Geographic Information Systems
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Lecture - 26
GIS Analysis – 06

Hello everyone! and welcome to new discussion which is GIS analysis part 6. After this, we will also have one more discussion on this and by that, we will be ending GIS analysis part. As you know that this is in 7 parts and the reason is obvious that GIS analysis is the main part of our GIS. And even the title of future lectures may not be GIS analysis.

But they will be all part of GIS analysis because before the GIS analysis lectures, we discussed the different types of data; spatial data, non-spatial data, types of attributes and many other things and then started developing our GIS database. So, that part is over. Now, most of the discussion in future, we are going to concentrate mainly on the analysis part.

And that is the basically heart or key of the GIS so that a GIS user must spend a lot of time on analysis and can create lot of good output and modelling and prediction maps and so on. So, let us start with that. In the previous lecture, we were discussing about the connectivity functions and under connectivity functions, we have also touched about the network analysis.
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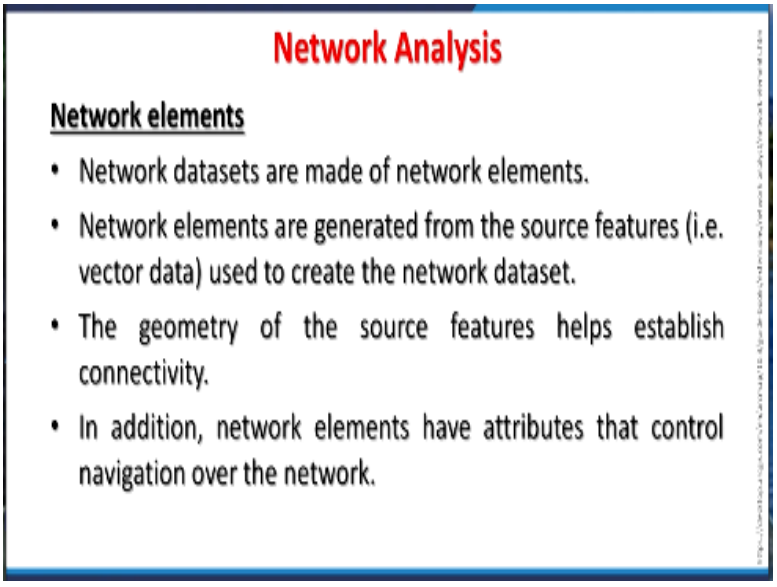

So, in this lecture and next one, we are going to discuss network analysis in much detail. Because nowadays, as you know that GIS is extensively being used for network related

applications. For example, maybe in transport, maybe in power transmission, maybe in other kind of transmission, maybe gas transmission and other things because these are all or the resource has to flow from one place to another. And therefore, these are very-2 important.

Similarly, if we talk about the traffic then you must have seen the apps which we are using especially in metros cities or large cities about these taxi operators' apps like Ola and Uber. They too are using GIS and along with that, they are using GPS and other things plus communication technology but in the background, they are also exploiting this network analysis.

So, from that point of view also and other day to day analysis of various kinds. If we talk in natural resources then network analysis though it might be one way in most of the time but like in drainage network or stream network, also there we can employ network analysis. Because there, it is a little simpler. In most of the cases, water is flowing in one direction and same in irrigation networks like in command areas, canal networks are there and then main canal then subsidiary and then minor cannel.

So there also, the network analysis can be employed of GIS. So, it is very important from all those perspectives. Now in network, what are the network elements? So, network data sets are made of network elements and mainly network elements, you can guess very easily are the polylines. And these network elements are generated from source features.

Obviously, when we say polyline that means vector data and which creates the you know the network of these polylines. And then the resource can flow from one end to another, maybe through you know distribution case like in case of canal or maybe a contributory system like a natural drainage system or a stream network. So, both kind of network analysis can be performed.

Related with this natural stream network or these drainage systems, we will be having a much more discussion when we will discuss the surface hydrologic modelling employ digital elevation models. So there also, this network analysis concept will be used. Now, as you know that the network geometry has to be established in order to establish the connectivity among these polylines of our vector data which might be residing in our database.

