Watershed Management
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Module No. # 06
Lecture No. # 22
GIS and Applications in Watershed Management

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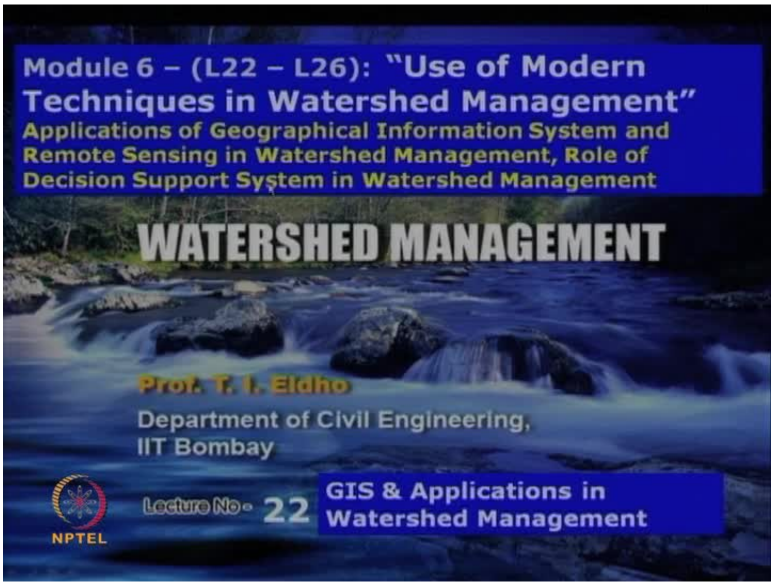

Namaste and welcome back to the video course on watershed management. Today, we will start a new module - module number 6. So, there will be 5 lectures in this module. The topic is on use of modern techniques in watershed management. So, the topics include applications of geographical information system, remote sensing in watershed management and role of decision support system in watershed management.

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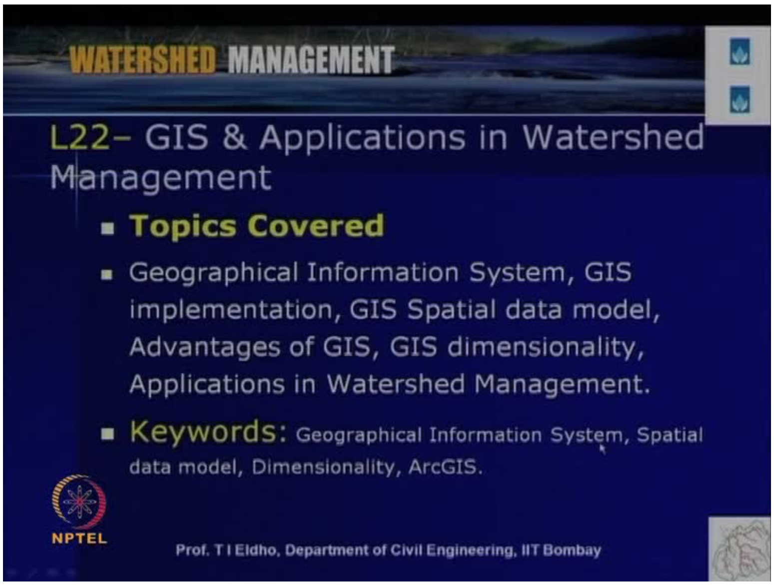

So, in module 6, today in lecture number 12 lecture number 22, we will discuss GIS applications in watershed management. So, in lecture number 22, GIS and application watershed management, some of the important topics covered include geographical information system, GIS implementation, GIS spatial data model, advantages of geographic information system, GIS dimensionality, applications in watershed management. Some of the keywords for today's lecture include: geographical information system, spatial data model dimensionality, arc GIS.

So, as we discussed in some of the earlier lectures, watershed management and planning is very complicated; very comprehensive plan we have to make or it is a very complicated process.

So, we have to deal with large data set. We have to manipulate various data sets and create say, new maps all those things are required. So, that way geographic information system or GIS, the so called GIS, is very much useful for the preparation of watershed management plans. So, in today's lecture, we will see what the important applications are as far as GIS is concerned for watershed management plans.

So, first, let us have a look into the introductory aspects of GIS and then we will see how we can effectively apply the GIS for preparing various watershed management plans and then as far as the implementation is also considered, we can use GIS.

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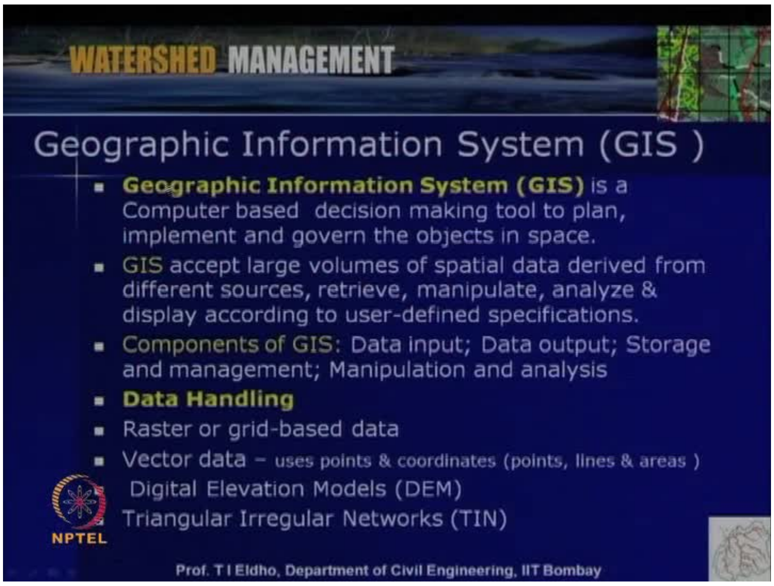

So, let us look into some of the introductory aspects of GIS. So, GIS or so called geographic information system is a computer based decision making tool to plan, implement and govern the objects in space. So, we can see that there is lot of variation is taking place, lot of data, we have to deal with say, as far as a watershed is concerned. Since watershed is an area of large size, we have to deal different types of data. So, that way this GIS is say, is a very useful tool. So, it is a decision making tool to plan, implement and govern various objects in a spatial format.

So, GIS accepts large volumes of spatial data derived from different sources, retrieve it, manipulate it, analyze and display according to user defined specifications. So, that way we can see that we can feed various data sets in a GIS platform, in GIS software to a computer and then we can manipulate those data sets to create new maps.

Say for example, for in the within the perspective of watershed management, we can generate a digital elevation model, we can generate soil map, land use, land cover map, then we can generate grids. Like that so many applications are possible as far as watershed management, which will be discussing later.

So, that way we can see that GIS accepts large volumes of spatial data and then we can make into user defined specifications. Some of the important components of GIS include data input, data output, storage and management and then manipulation and analysis.

So, actually, GIS is a software. So, that way once we install in a computer, so that through that through the computer, we can give the data input and then we can obtain the data output from the computer and then storage and management things can be done within the computer.

The software does various manipulation and analysis so that we can generate new maps or other kinds of things, which are possible within the geographical information system. So, main aspect is data handling. So, GIS is a tool for data handling. So, as far as this data is concerned, it can be raster or vector. So, raster means it can be a generally a grid based systems.

So, we can see that we can have a grid like this and then we can represent various objects or various data with respect to this grid. So, that is so called raster based data and then the data can also be vector based, where we can use points, then coordinates, lines polygons areas etcetera. So, that is the vector based data set.

Using this as I mentioned, we can generate say, within the spatial variation, how the elevation is varying. So, that way we can make a digital elevation model and then extract various things and how the system is behaving and then also, we can use triangular irregular network, the so called TIN.

So, we can represent the system using the various triangle connected networks say, irregular triangular connected network and then represent how the variation say for example, how the direction of a river changes or how the position of a well or say where the pond is located. So, like that many aspects of many objects within a watershed, we can represent within a GIS environment.

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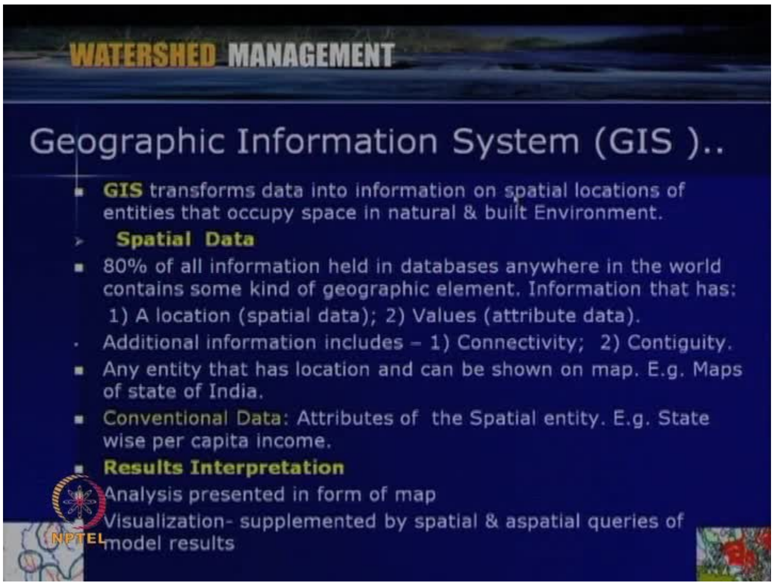

That way, GIS transform data into information on spatial locations of entities that occupy space in natural and built environment. So, it can be either natural environment or built environment. That way, the GIS transform whatever data we put in and then we can see the variations. So, the data generally will be spatial data. So, spatial say whenever Especially, in the case of watershed management plans, we have to see how the variation is taking place for various parameters, for example hydraulic conductivity or the rainfall variation or soil type variation.

So, all those things are spatial variations or spatial data sets, which we have to utilize for various purposes. Some of the research says that 80 percent of all information held in databases anywhere in the world contains some or other kind of geographical elements. So, that means it can be with respect to spatial variation of various objects. So, that is what is generally, we call it as data.

80 percent of all information is some or other kind of geographic element. will be there. So, information that has say, for example, a location, where is it located, whether it can be represented as a point or it can be a line or it can be a polygon and then values. So, we can specify various values, the so called attribute data.

So, then also, we can have additional information like connectivity. For example, say one place to another place, how we can connect say through roads or through channel network or what kind of connectivity is possible and then second one is contiguity; that means the continuous variation, how it is taking place. So, that way GIS gives the information about any entity that has location and can be shown on map; that variation we can obtain. Example: maps of state of India or any country. From that map, we can identify, where some specific place is located or specific institute is located or specific things are located.

