Watershed Management

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Module No. # 06

Lecture No. # 24

Decision Support Systems and Applications in Watershed Management

[FL] and welcome back to the video course on Watershed Management.

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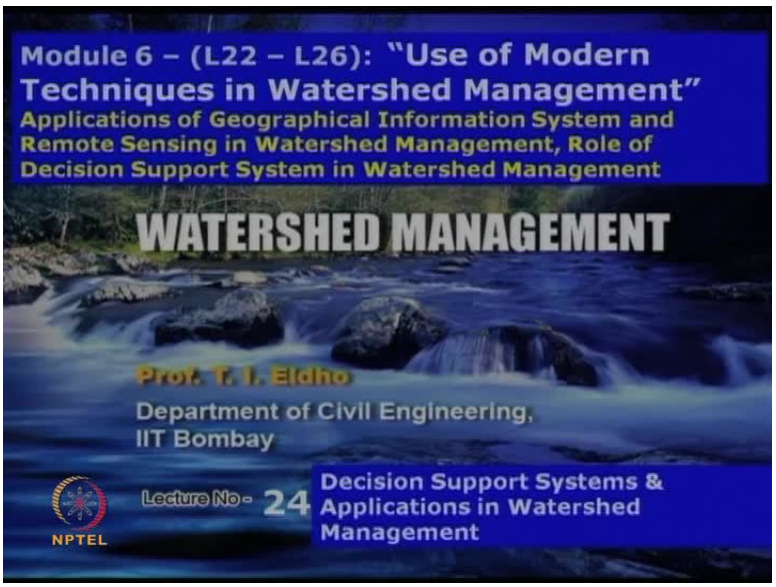

In module number 6, Use of Modern techniques in Watershed Management – lecture number 24, today, we will discuss Decision Support Systems and Applications in Watershed Management.

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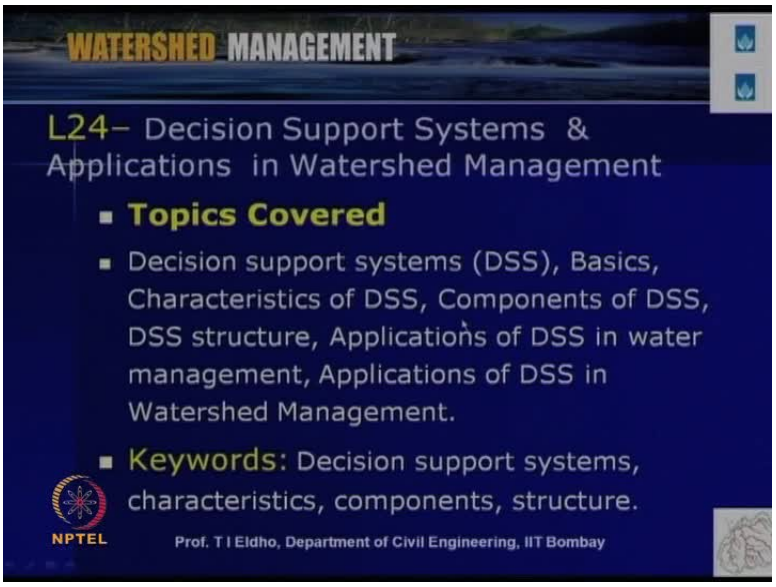

Some of the topics covered in today's lecture include Decision Support System, its basics, Characteristics of Decision Support System, Components of Decision Support System, DSS structure, Applications of DSS in water management, Applications of DSS in Watershed Management. Some of the keywords: decision support system, characteristics, components and structure. As we discussed in some of our earlier lectures, when we deal with the watershed management, we have to develop different plans, different scenarios. For each kind of plan; for example, if you are going to develop a check dam structure, there can be different scenarios like – we can have different locations for the particular check dam or specific height of the dam can vary. So, like that various scenarios can be there. However, each scenario – when we are constructing a dam in a particular area in a watershed, then it has its own impact like – how much water can be stored, how much flooding can take place within the watershed? So, all those impacts will be there.