And also in network elements, we have that attribute. You know say if I talk about the canal system then what is the width of the canal? What is the flow condition in the canal? What is the depth of the canal? So, all these information and even suspended particles; turbidity and other things, all this information can go as attributes in this polyline database and which can be used to develop this connectivity.

So, we know that how the source will flow? Or how people will navigate within these channels if that system is also there? Now among the other network elements, basically we can divide in 3 kinds of network elements. The first one is the edges and edges means here to connect other elements or junction.

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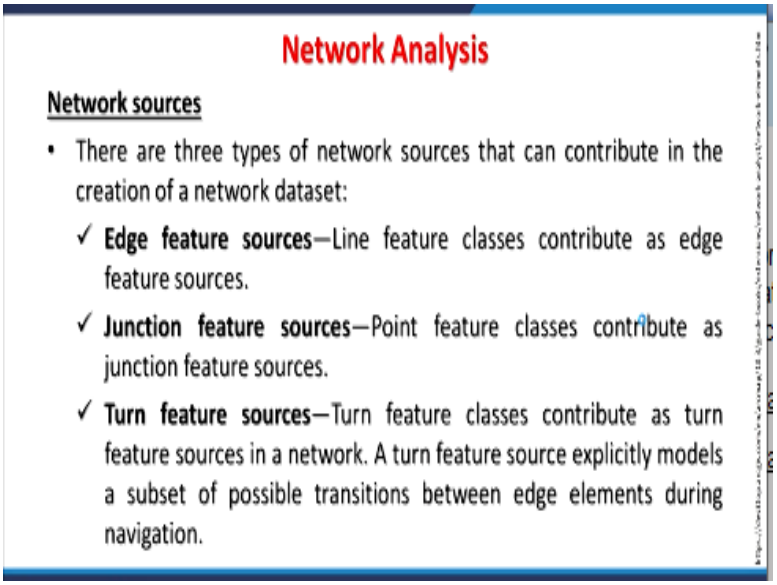

Because like in case of the drainage network, we may start with first order of streams then 2 first order streams as per one scheme of networking. Then these 2 first order streams can become second order stream and likewise. So, are the links over which agents travel or the resource travel? So, edges are one element. Another element is the junction and these junctions basically where these networks will join.

So, these networks of junctions connect edges and facilitate navigation. Navigation means here is not always from transportation point of view means like ship or boat navigation. It may be navigation of vehicles or navigation or flow of certain resources like water or other things. So, a common term is being used here is navigation; not always mean that is a transport related thing and from one edge to another edge through this junction.

And finally, the third element of network element is the turns. How you know the bending are they? How they store information that can affect movement between 2 or more edges? So, those 3 elements are important and they are basically developed. And when one digitises a network, these things will lie in the system as simple polylines. Now, this network has to be developed and once it is developed using all these 3 basic elements; edges, junction and turns then we can employ for further analysis.

So, now among in network elements that if we discuss individual and in combining, the edges and junctions form the basic structure of any network. And the connectivity in a network deals with connectivity connecting edges and junction to each other. As it is easy to understand that all that information has to be residing into our database then only network analysis can be performed.

What I mean here is that if all polylines are lying in isolation as we call as a in Spaghetti model like a plate of noodles; all noodles are lying in isolation though they are in a group but there is no connection between them. And therefore, individual elements are there then network analysis cannot be done.

Finally, that the turns; the third element of network that the turns are optional elements that store information about a particular turning moment, for instance maybe a left turn in case of you know traffic or some other scenarios. So, that kind of information is also very much required. Now, what are the network resources which has to move?

So, there are 3 basic types of resources that can contribute in creation of network data set. The first one is the edge feature sources. Another one is obviously as per the elements; the junction feature sources and third one is the turn feature sources. So, individually these sources basically you know, allow us to model the things or predict the things. So, like if I take example of edge features sources, the line features because these are polylines basically, classes contribute as edge feature sources.