So, the data can be generally conventional data with attributes of the spatial entity. Example: state wise per capita income or how is the population variation, what is the education of the population or how is the literacy rate, where are the wells located or say how the water resource availability varies.

So, like that, these kinds of things, we can represent as a spatial data generally in a conventional way. Then we can have the various things based upon the data; we can manipulate the data and then we can obtain various other kinds of maps or results can be produced and then we can interpret these results. Then these results can be represented in the form of a map. So, you can see that here, say a channel network map or the variation of the soil variations or soil map or it can be the land use, land cover map, like that.

Then we have to put it in a visualization model. Visualization is coming from the computer output. So, that way this can be supplemented by spatial and aspatial queries of model results. So, whatever we give different types of data inputs and then we process it within the computer or within the software and then we create various outputs either in map form or the spatial variation form or spatial queries as the model results. So, that way the geographic information system or GIS works.

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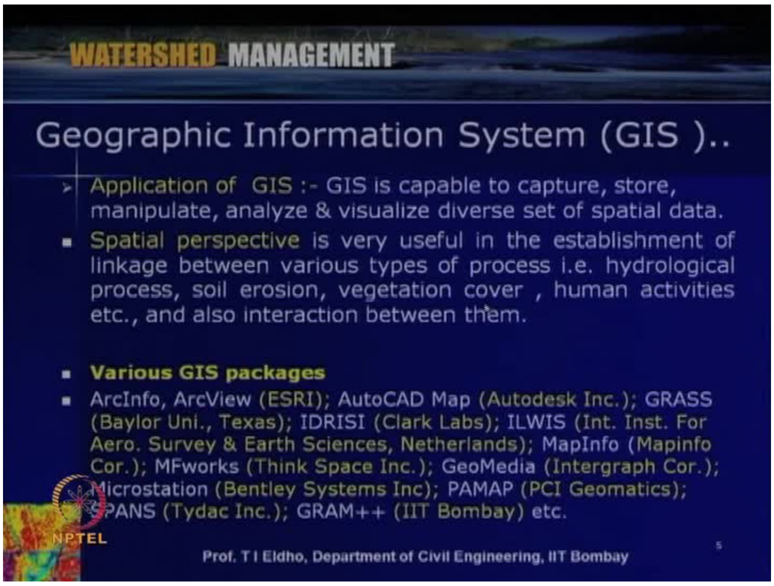

So, there are a large number of applications as far as GIS is concerned. It is not only watershed management, but town planning, then say, like the geographic the various city planning or say, the population behaviour or the social economical aspects, so many places we can use the GIS.

So, that way GIS is capable to capture, store, manipulate, analyze and visualize diverse set of spatial data. So, as I mentioned, this is what is happening within a GIS environment; GIS capture, store, manipulate, analyze and visualize.

So the So, that way the various spatial data set, we can say, gives input and make different kinds of different data set as output.

So, spatial perspective is very useful. The establishment of linkage between various types of processes that is say for example, if water is concerned, the hydrological processes, soil erosion, vegetation cover, human activities etcetera and also how they interact between them. Say, for example, say, how the people say, the human interaction takes place within a watershed or say, how the vegetation cover is varying.

So, like that a spatial say, with respect to the spatial perspective, we can get lot of information back with by using the GIS. So, if you look into the literature, various GIS packages are available. Some of the most commonly used packages and the companies which market these products are listed here.

So, most widely used GIS package is ArcInfo or ArcView and that is marketed by ESRI. Then autocad map which is marketed by Auto desk, then GRASS which is an open GIS software, which is freely available and which is produced by Baylor university, Texas.

Then IDRISI produced by Clark labs, then ILWIS - I L W I S, Institute for Aero Survey and Earth Science in Netherlands - International Institute; so, this is from Netherlands. Then MapInfo - Map Information Corporation, MFworks - Think Space Inc, Incorporation, Incorporated, GeoMedia - Intergraph company, then Microstation - Bentley System, P A M A P, PAMAP - P C I Geomatics, SPANS - Tydac income, GRAM plus plus say, for example, I I T Bombay's GIS software.

So, like that in the market, depending upon the needs, what kind of work you are looking to do with a GIS package, various types of packages are available. So, depending upon your needs, say, specific packages, we can buy and then utilize, but one of the most commonly used GIS package is so called arc info or arc view from ESRI.

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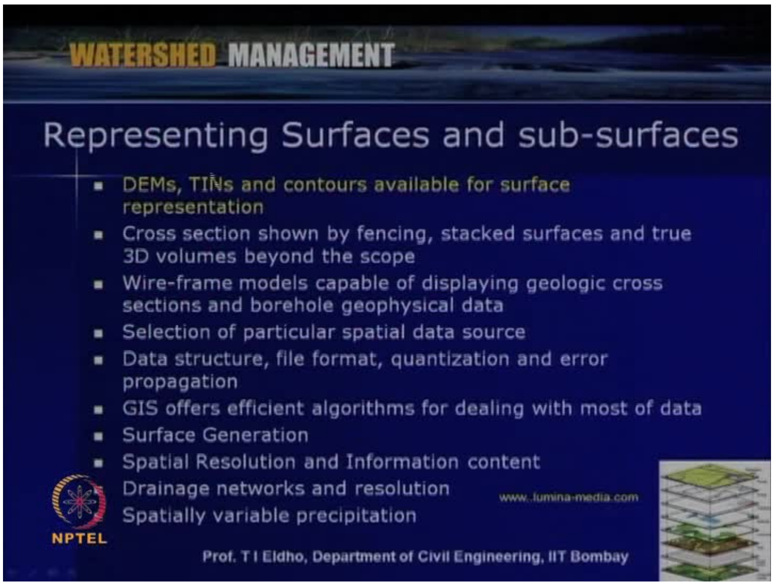

Now, let us see what happens say, within a GIS platform. How to represent the surfaces or sub surfaces, which we have to generally deal within watershed management plans? So, as I already mentioned, we can generate digital elevation models or triangular irregular network tins and then say and contours available for surface representation. So, we can represent the surface either using the say, grid based system, by using digital elevation models or triangular irregular networks or contour and contours available.

A cross section shown is generally shown by fencing or stacked surfaces and so, you can see that stacked surfaces are just shown in this figure. We can have various stacks like this, and then say but generally, 2, 3 dimensional volume representation is beyond the scope of most of the GIS packages.

Then also, we can represent by wire frame models capable of displaying geological cross sections and borehole geophysical data say, for example, when we are dealing with watersheds, we have to deal with the boreholes and then, its data. So, that also, we can represent. Then selection of particular spatial data source, then data structure, file format quantization and error propagation. Then GIS offers efficient algorithm for dealing with most of the data sets.

So, by using various things, we can generate the surface and then we can represent either in a stack form or say by various attributes. So, surface generation can be done and then the spatial resolution and information content, we can cross check and then say, for example, when we have to deal with the drainage network within a watershed that also, we can represent with respect to the surface or sub surface modeling. Then say, if you want to represent say, for example, the spatial variations of the rainfall or precipitation, then also, we can represent using the contours or the various polygons filling like that. So, various aspects are available, when we are trying to represent the surfaces and subsurface within the GIS environment.

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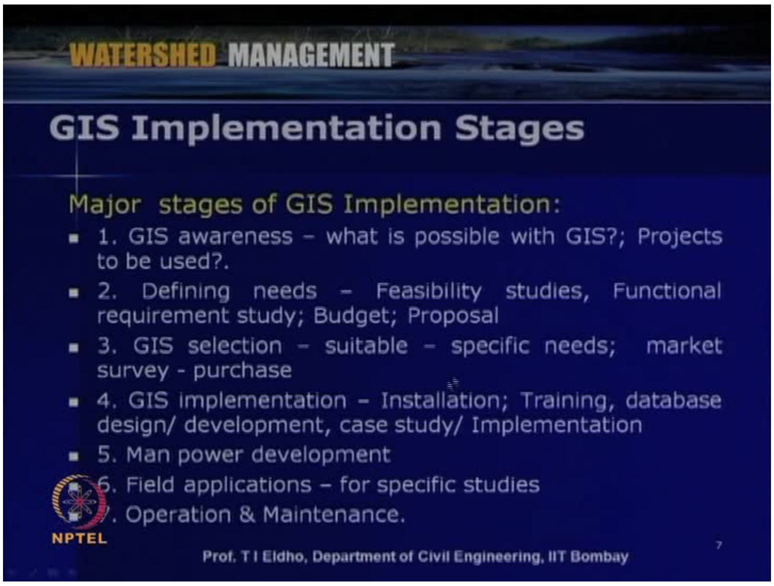

So, now, say, for example, if you are going to say, use GIS say, what are the major stages of GIS implementation. So, that I have listed here. So, first of all, you should have GIS awareness. So, say what a GIS package can What is GIS? What GIS can do? What are the objectives? Depending upon your needs, what kind of problem can be solved? So, all those things we should understand. So, there should be some at least some introductory GIS awareness as far as when you are before you implement the GIS in your system for various purposes.

Then second stage is defining the needs. So, what are your needs? So, project specific or what kinds of needs are there. So, that we can obtain details from by using the feasibility studies or say, the functional requirement study and then we have to see that what the budget is which can be spent for the GIS implementation and then its training and other things. So, that way we can come up with a proposal.

Then, say, we can in the third stage, we can select appropriate packages depending upon the suitability, specific needs, then market survey and so that we can purchase. Then fourth stage is GIS implementation. So, here say. we can obtain the package from the vendor and then we can install it in the computer, then we can train the manpower within the organization and then say, for the given specific projects, we can create the database and depending upon their needs. So, database design and development and then say, we can check, whatever the things which we are looking for, whether the considered software or GIS can do.

So, case study and implementation and then, we can develop manpower within the organization and then field applications for specific case studies, specific projects depending upon the needs, we can utilize it. Then, we have to the operation and maintenance, we have to see so that some administrator who is generally dealing with the GIS package, we can entrust to that person as far as the operational maintenance. So, these are the important or major stages of GIS implementation.