When such a plan comes to the decision maker, who is going to implement the project and then who is deciding what is to be done, where to be done – all those things, we have different scenarios. So, different options are there in front of the decision maker. So, the decision maker has to make a decision that yes, this is the best solution, then he has to adapt it and then he has to go for implementation. So, when we are looking for considering a particular scenario or particular option, we can have a system called decision support system.

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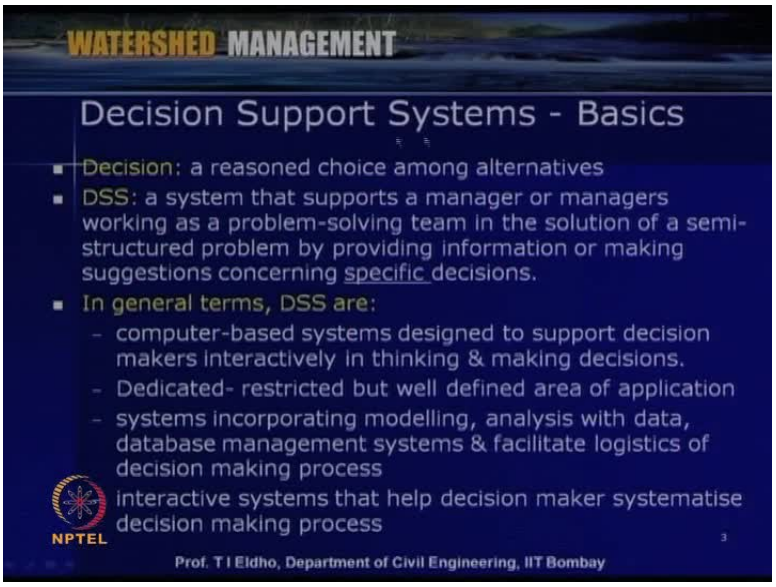

Decision support system means a system, which helps the decision maker to make a specific decision. So, that way the decision support system – we can say that a decision is a reasoned choice among alternatives. So, we can have different alternatives among that. The recent choice is so-called the decision and it is done by the decision maker. A decision support system or a DSS means a system that supports a manager or managers working as a problem solving team in the solution of a semi-structured problem by providing information or making suggestions concerning specific decisions. So, as I mentioned, we can have different options or different scenarios; out of that, the decision maker has to make a specific decision – this is what the particular thing, which he has to do. This can be a single manager decision, or a group of managers will be taking the decisions as a team. Then, DSS, a decision support system means – it is a semi-structured system, which helps the decision maker to take the specific decision or the specific decisions.

In general terms, the decision support systems are computer-based system designed to support decision makers interactively in thinking and making decisions. Here, we say – the very interactivity in thinking and making decision – these are very important words in DSS, decision support system. So, the decision making can interact with the various scenarios, then, the outcome of that particular scenario and then accordingly, you can take the decision. DSS is a dedicated system, restricted, but well-defined area of application. So, that way we can see that a decision support system is a dedicated one,

but it is restricted, but with well-defined area of applications. DSS are systems incorporating modeling, analysis with data, database management systems and facilitate logistics of decision making process. So, DSS is a group of various applications like – it can include modeling; then, it can include analysis with data, digital system or database management systems, and then various logistics that support or that helps the decision maker. Finally, when we look into all the systems, we can that the DSS are the interactive systems that help decision maker, systematise the decision making process. So, that way we can that the decision maker interacts to use the DSS; that means he interacts with the DSS, or it is an interactive system that helps the decision maker to take the decision.