And whereas junction feature sources, point features which are classes contribute at the junction feature sources. And the turn as you know that it is keeping information because it is a vector, basically. So, it is not difficult to know which is on the right side and which is on the

left side because this is a typical vector. So, turn information can also be a stored or develop in our GIS database especially related with network.

And these each feature class that contribute to a network as a source generates elements based on its assigned role.

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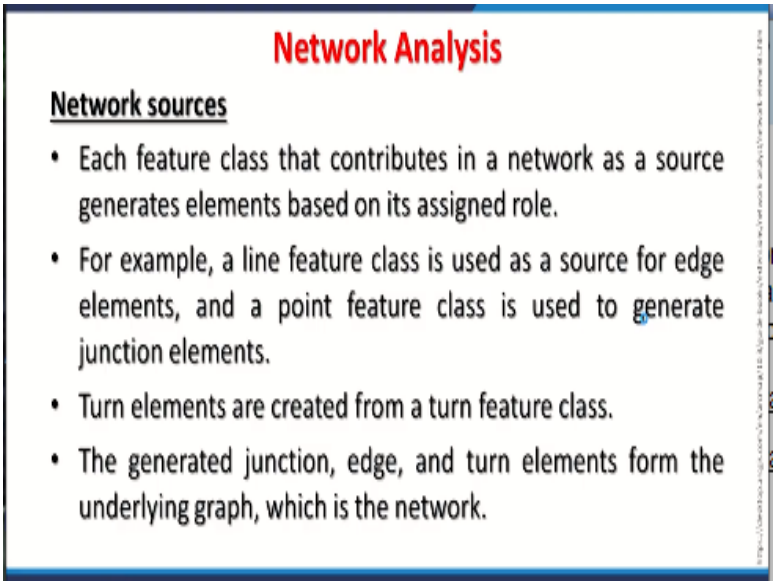

So, we have to basically assign what are the different roles of different these features or sources? For example, a line feature class is used as a source for edge elements and a point feature class is used to generate junction elements. So, different features that means different vector entities will be employed for different purposes. And of course, turn elements are created from a turn feature class.

And then these generated junctions which will be junction or edge or turn elements form the underlying graph which is the network. So, once that is done then network is created. In future demonstration, I will try to bring that one also that how this network, we can see on the system. Otherwise, when we will be discussing surface hydrologic modelling, definitely this discussion will come in much detail.

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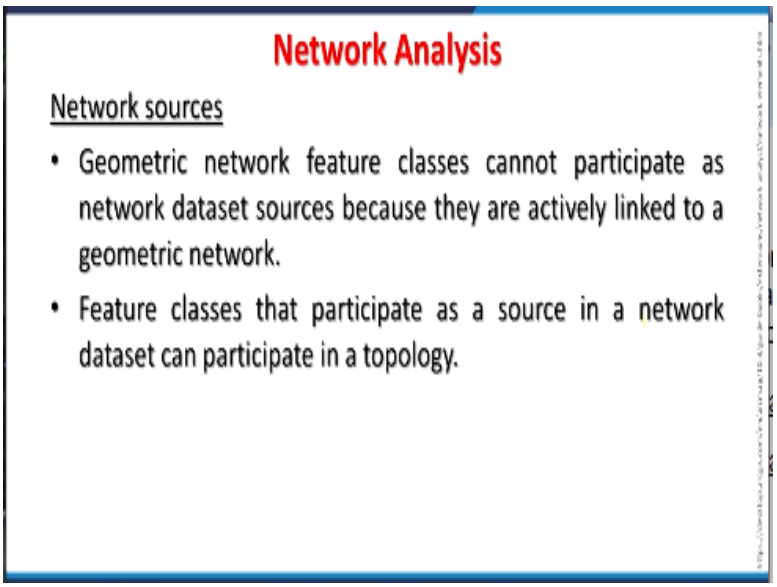

So, in this geometric network features, classes cannot participate as a network data set resources because they are actively linked to a geometric network. So, we have to develop a different. And what are these feature classes that participate as a source in a network data set can participate in a topology. So, remember then when we are discussing about topology, we mainly focus at that time on path polygon topology; there it is equally important.