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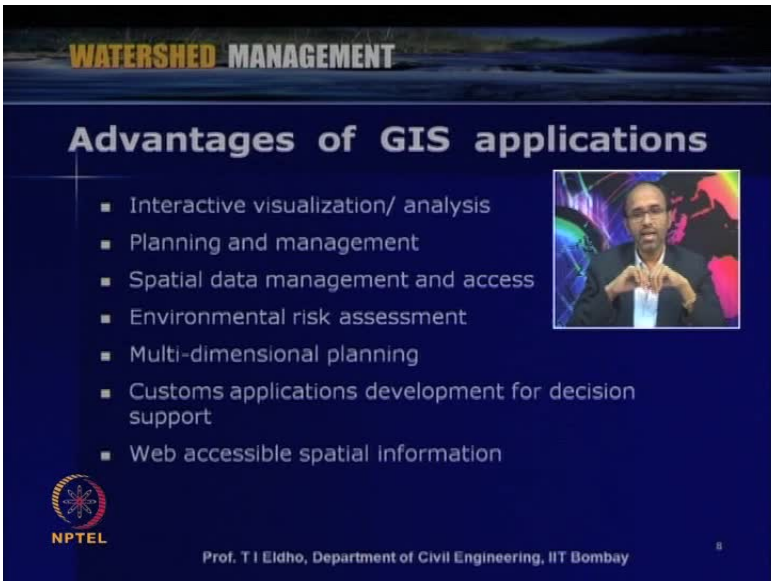

Then So, as I mentioned GIS can be used for various applications. So, let us look into what are the important advantages of GIS usage? So, say, as I mentioned already it is a computer software, which we install in a computer and then we give say input and then we generate various outputs in terms of maps or various objects.

So, that way So, let us look into what are the advantages of GIS implementations. So, GIS is first of all, it is interactive. So, say, from one we can overlay various maps and then see what is happening. So, interactive visualization and analysis are possible within the GIS. Then, we can utilize this GIS for the planning and management of various schemes, just like watershed management plans, then say, the city development plans like that. Then say spatial data management and access. So, we can say keep on adding data input to the system and then say, we can access whenever it is needed in various formats.

Then we can use it for environment risk assessment say, once it is set, we can see that how the system say, how the behaviour is within, as far as the system is concerned; that we can study using the GIS. Then GIS can be used for multidimensional planning, even though mainly spatial variation, but we can create the spatial variations for various scenarios and then we can use GIS for planning.

Then customs applications development for decision support - customize the applications say, for specific type of works. So, we can create a system and then that can be utilized for decision support for the decision support system and then, also we can have web accessible spatial information is possible. So once it is various inputs are given, and we can say, any general public can access through web say and then visualize what are the scenarios? What are the various alternatives for particular projects? So, like that.

So, these are some of the advantages of a GIS implementation for a particular project say, within the GIS environment. So now So, by now, what we have discussed is the introductory aspects of geographic information system. So, now, we will come back to our major topic of watershed management. So, how effectively we can utilize geographic information system within the perspective of watershed management. So, let us look into various aspects of the vital components of watershed management say, various aspects are listed here.

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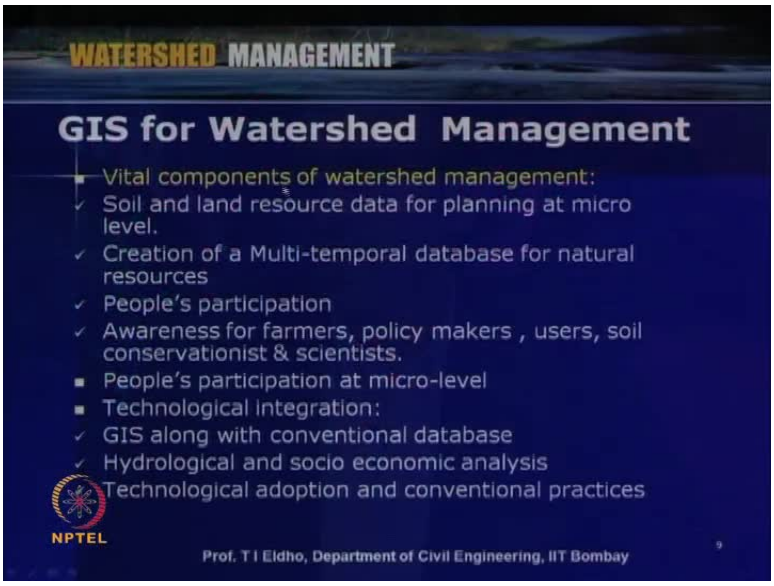

So, generally, we may deal with soil and land resource data for planning at micro level or say, large scale, macro level. Then, say, we can create a multi temporal database for natural resources. So, how the with respect to time, how the variation is taking place? so each Say, particular year or particular season, we can create the database and then how it is behaving that we can study. Then we can say within the perspective of watershed management, people participation is very important.

So, people participation say, within the GIS environment, we can load various data sets input and then within from that we can obtain say, the road network or the location of various houses or the water availability. So, all those things we can do within the GIS and so, the awareness of farmers, policy makers, users, soil conservationists and scientists, say, everybody say, either it can be farmer policy makers, engineers, scientists, all people can utilize GIS in a very effective way for the development of plans or implementation or say, an overall watershed management perspective. So, people participation, we can go at micro level, very small say, for example, in stake holder level itself, we can see how they say, we can make GIS data available for the stakeholder each stakeholder.

Then various hydrological modeling or various things we can integrate. So, technological integration is possible and then GIS along with conventional database, we can generate various types of maps. So, that will be very useful as far as watershed management is concerned. Then, also hydrological modeling, we can utilize the geographical information system and then, also we can use for economic analysis like the economic viability or to identify the benefit cost ratio. So, all those places we can effectively utilize the GIS. So, technological adoption and conventional practices, we can effectively manage with the help of a geographical information system.

So, now, we have seen that GIS can be utilized for various purposes say, within the perspective of watershed management. So, let us look what are the basic steps in typical GIS application as far as watershed within the watershed perspective is concerned.

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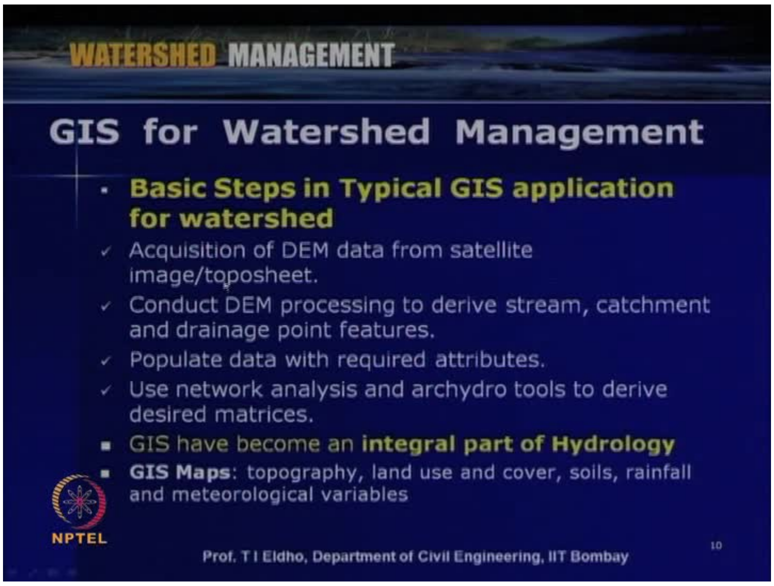

So, as I mentioned say, we can generate digital elevation model say, within the perspective of watershed and then this acquisition of digital elevation model data from say, for example, from toposheet or we can generate the DEM or we can get through various sources. Then conduct digital elevation model processing to derive stream catchment and drainage point features.

So, once a watershed is delineated by using a GIS and then a digital elevation model is generated, we can utilize to identify the drainage location, the stream pattern, then the drainage point etcetera. Then, we can populate the data with required attributes to identify various things within the watershed. So, we can also use network analysis and say, for example, within the arc info environment, we can use arc hydro tools. So, in the arc info or arc view has arc hydro tools related to water related issues. So, that we can utilize to derive desired matrices and then we can plan say, we can generate various related maps.

So, that way, now, geographic information system has become an integral part of hydrology. So, GIS has become an integral part of hydrology. So, in each and every aspect of hydrological modeling or hydrological planning or watershed management, we can utilize geographic information system. So, various types of maps we can generate using the GIS just like a topographical map, land use map, land cover map, soil map, then rainfall related maps, then meteorological variables. So, like that GIS helps to generate various types of maps which are very useful in hydrological modeling and watershed management.

So, now let us look into say, as I already mentioned, geographical information system is say, is working based upon the data input and data manipulation. So, data source is a very important, data structure is very important. So, let us look into various aspects of data sources and structures

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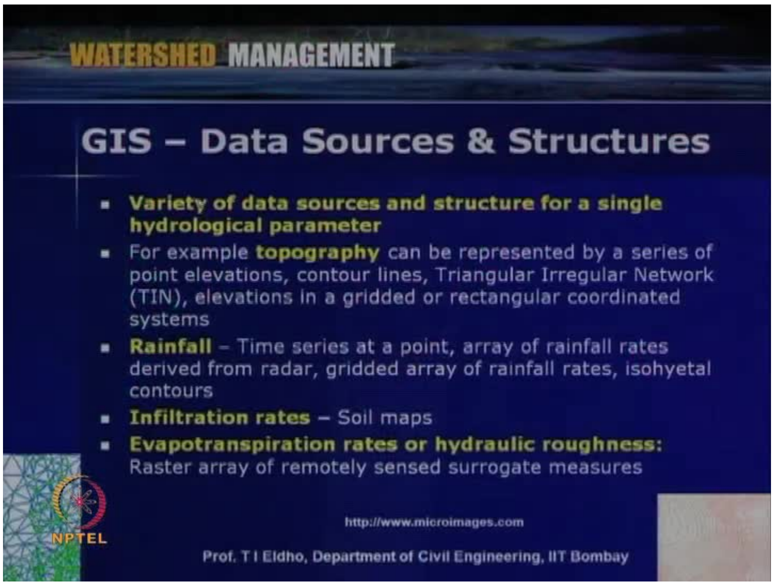

So, a variety of data source and structure for a single hydrological parameter, we can say, is put through GIS. So, for example, topography can be represented by a series of point elevations, contour lines and triangular irregular networks - so, we can see that like this, triangular irregular network, elevation in a gridded or rectangular coordinator system. So, each and every aspect of the hydrological parameters or watershed related things, we can represent by various things like it can be either using the points, lines, polygons or triangular irregular network or contours or elevations.

So, like that various things we can represent and based upon that we can generate various other maps and then say, for example, rainfall is concerned, we can have time series at a point, array of rainfall rates derived from radar, gridded array of rainfall rates, isohyetal contours.