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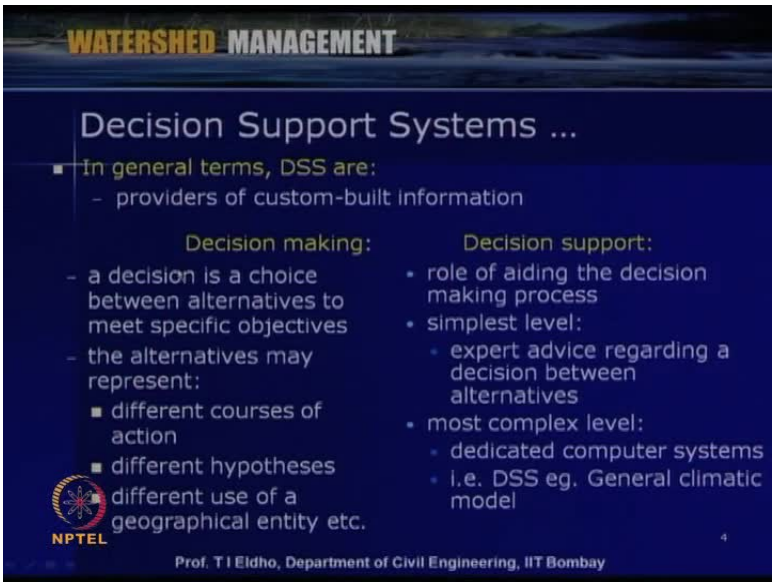

When we looking into the DSS or decision support system, the two processes are there: one is the process of decision making and then the various things, which supports the decision. So, we can see the differences between the decision making and the decision support. As I already mentioned, decision is a choice between alternatives to meet the specific objectives. So, we have got the specific objectives like in the construction of a check dam or the various rain water harvesting implementation, or whatever it is; there is a specific choice for the decision maker; for those choices, we have the specific objectives. So, decision making is a process, which represents different courses of action. Actually, the objective may be one objective or different objectives, but there will be different courses of action as far as the decision and its implementation is concerned.

Then, as far as the decision is concerned or the various choices, which we make, different hypotheses can be used and a different use of a geographical entity – all these are possible in decision making.

Now, coming back to decision support; decision support means it can be a model or any other system, which supports the decision maker to make the decision. So, decision support role is to aid the decision maker in the process. In the simplest level of decision support, there can be an expert advice regarding decision between the alternatives. So, the engineers or scientists make different alternatives. The decision maker has to take the decision by considering the various aspects of different scenarios. Then, this is what is happening in the simplest level. In the most complex level, there can be dedicated computer system or dedicated software. Then, this decision support system; for example, the general climatic model, which consider many alternatives, many scenarios have system, which is totally dedicated. Then, what are the possible things? For that, accordingly, the decision maker can do various things for the system, which he is trying to take the decision.

Decision support system is the process of decision making and then the things, which are helping to take the decision – so-called a decision support. So, we have seen that decision support system has got its own characteristics; it includes many computer models; then, generally, a graphical user interface, where the decision maker or the other people can interact within that, and then say that this is what is going to happen and this way decision can be taken.

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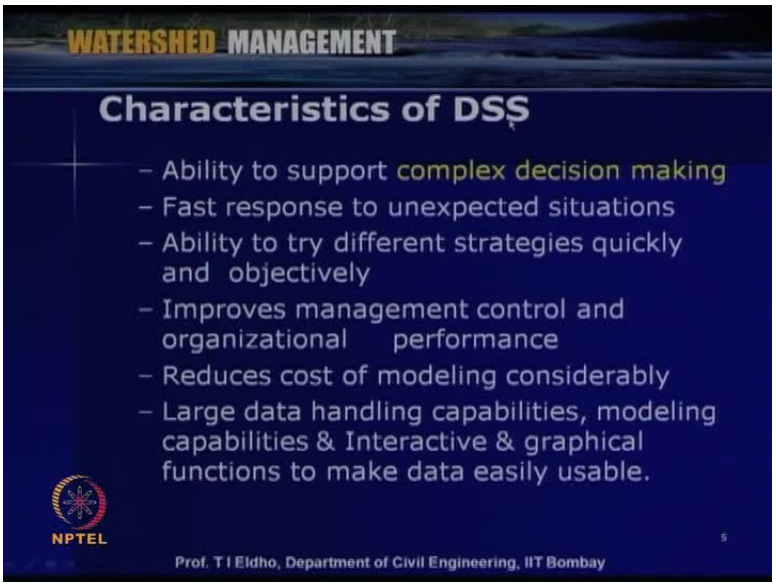

Let us look into some of the important characteristics of the decision support system. This includes the ability to support complex decision making. So, the DSS should have the ability to support complex decision making. Then, DSS should give fast response to unexpected situations; for example, if heavy rain fall is going to take place and then there is possibility of flooding in a particular area, then the decision maker has to make whether the people should be shifted from the particular locality. So, the decision support system should be very fast at any kind of unexpected situations, so that the decision maker can make the decision easily.