But the same time when we go for network analysis then topology for polyline data is also important. Because each feature has to know or each junction has to know that from which direction, the resource will come. So, which is on the left side, which is on right side; everything has to be developed within our network database.

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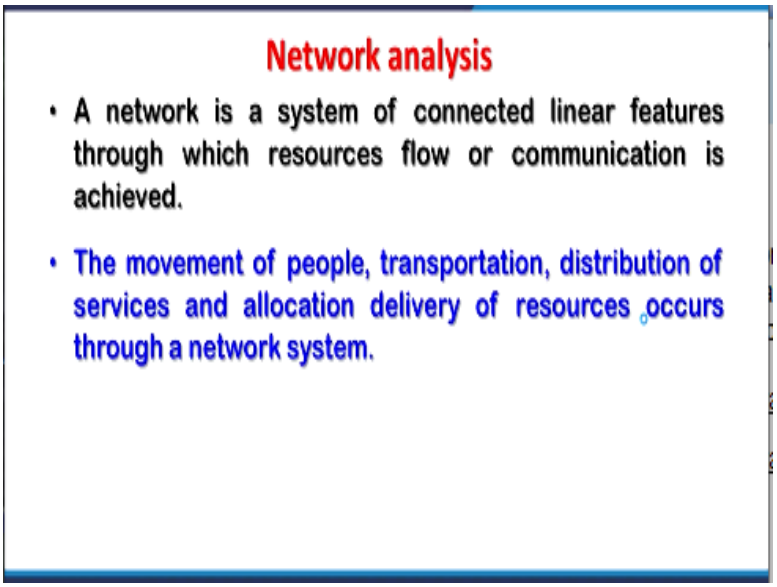

And a network is a system of connected linear features through which resources flow or communication is achieved. Now I have already given examples of various kinds of networks which we see in our day-to-day life. And one network is from natural system is like drainage network, canal network. There might be electricity power cable network, there might be network related with some like traffic or rail network or road network.

And nowadays, there are various-2 like OFC network very common nowadays which we see. So, among resources, we can keep ourselves also like moment of people, transportation, distribution of services, allocation, delivery of resources occurs through a network system. And that network may be a road network, rail network also. So, everything if organised can be model that how these resources will flow from one end to another?

And the movement along these lines or these polylines or network is affected by other elements and their characteristics in the network. And that means that if there are too many junctions then it will affect our network. If there are too many turns in our network, it will affect our movement of resources. So, that is another very important thing here.

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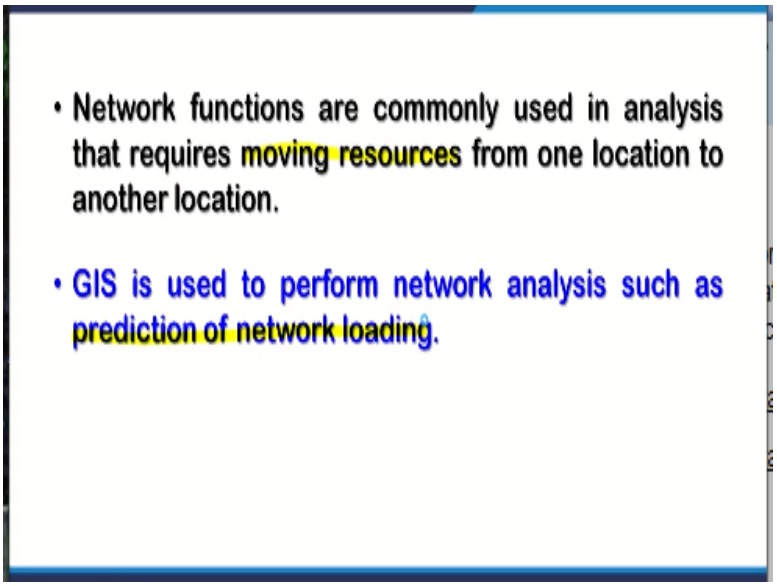

Now, these network functions are used in analysis that requires moving resources from one location to another. So, the key word here is the moving resources. Of course, if anything is not moving then no network is basically required. So, moving resources; that moving resources maybe water, maybe sediments, maybe gas, maybe electricity, anything. So, in this, GIS is used to perform network analysis such as prediction of network loading.

