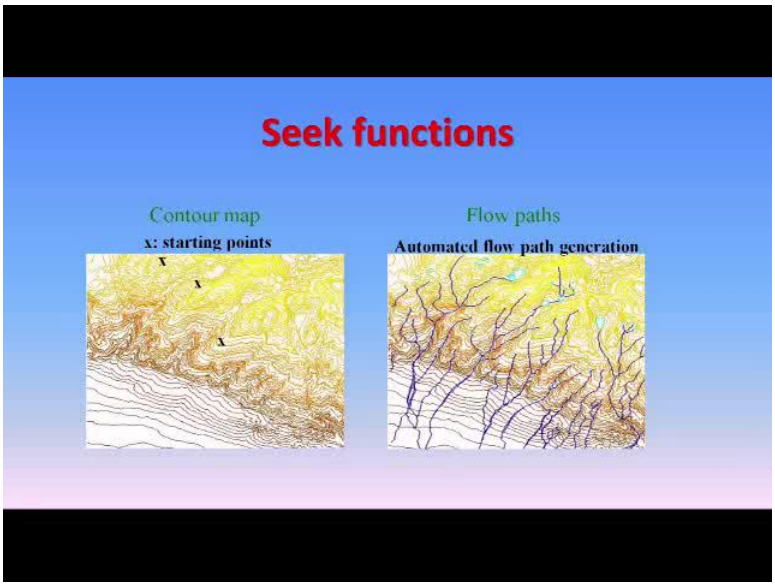

So, this is a seek function and how it is been determined as you can see the process is repeated till one or more decision rule becomes applicable. So, this is based on decision rules, decision rules will come through the surface hydrologic modeling concepts the input is digital elevation model you decide and then you can create automatically the damage network, you can also create the (Refer time: 38:47) boundaries you can also

create this stream ordering and so on so forth using hydrological modeling and using seek functions. So, this brings the end of third part of GIS analysis.

Thank you very much.