So, all these things, we can represent, once the rainfall data is given within a GIS platform. We can have either say, time series or the contours or isohyetal contours. Then say, for example, if we consider infiltration rates. How the infiltration is varying within a watershed? We can Say, we can have the soil maps and then according to the soil nature, infiltration rates also varies as we already discussed earlier. So, these soil maps can be used to represent within a GIS environment to identify how the infiltration rise is taking place.

Then evapotranspiration rates or hydraulic roughness say, depending upon the land use and land cover, the hydraulic roughness will be varying. So, that by using say, a land use land cover map, we can identify the hydraulic roughness variation within the GIS environment. Then evapotranspiration variation with respect to vegetation or with respect to various water bodies, we can identify within a GIS environment. So, raster array of remotely sensed surrogate measures also can be used as far as the to identify the evapotranspirations or the hydraulic roughness

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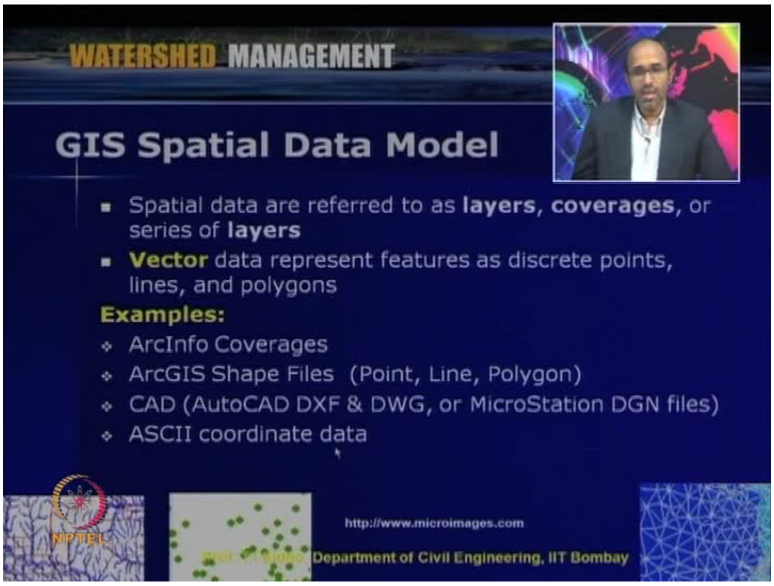

Then say, GIS as I mentioned it is giving the spatial variation and then based upon that we are generating new maps or new data sets. So, this spatial GIS has a spatial data model. So, the spatial data referred to as layers or coverages or series of layers. So, as I already mentioned, it can be say single layer or it can be various coverages within that layer itself or it can be series of layers superposed over layered depending upon the needs.

So, that way the data can be put as either raster variation or vector variation. So, raster is grid based and vector is a point based or lines or polygons. So, vector data represent features as discrete points, lines and polygons. So, say, for example, arc info coverages. So, this we can utilize for to represent the lines, points or polygons. Then arc GIS shape files can be used for point, line or polygon. Then cad say, auto CAD DXF or DWG or micro station DGN files, then ASCII coordinate data can be used to represent points or say lines. So, like that various spatial data modeling can be done within the GIS environment.

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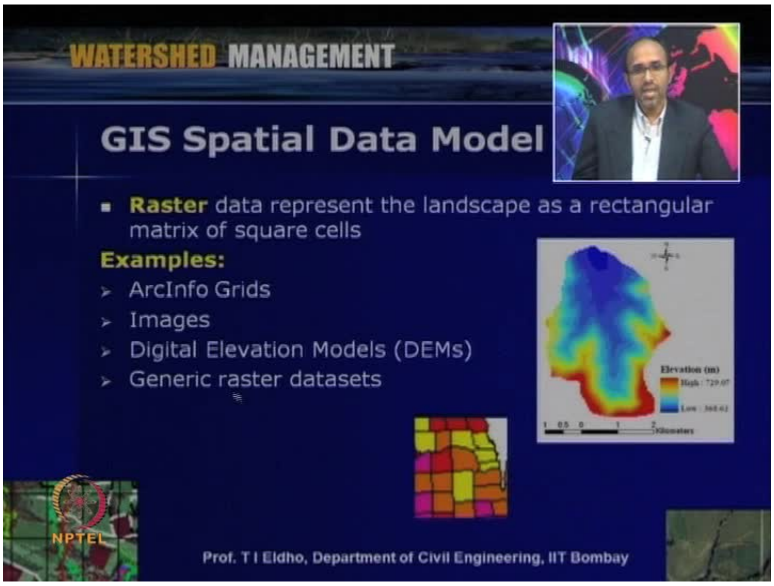

So, as I mentioned, the data can be either raster based or vector based. So, raster is concerned, raster data represents the landscape as a rectangular matrix of square cells. We represent the system as a rectangular matrix of square cells and then within that grid how the variation of various parameters is taking place; so, that way is the raster representation. So, earlier we discussed about the, last slide discussed, about the vector variation; now, the raster variation.

So, some of the examples - arc info grids, which directly we can utilize or the images, how the images we can represent in a raster format, then digital elevation model by using a spatial variation raster way and then using the contours and then generic raster datasets.

So, all those things we can utilize say, as far as GIS spatial data model is concerned. So, that way say, depending upon the package, depending upon the need whether we can have a raster based system or vector based system and then say, one to another conversion also possible in most of the GIS packages.

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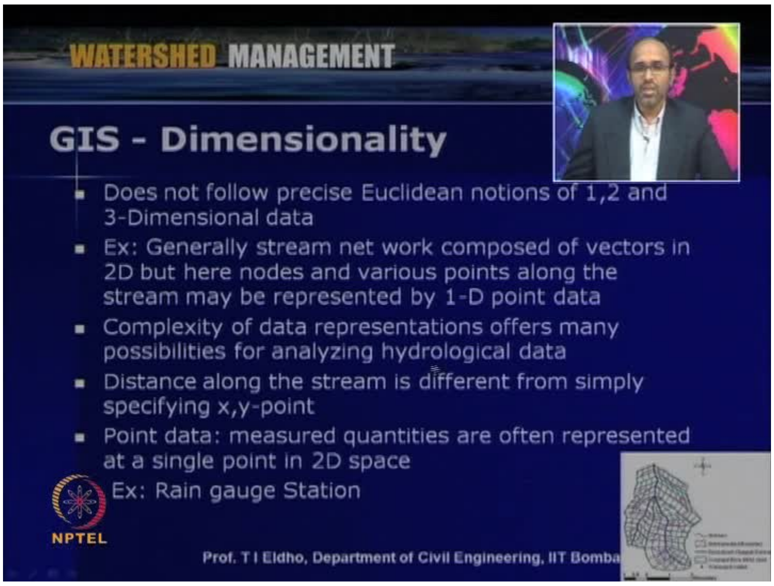

So, now, let us look into the GIS dimensionality. So, as far as dimensionality is concerned, GIS does not follow precise Euclidean notions of 1, 2 and 3 dimensional data; it is not exactly following, but with some variations. So, example, generally stream network is composed of vectors in 2D, but here nodes and various points along the stream may be represented by 1D point data. Say, for example, this is a watershed, where you can see various stream networks; so, this will be represented by 1D point data.

Then complexity of data representation offers many possibilities for analyzing hydrological data. So, as I mentioned, hydrological data is concerned, say, it can be the location of the streams, lakes or the hydro geological parameter variations.

So, these complexities, we can directly, easily deal with the help of GIS. So, distance along the stream is different from simply specifying (x, y) point, a particular point. So, that way we cannot we will not have precise Euclidean notions. Then, point data is concerned, it is measured quantities are often represented at a single point in 2D space. So, just like a rain gauge station. So, in this particular location of the rain gauge stations and then it is measured quantities are often represented by using this. So, now, some other issues like a map scale and spatial details within the GIS environment.

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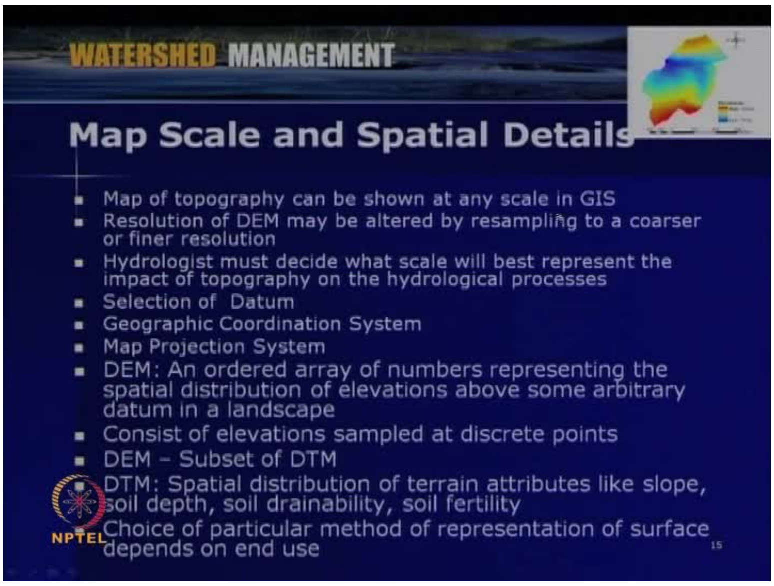

So, the details are mentioned in this slide. So, map of topography can be shown at any scale in GIS. So, it can be 1 is to 50000, 1 is to 10000, whatever say, scale we can represent. Resolution of digital elevation model may be altered by resampling to a coarser or finer resolution. So, if coarser data is available, we can make it finer by using the option of resampling and then hydrologist must decide what scale will be best say, to find out the impact of topography on the hydrological processes.

Accordingly, we can choose this particular scale, 1 is to 100, 1 is to 10000 or whatever scale we are looking for and then we have to always as the various data set is given with respect to certain datum, so, we have to select specific datum like either mean sea level or whatever specific datum, we are using, we have to select that datum. Then we have to say provide geographic coordinate coordination system. Within the GIS environment, we have to identify the coordinate system.

So, we can use the geographic coordination system by providing at least 3 specific points, where the details are known and then with respect to that the variation can be represented. Then map projection system – so, when we are projecting the map how the system is behaving and then as far as digital elevation model is concerned, as I have already mentioned there, DEM is an ordered array of numbers representing the spatial distribution of elevations above some arbitrary datum in a landscape.