Other characteristics include the ability to try different strategies quickly and objectively. So, different strategies should be tried very quickly and objectively according to the set objectives. Then, the DSS should improve the management control and organizational performance. So, the system, the so-called DSS should help the manager or the decision maker to improve the total system; should have better control over the system and performance should be improved. Then, the DSS should reduce the cost of modeling considerably. So, in DSS, number of models and number of system behaved things will be there; this total system should help the manager to reduce the cost as far as the particular selection or particular implementation is concerned.

Then, large data handling capabilities should be there for the DSS. Especially when we are dealing with water source management or watershed management, we have to deal

with large quantity of data like geographical data, climatic data, land-related data – like that. So, the system should be able to handle large data. Then, there should be good modeling capabilities and interactive and graphical functions to make data easily usable. So, these are some of the important characteristics as far as DSS is concerned – like modeling capabilities, interactive. Then, appropriate graphical user interface should be there, so that those who are feeding the data, after feeding the data, have to run the models and various scenarios has to be generated. That corresponding thing should be seen in the interface, so that the decision maker can easily understand what are the various scenarios or alternative plans, and then accordingly he or she can take the decision.

Now, within this context, let us look why we need a DSS. Decision support system, the characteristics we have seen, let us look into why we need a DSS. As we can see that, many of the water source related problems or watershed management problems, the problems are very complex. Then, simply the decision maker cannot take a decision without considering the various aspects of the problem, and then without considering various alternatives or scenarios or plans. Accordingly, to deal with such complex system, we need a decision support system.

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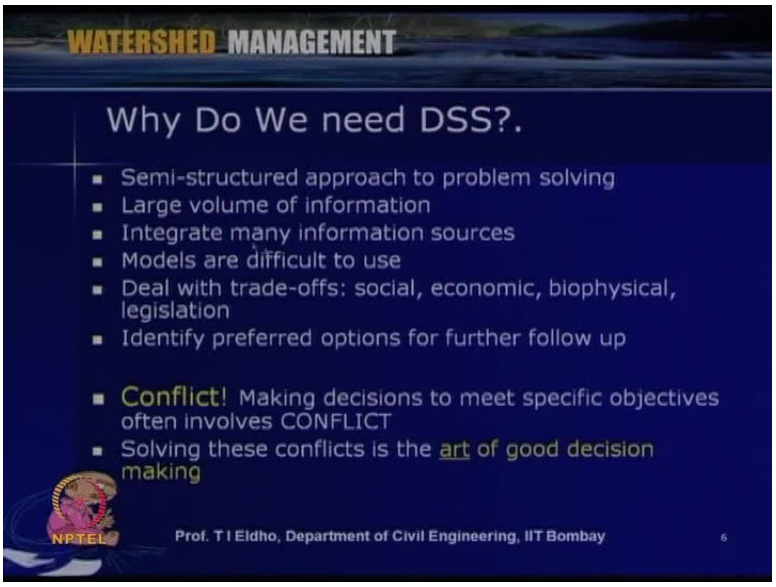

Here I have listed some of the important points like a semi-structured approach to problem solving as for as DSS is concerned. Then, wherever large volume of information

is there, then DSS is very useful. Then, a DSS integrates many information sources either through web or through various computer network; the DSS can integrate a many information sources. Then, most of the time, models are very difficult to use if there is no appropriate decision support system. Then, DSS deals with trade-offs like the trade-offs between the social, economic, biophysical, legislation, etcetera. So, the DSS gives appropriate links and appropriate scenarios, when it deals with various things related to social aspects, economical aspects, or biophysical aspects, especially when we deal with a watershed management or water related problems. Then, DSS identifies the preferred options for further follow up. So, that is also another important point; that is why we have to go for DSS.