Basically, what we are doing through network? Initially, we may employ this network analysis of GIS about the predicting; how things will move? What would be the load on the existing network? And this will become the part of modelling. But in day to day monitoring also especially like power you know management; there this GIS analysis is being implied for the network-based analysis.

Also, this is a very common application of network analysis of GIS is about the determination of the shortest path.

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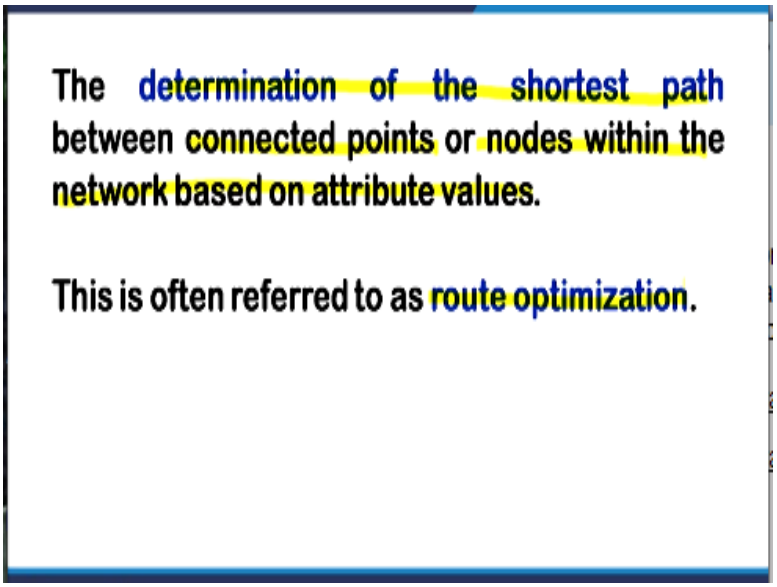

And that shortest path between connected points or nodes within the network based on the attribute values. Let me give you one example here. Few years back, I read that in some Western countries; the newspaper men, he wanted to know the shortest path to deliver newspapers every day in a part of city. So, he wanted you know the shortest path or optimum path through this GIS analysis, that can also be done.

And by which that you know, the newspaper hawker can save his time and resources also. So, even to that extent, network analysis of GIS can be implied. Sometimes say instead of calling network analysis, some software in literature you may find another term which is used to called route optimization. Basically, finding the shortest route or finding the optimum route; that is route optimization. You might have seen in our example like Google map.

If I put that I want to travel by road from Roorkee to Dehradun. Now immediately, it will show minimum 2 routes to me; one is via Haridwar. Another one is via this Chhutmalpur and

Mohand. And for both routes; it will let me know that what is the distance of these 2 different routes and how much time it is going to take depending on the present traffic conditions.

So, how it gets the present traffic condition? That is another very interesting. It is coming through crowd sourcing and through the mobiles. So, if traffic is moving normally, smoothly then that means these mobiles of individuals who are in the cars or vehicles which is a moving resource, they are changing one tower to another in a normal way. And therefore, the that part of the route would be shown as a blue colour.

And if it is moving slow, it might appear as yellow and if it is really standstill; that means individual mobile is not changing from one tower to another, that means there is a traffic jam. So, both routes will also show this information which is coming from other. And of course, there is another algorithm which is working in the background that it only shows along the roads. You know side of the road if there are 1000 people has assembled for some function, that information will not come on the road.