So, DEM consists of elevations sampled at discrete points. So, that way say, we will be having the spatial variation and then the vertical or the contour based variation. So, this DEM is actually a subset of digital terrain modeling; So, dt of that means, it is a subset of DTM. DTM or digital terrain modeling, it gives the spatial distribution of terrain attributes like slope, soil depth, soil drainability, soil fertility etcetera say, within the perspective of watershed management. So, then say, we can choose particular method of representing the surface or sub surface. So, the choice depends on the end use, so, what kind of use finally, we will be looking for. So, accordingly, we can choose the specific system.

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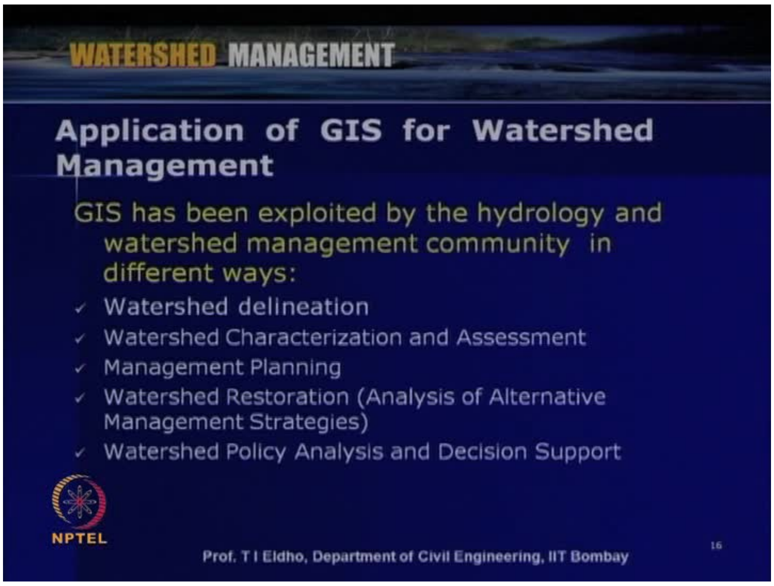

Let us comeback to the watershed management application as far as GIS is concerned. So, as I already mentioned, GIS has been very much used in most of the watershed management plans. So, GIS has been exploited by the hydrology and watershed management community in various ways.

So, some of the important aspects I have listed here. So, we can utilize geographic information system for watershed delineation. So, these details we have seen in one of the earlier lecture. Then we can use GIS for watershed characterization and assessment. Then GIS can be used for watershed management and planning. Then watershed restoration like analysis of alternative management strategies, we can develop and check within the GIS platform.

Then, we can also use GIS for developing watershed policy and then analyze it and then we can generate a decision support system, which we which the decision makers can utilize to see which the best alternative is. So, that way a large number of applications are there for GIS as far as watershed management is concerned.

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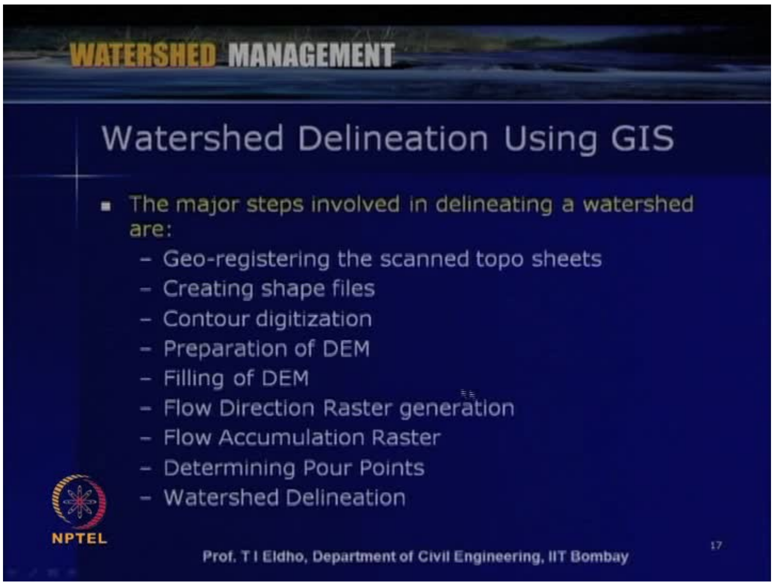

So, let us look into various type of this application in a detailed way in the next few slides. So, as far as watershed delineation, we have already discussed in an earlier lecture. Some of the major steps involved in delineating the watershed, I have listed here.

So, first we can geo-register the scanned toposheet, then we can create the shape files, then contour digitization can be done. We can then prepare digital elevation model and then we can fill the digital elevation model. Then flow direction we can identify; then flow accumulation raster can be generated; then we can identify which are the pour points and using that we can delineate the watershed. So, this watershed delineation, we have discussed in detail in one of the lecture earlier. Then the second aspect is say, we can utilize GIS for watershed characterization and assessment.

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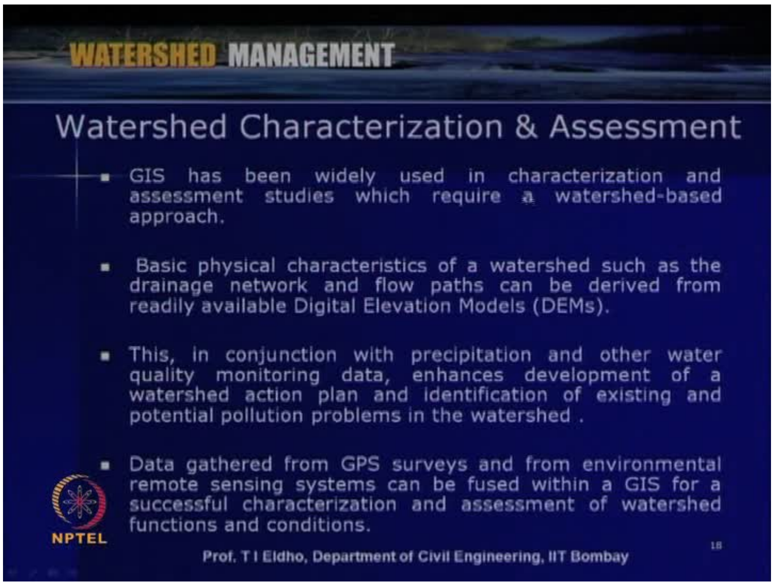

So, GIS has been widely used in character watershed characterization and assessment studies. So, say, to characterize various characteristics of a watershed, we have already seen like the topological features, geographical features, so, various characteristics or the shape of the watershed or the say, the elevation variation, so all these characterization, we can study or we can analyze using the GIS.

Then basic physical characteristics of a watershed such as the drainage network and flow pass can be derived from readily available digital elevation models or we can generate our own digital elevation model depending upon the available data or DEM can be directly utilized to identify the drainage network.

So, this in conjunction with precipitation and other water quality monitoring data enhances development of a watershed action plan and identification of existing and potential pollution problems in the watershed. So, it is the GIS not only, we can utilize to identify the source of water or the quantity water quantity issues, but we can also use GIS platform to identify the possibility of water pollution or the environmental related issues.

So, that way the data gathered from say, for example, GPS surveys and from environmental remote sensing systems can be fused within a GIS for a successful characterization and assessment of watershed functions and conditions.

So, that way we can utilize the GIS software for watershed characterization and assessment say, for example, how much water is available as a water source or water as a resource. Then what the water quality issues are, whether particular water source will be polluted, so, all those aspects we can study within a GIS environment.

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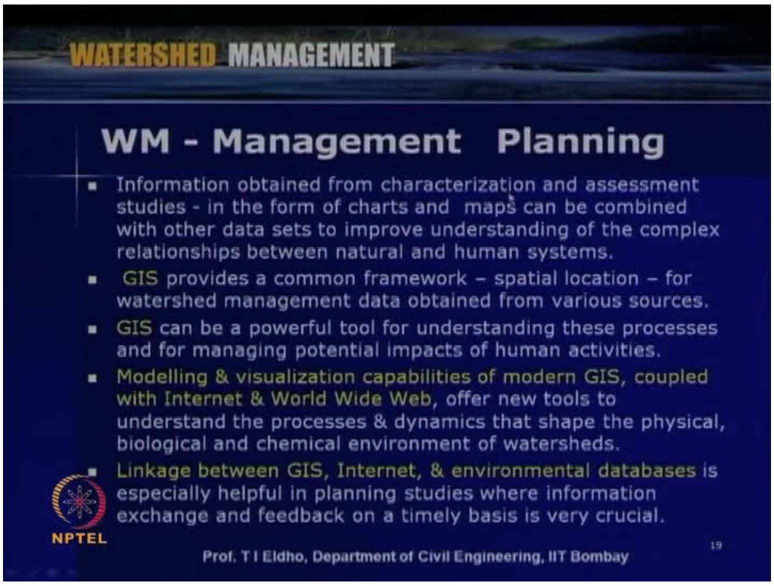

So, then next aspect is watershed management planning. So, as far as a watershed is concerned, information obtained from characterization and assessment studies, we can utilize in the form of charts and maps. So, this we can combine with other data sets to improve understanding of the complex relationship between natural and human systems

So, as I as we have already studied or as already discussed, within the perspective of watershed management, it is human interactions with various natural resources of flora and fauna. So, when we put all these input data within the GIS environment, we can easily study what will happen if this particular project is implemented or particular things are done within the watershed area.

So, then GIS also provides a common framework like a spatial location for watershed management like that. Then GIS can be a powerful tool for understanding these processes and for managing potential impacts of human activities. So, as I already mentioned, GIS can be utilized for environment impact assessment or say, for example, if a particular check dam is constructed, so, using GIS, say, data sets we can identify where the particular say, which of the area will be flooded or where this water can be taken from one from the reservoir to the various locations within the watershed.

Within the GIS environment, modeling and visualization can be done coupled with say, and once this GIS is coupled with internet and world wide web, new tools we are getting to understand the processes and dynamics that shape the physical, biological and chemical environment of watershed.

So, when we utilize the GIS platform, then the internet and the world wide web, so, we can integrate all these things within with respect to say, for example, hydrological modeling systems. So, we have very specific tools or very efficient tools to assess what will happen particular watershed management plans are implemented. What will be the future? All those things, we can asses within the GIS environment. So, that way GIS can be used for watershed management and planning. Also, the linkage between GIS internet and environmental databases is especially helpful in planning studies, where information exchange and feedback on a timely basis is very crucial.

So, that way we can utilize GIS within the perspective of say, by using GIS internet and world wide web say, within the perspective of hydro informatics say, for example, we can integrate various tools and then we can see say, we can generate future scenarios and then see what will be happening. So, that way GIS can be used for watershed management planning.