Generally, what happens is that when particular decision to be made by the decision maker, various alternatives will be there. Then, to meet these specific objectives, often complex will be there; if you implement particular scenario, particular plans, then what will be the problems and then another scenario, some other problems. So, there can be conflicts. Solving these conflicts is the art of good decision making. So, each scenario or each alternative has its own problems and then there will be conflicts between the alternatives. So, as far as the decision making is concerned, we can say good decision means to solve these conflicts and then come up with the best solution. So, that way the DSS will help a decision maker to make the best solution. As we can see that decision support system is not making the decision; the manager or decision maker will be always there. It is only a support system to the decision maker.

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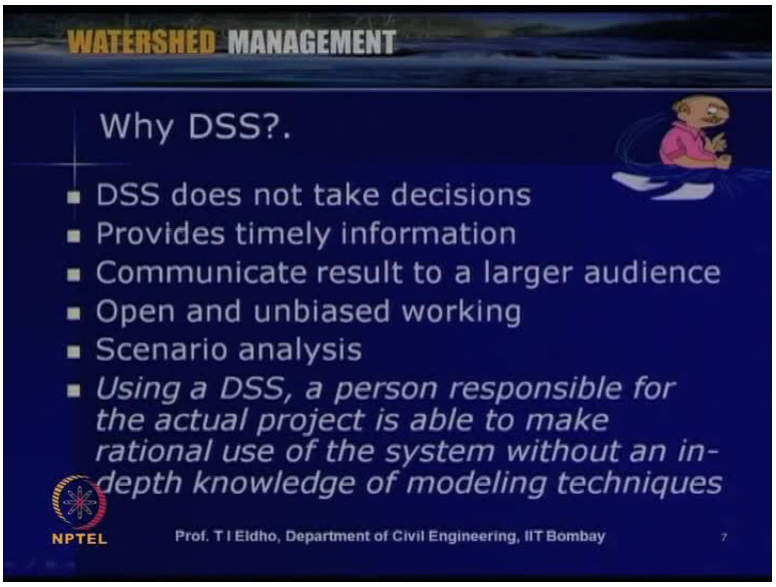

DSS as such does not take the decision, the decision maker has to take the decisions, but it provides timely information, then communicate result to a larger audience, open and unbiased working, then scenario analysis. So, all these things are possible with a decision support system. Using a DSS, a person responsible for the actual project is able to make rational use of the system without an in in-depth knowledge of modeling techniques. So, we can see that when various alternatives or various scenarios or various plans are there, we have to make models and then run the models to see that what will happen if that particular scenario is done or the plan is done. So, actually, the decision maker - he or she does not need to know about all these modeling techniques. So, these models will run within the background of the decision support system. Then, the various alternatives and its corresponding outcome will be generated. Only the decision maker has to understand these outcomes, and then accordingly, he has to choose the particular alternative or particular plan. So, that way decision support system is a supporting system for the decision maker to come to a particular decision.

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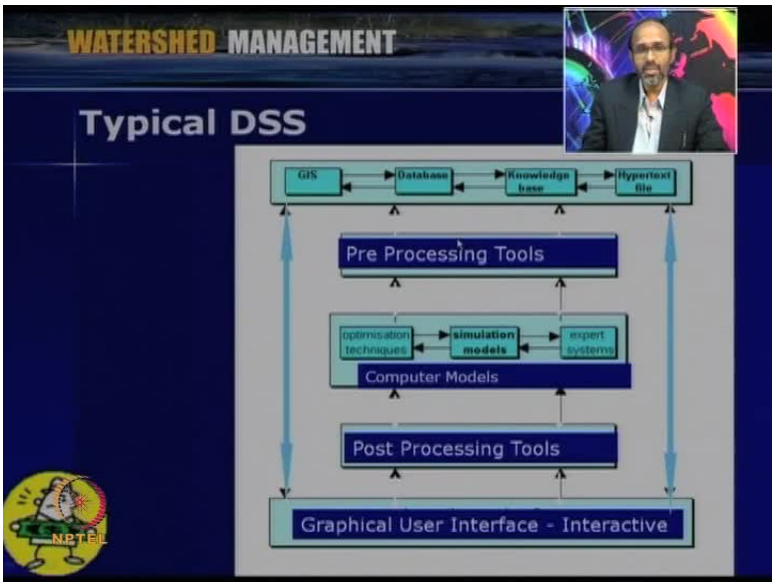