So, only information about this you know crowd sourcing of vehicles or people who are having mobile are in vehicles, that information is shared. So, immediately you know the 2 routes, distances and traffic conditions. And also, you can choose that I may follow the longest route but it might take less time or convenient. And further it also tells us that whether they are having toll plazas or not. Because some people would like to avoid toll plazas because of crowding sometimes at toll plaza.

So, all that information, from where it is coming? Definitely it is coming through network analysis of GIS.

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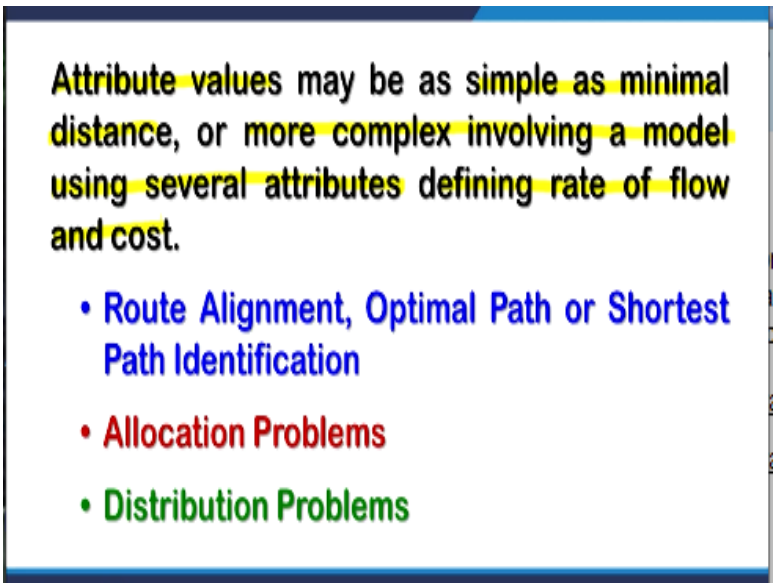

And whatever the information about mobile density and other information which I am telling you which is being used in network analysis is coming as attribute values and it is getting updated almost every minute or so. So, attribute may be simple as minimal distance as in case of like road example, I have given or more complex involving model using several attributes defining rate of flow and cost.

And this is how it tells or predict that if I start now from Roorkee to Dehradun then this much of the time, it is going to take. And of course, then using distance and speed, we can also determine the cost. I am sure in future as per your vehicles design or average mileage, it will start also predicting that how much it will cost. So, those things, it is nothing but coming from attributes.

So, that has to have the information about the type of car and mileage then it can be also predicted. So, this network analysis is used for route alignment, optimization of route, optimal path, shortest path identification, location problems and some resources are not reaching at say a minor canal is not getting water, what is the problem? So, those problems can also be solved.

And then of course, it is also linked with the distribution problems because through network, you are distributing resources from one end to another. And therefore, if there are problems; bottlenecks, junction which are creating problems can be solved by through this modelling. Now, further in this network analysis discussion that its facilities management is based on the network analysis.

Facility management; I have already told like you know, these taxis which are nothing but facility management. Similarly, the big truck operators or the fleet management, they use also. Indian Railways have also started employing GIS along with the GNSS; that is Global Navigation Satellite System to know where exactly different engines because on the engines, they have installed these GNSS receiver.

So, on the network, immediately they know that where individual engine is and with which train, it is and at what speed is travelling, how much time it would take? And in future, we are going to have a very good prediction about the timing or late of train based on all through this network analysis and facility management.