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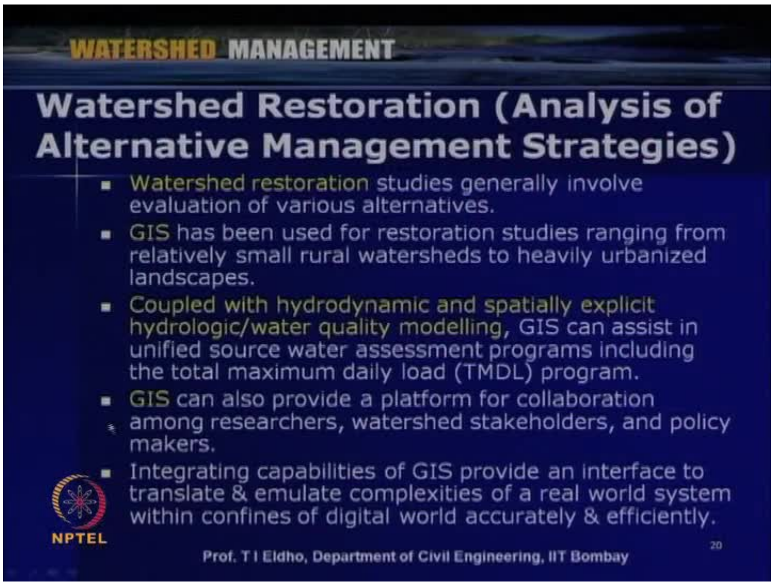

Then also, say, GIS can be used for watershed restoration. That means, various alternative management scenarios, we can generate and then assess. So, that way watershed restoration studies generally involve evaluation of various alternative - so, various scenarios we can generate and then we have to evaluate those scenarios and then identify which will be the best solution.

So, GIS platform can be used for that purpose. So, GIS has been used for restoration studies ranging from relatively small rural watersheds to heavily urbanized landscape. So, that way we can effectively utilize GIS. So, coupled with hydrodynamic and spatially explicit hydrologic or water quality modeling, GIS can assist in unified source water assessment programming including the total maximum daily load programs. Say, to assess whether a stream will be highly polluted with respect to the various pollutant sources, we can easily use the GIS environment.

So, GIS can also provide a platform for collaboration among researches, watershed stakeholders and policy makers. So, as I already mentioned, say, within the perspective of hydro informatics, so, GIS is one of the major component of hydro informatics system. So, when we combine the GIS, the internet and world wide web, the researchers and decision makers, stakeholders all can come together within this environment and then can collaborate for various watershed development plans. So, we can integrate the capabilities of GIS, which provide an interface to translate and emulate complexities of a real world system within the confines of digital world, accurately and efficiently.

So, say, as I already mentioned earlier, watershed or a river basin is a very large area. So, say, we cannot move through the area and then identify what is the how the variation or how the system is behaving. But if we can obtain within a GIS environment, all the maps or all the details say within a computer and then within a computer display, then it is we can do various planning and management in a very accurate way and very efficient way. So, that way GIS is very helpful.

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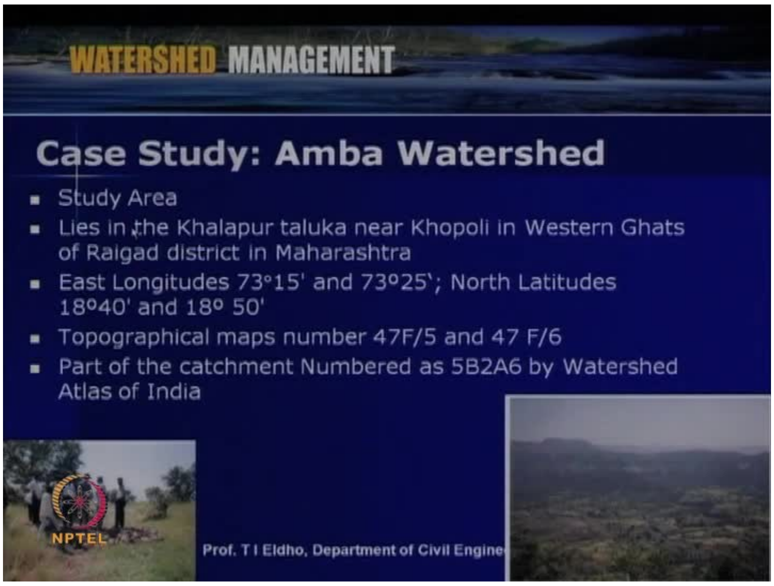

So, now say, let us look into a case study say, how effectively GIS can be used for watershed management development plans. So, this case study is Amba watershed area. So, here say, we have used GIS effectively to say, generate various maps and then do a hydrological modeling. So, the study area lies in the Khalapur taluka, near Khopoli, in western Ghats of Raigad district in Maharashtra. So, the location is east longitude 73 15 and 73 25and north latitude 18 40 and 18 50.

The topological maps number of survey of India 47F bar 5 47F bar 6 are used for this watershed. So, part of the catchment is numbered as 5B2SA6 by the watershed atlas of India. This shows some of the photographs of the area.

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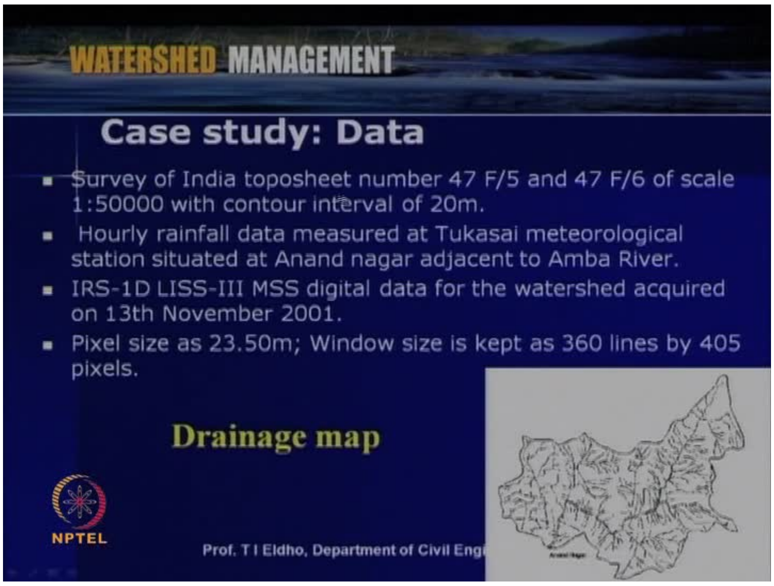

So, survey of India toposheet say, within a scale of 1 is to 50,000 with a contour interval 20 metres is used in this study. So, hourly rainfall data is measured at Tukasai meteorological station situated at Anand nagar adjacent to Amba river is used. So, this is the location, where the meteorological data is collected and here, say, remote sensing data is also used. IRS 1D LISS-III MSS digital data for the watershed acquired is obtained for or on the thirteenth November 2001. Here, we use a pixel size of 23.5 metres and window size is kept as 360 lines by 405 pixels.

So, this is the drainage map of Amba watershed. So, here, there is a major stream which is going like this and these are some of the minor streams within this watershed. This is predominately a forested area and some agricultural land is there at this region.

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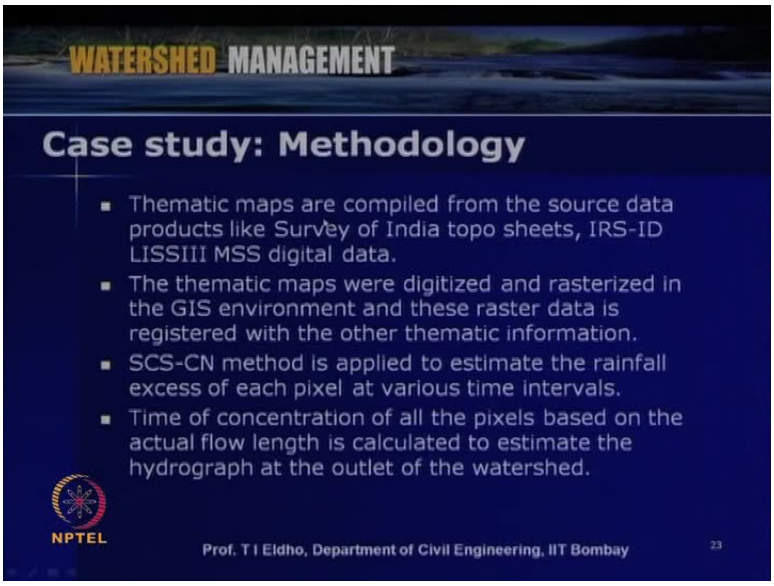

So, the thematic. So, here, the methodology we used within this GIS environment is explained here in this slide. The thematic maps are compiled from the source data products like survey of India toposheets, IRS 1D data. Then thematic maps were digitized and rasterized in the GIS environment and this raster data is registered with the other thematic information.

So, here, we have already discussed about the soil conservation service curve number method. So, that SCS-CN method is used for hydrological modeling here to estimate rainfall excess of each pixel at various time intervals. Then time of concentration of all the pixels based on the actual flow depth is calculated to estimate the hydrograph at the outlet of the watershed.

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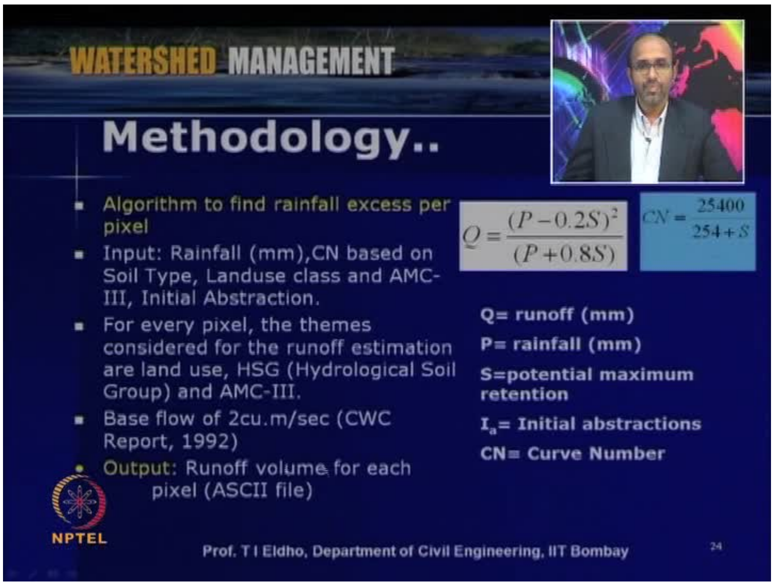

So, here the methodology used is further explained. The algorithm to find the rainfall excess per pixel is say, input is rainfall in millimeter, curve number based on soil type, land use class and AMC-III, initial abstraction is considered. So, for every pixel, the themes considered for the runoff estimation are land use, hydrological soil group and then antecedent moisture condition - three level is used. Base flow is assumed as 2 cubic meter per second as per central water commission norms. Then output will be runoff volume for each pixel.