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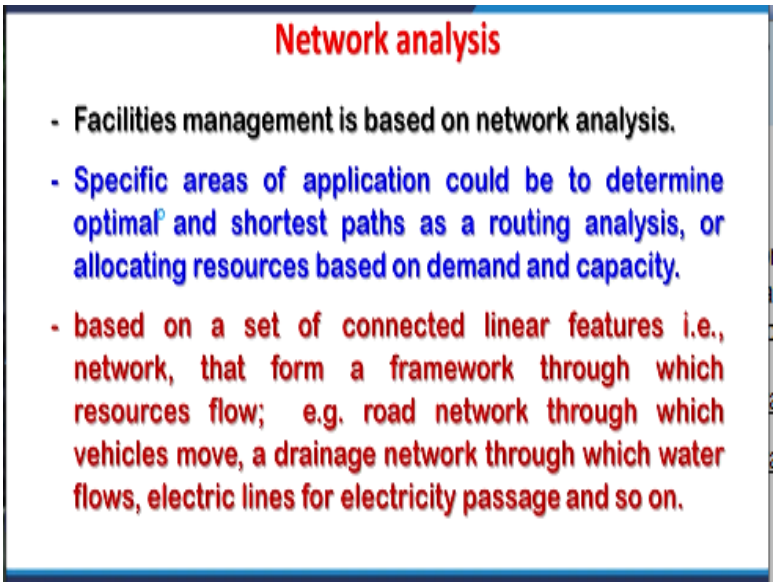

So, specific areas which are benefited or applications could be to determine optimal and shortest path as routing analysis or allocating resources based on demand and capacity. And based on a set of connected linear features for example, the network; that is what we are discussing that form a framework through which resources flow, maybe road network; through which vehicles move, a drainage network; through which water or a sediments flow, electric lines for electricity passage and several other such applications can be there.

Now basically in network analysis, there are 4 components which are considered. Apart from 3 basic elements, 4 components are that first as if you recall the our overall this discussion on related with the connectivity functions, there also we have been discussing that for different

type of analysis within connectivity like for proximity or others which are these components are required.

So essential components, first is required about a set of resources. What is the resource which has to move through that network, that much information is very much required.

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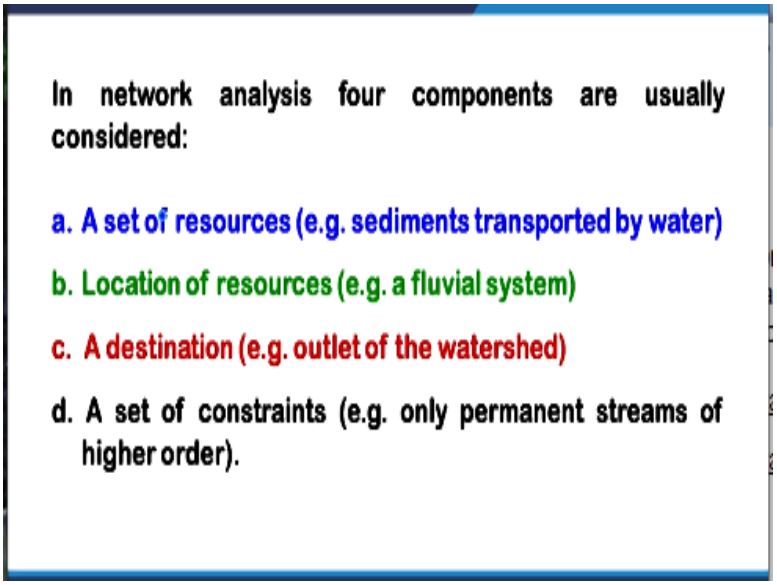

For example, sediments transported by water, that is one or water itself is also a resource. Then location of resource. And when we are on GIS, location is not a problem and we will get that information also. For example, if I take a fluvial system that means the drainage network or stream network. So, that information is there within the system that which are the higher points, which are the lower points in this fluvial system.

So, I would know from where to where, the water will flow along with sediments. And then the third one is the destination. For example, maybe outlet of a watershed if we are thinking in terms of natural drainage system. And the final one is set of constraints that these set of constraints can only be provided by the experts of that field; those who work in this hydrology if we discuss about the water relate thing then a set of constraints.

If somebody is good in power supply then he would let us know what are the constraints or conditions, rules. For example, in case of this natural drainage system, only permanent stream of higher order which will have the water otherwise generally you do not have water. Those are the perennial streams which are being discussed here. So, 4 components are usually considered or required before the network analysis.

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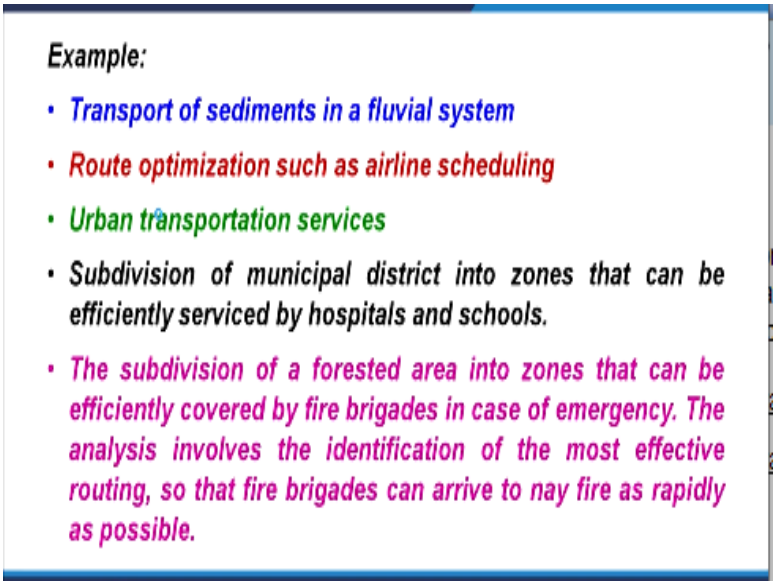

For example, transportation of sediment in a fluvial system, route optimization such as airlines ruling, they too have started implying GIS. Urban transportation services for city buses, etcetera. For metros, for other like road networks and subdivisions of Municipal District into zones that can be efficiently serviced by hospitals and schools. There also that how much time, a kid will take to reach to the school.

So, those optimizations can also be done if that is required. Same with the hospital, same with the emergency services like for fire brigade, ambulance, etcetera. These things can be employed. For example, also like subdivision of a forest into zones that can be efficiently covered by fire brigades in case of a emergency. It is a very common thing in Garhwal, Himalaya where every year in the month of April, May or sometimes even June, we are having forest fires.

So, if we know the which are the routes which are available then efficient system can be established or can be developed so that the fire brigade can reach very quickly to the spot where the fire has occurred. So, this kind of analysis basically involves the identification of most effective routing. So that the fire brigade or ambulance or any emergency services can arrive to nay fire as rapidly as possible.

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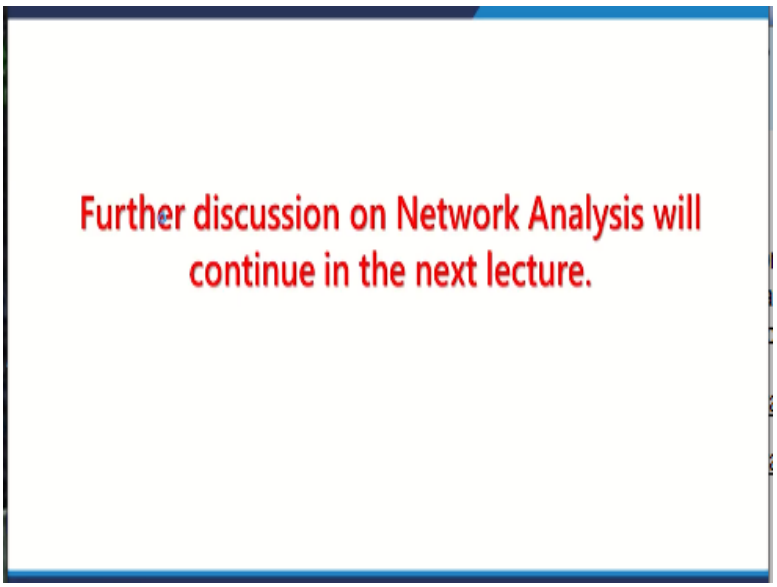

Now, further discussion on network analysis as said, we will be in the next lecture. So, for timing being, thank you very much.