So, as I mentioned here, for hydrological modeling, we have used the SCS-CN method which we have discussed earlier. So, the governing equation is this one and then the curve number is obtained from this, where Q is the runoff in millimeter, P is the rainfall, S is the potential maximum retention and I is initial abstraction and CN is the curve number.

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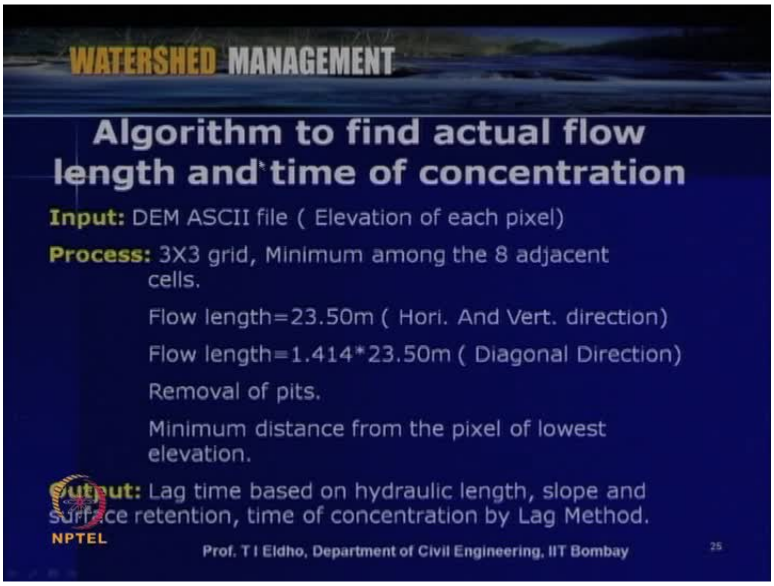

So, now say, the algorithm to find actual flow length and time of concentration. So, input is as I mentioned, we give it as digital elevation model in ASCII file. That means, elevation of each pixel and process is 3 by 3 grid, minimum among the 8 adjacent cells and flow length is 23.5 metre, horizontal and vertical direction and flow length is 1.414 into 23.5 diagonal direction.

So, the removal of pits is done as in within the when we develop the detail elevation model and then minimum distance from the pixel of lowest elevation is considered. Output is lag time based on hydraulic length, slope and surface retention time of concentration by lag method.

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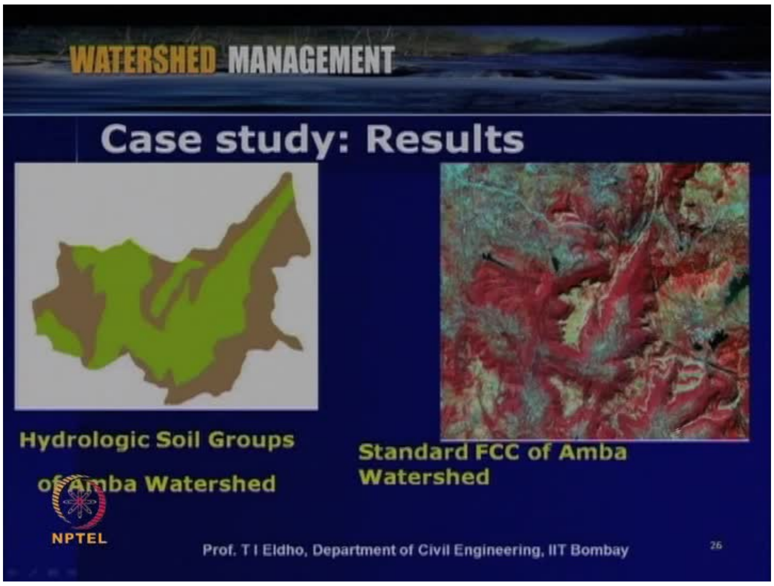

So, based upon all this available data, within the GIS environment, here, we used the GRAM plus plus package, which belongs to IIT Bombay. So, based upon various data available toposheet, the remote sensing data and then various field information, we have generated various maps within the GIS environment.

So, here, this figure shows the hydrologic soil groups of the Amba watershed based upon the available data, which we fed into the GIS platform and then that has given this map. This is the hydrologic soil groups and then using the remote sensing data, first we did a false colour composition analysis for the Amba watershed.

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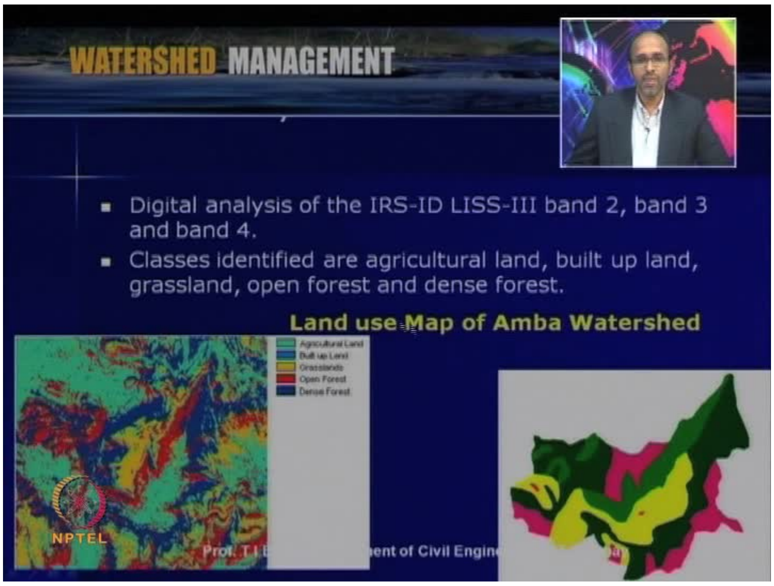

So, this shows a standard FCC of Amba watershed within the GIS environment and then say, digital analysis of the IRS 1D LISS-III band 2, band 3 and band 4 is done. Classes are identified as agricultural land, built up land, grass land, open forest and dense forest. So, using the false cover composition, now, we have identified the various land use and land cover and based upon that, for the watershed area, the land use map is produced. So, here, we can see the green indicates agricultural land, blue indicates built up land, then this is grass land, open forest and dense forest.

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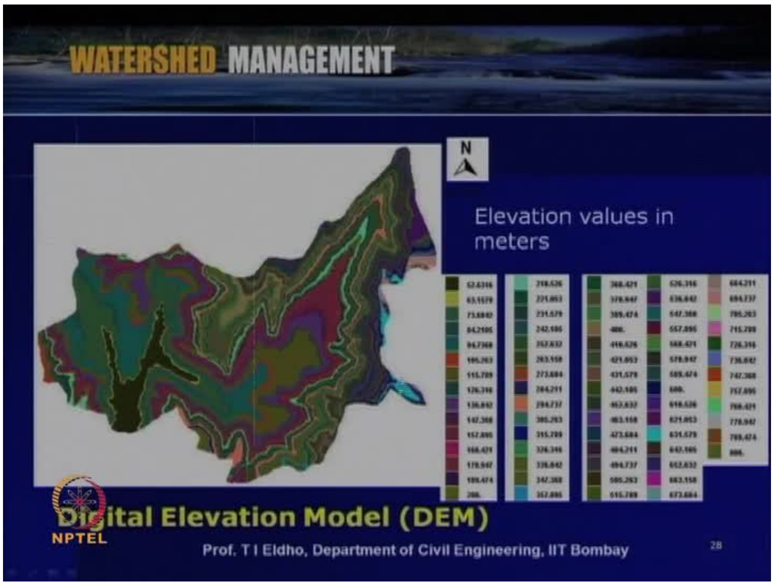

So, then using this specified procedure, we have generated a digital elevation model. So, this shows the digital elevation model for the Amba watershed. So, elevation values are listed here in metres. So, the elevation varies from 52.6 metres to 800 metres above the mean sea level. So, this is the digital elevation model for the Amba watershed.

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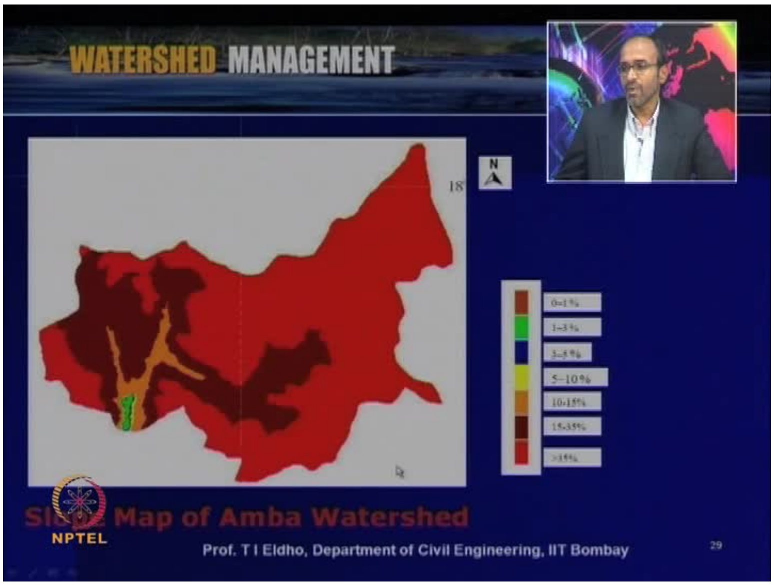

This shows the slope map. So, based upon the digital elevation map, DEM, we have generated the slope map. The slope is varying say, 1 to 35 percent. So, these are all hilly regions and this is where the stream is going and this is some of the flat area, where some agricultural land is there as you can see here, in the previous slide. (Refer Slide Time: 53:44) So, this is grass land or some of this is our forested land.

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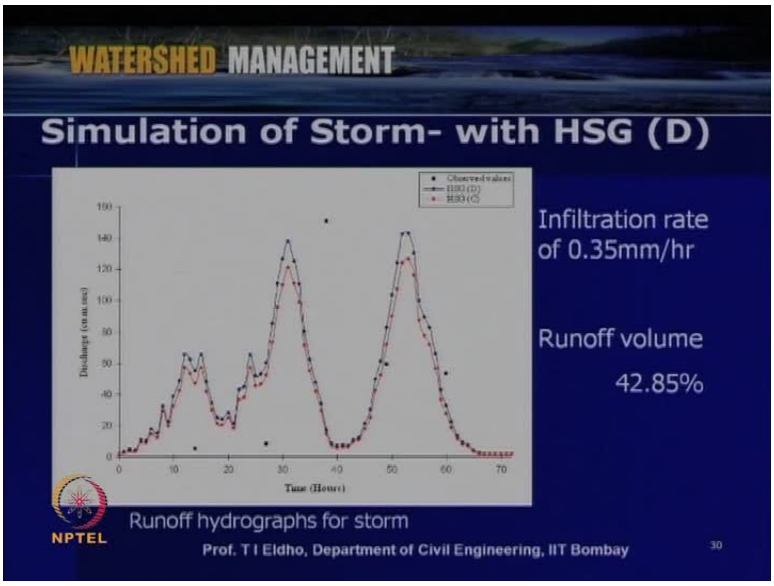

So, then as I mentioned, we use the SCS-CN method. We have say, for some of the rainfall events, by using the digital elevation model and various maps, we run the model to obtain the runoff. So, this shows the discharge versus time. So, here, the rainfall data, these details I have not given here, but here the main purpose of this case study is how we can effectively utilize geographic information system to produce various maps, various data sets for a hydrological modeling. So, that was the purpose. So, here infiltration rate is given as 0.35 millimetre per hour and runoff volume was estimated for this particular thing as 42.85 percent.

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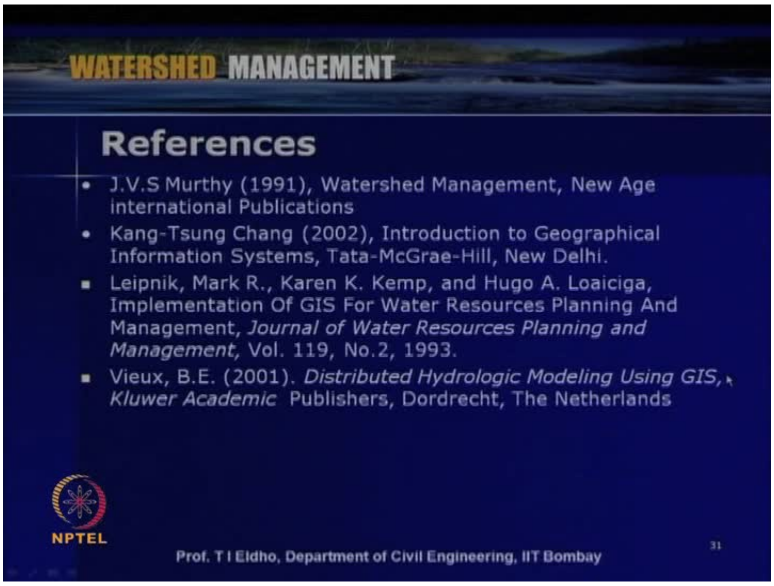

So, that way, we can utilize the GIS platform for generation of digital elevation model, soil map, land use land cover map, slope map, like that. So, that will be very useful for the hydrological modeling or that way these details, we can utilize for water for the development of various watershed management plans. So, these are some of the important references used for today’s lecture.

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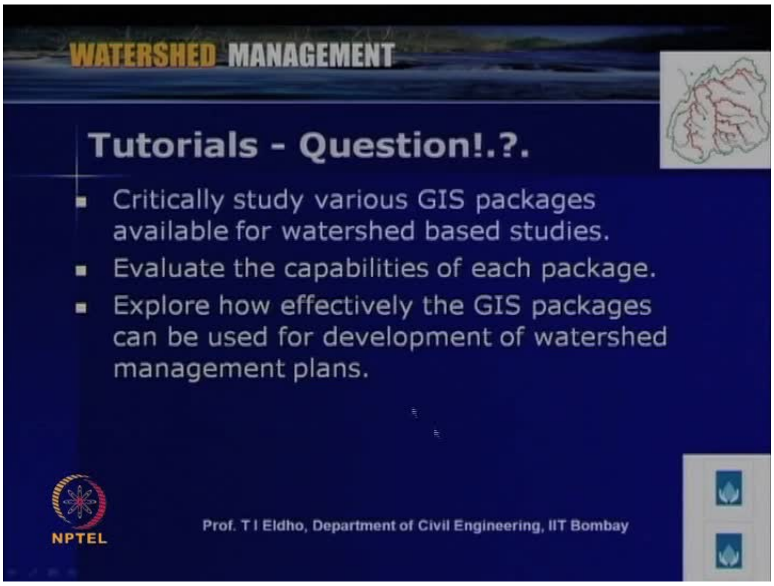

So, before closing down some of the questions, tutorial questions. Critically study various GIS packages available for watershed based studies. So, this you can get from the internet for various packages we have discussed earlier and evaluate the capabilities of each package. Explore how effectively the GIS packages can be used for development of watershed management plans.

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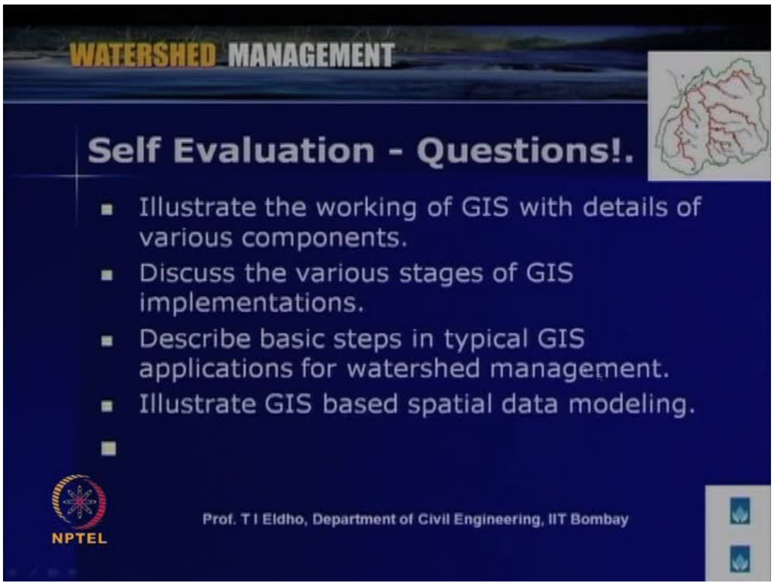

Then some self-evaluation questions: illustrate the working of GIS with details of various components; discuss the various stages of GIS implementations; describe basic steps in typical geographic information system; applications for watershed management and illustrate GIS based spatial data modeling.

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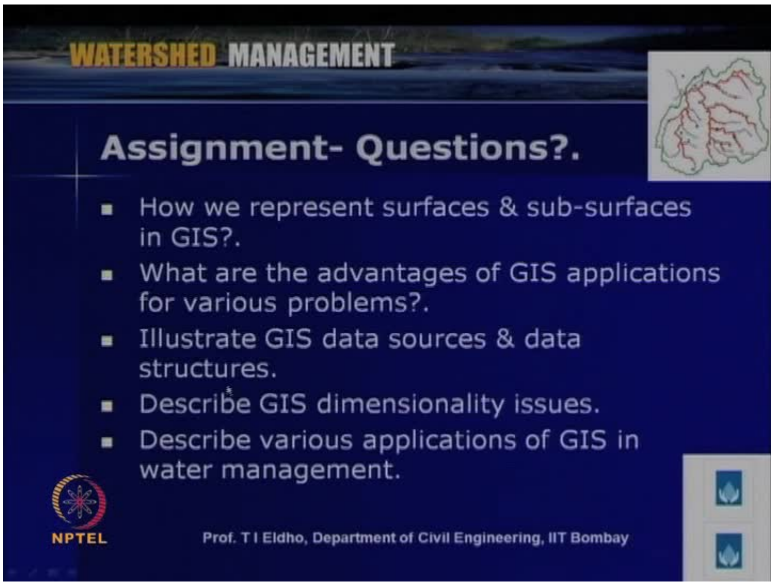

So, these details based upon today's lecture, you can get the answers. Then some assignment questions: how we represent surfaces and sub-surface in GIS and what are the advantages of GIS applications for various problems; illustrate GIS data sources and data structures; describe GIS dimensionality issues; describe various applications of GIS in water management.

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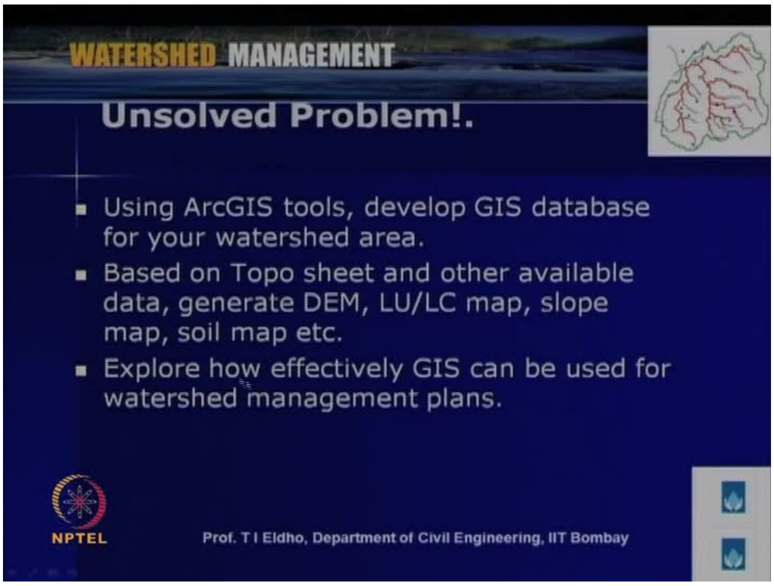

Now, before closing down say, the unsolved problem – so, for your watershed using arcGIS tools, develop GIS database. Then based on toposheet and other available data, generate digital elevation model, land use land cover map, slope map, soil map etcetera. So, this we can use once it is developed, for your area, you can use for various other purposes for watershed management development plans and explore how effectively GIS can be used for a watershed management plans.

So, today, what we discussed is the basics of geographic information systems and how we can effectively utilize GIS for a watershed management and development plans. Thank you.