Now, let us look into typical decision support system. There can be various sub-systems within the decision support system. We can see that in most of our problems, especially watershed management problems, main thing is we have to deal with large quantity of data. To deal with large quantity of data, we have seen in some of the previous lectures, geographical information system or remote sensing – all these helps. Most of the time, when we deal with watershed or water related issues, GIS is always a good pre-processing tool. So, GIS is one of the components. Then, based upon the available data, database can be generated. Then, a knowledge base, where the appropriate data can be put on, corresponding pre-processing can be done. So, that is so-called a knowledge base. Then, corresponding hypertext file, where anybody can look into those files and then say the comments.

One of the important parts of a typical decision support system is the pre-processing tools as listed here. While using this data, we have to run various simulation models or organizational models; various kinds of modeling we have to do, and then we have to run these models within the computer. So, that is the processing within these subsystems, so-called computer models. Based upon this pre-processing data, the computer models will run and then particular scenarios will be generated. These scenarios, actually the computer use in terms of numbers. So, the decision maker will not understand what those data are. So, we need another subsystem called post-processing tools.

Here this post-processing of the simulated results can be represented in graphical forms, in bar charts, or in animations, or contours, or in tabular form. These outcomes are given to the decision maker by using the graphical user interface. This graphical user interface should be interactive, so that the decision maker can even feed various things within the system, and then see that what will be happening – if any alternatives solutions are possible.

In a typical decision support system, mainly, there would be three components: one is the pre-processing tools, then second one is the modeling tools like computer models, and third one is the post-processing tools. Now, as we can see, this is the typical structure of a decision support system. Then, depending upon the decision support system, various modeling to be done, or various things within the system, or various components can be there.

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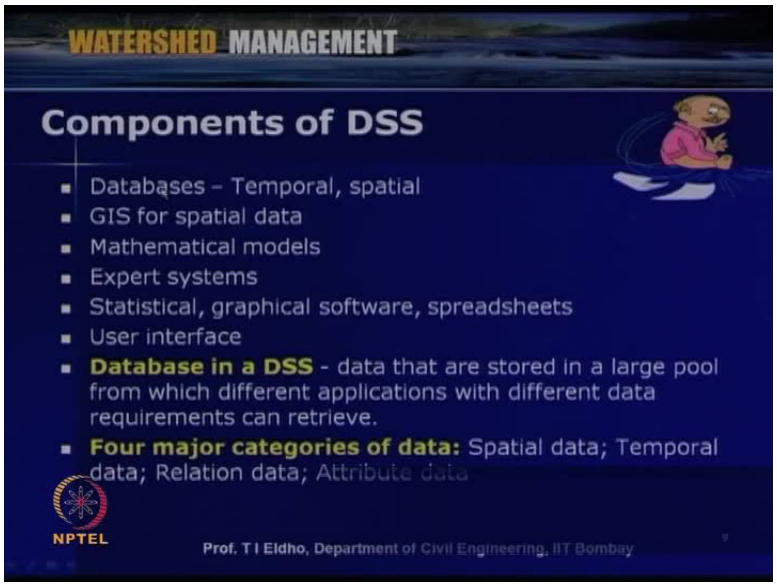

Various components of a decision support system, I have listed here. First one is the database; generally, it can be the spatial variation; that means spatial data. Then, time dependent or temporal data. As I mentioned, GIS or remote sensing – we can use for spatial data; like various maps and all those things can be generated. Then, another one is the mathematical models. So, the computer models, which you will be running and then generate the results. Another component can be the expert systems. So, for each kind of particular problem or the model, we can have expert system related to simulation or

optimizations; also that can be a component of the decision support system. We can also use the statistical models, graphical software, spread sheets, etcetera, within the DSS. So, whatever is useful for the depletion or particular scenarios, accordingly we can utilize.

Other important component is the usage interface. Generally, nowadays, we are having very effective interactive graphical user interface. So, that is also one of the important components of any of the effective decision support system. Then, database in a decision support system – as I already mentioned, data that are stored in a large pool, from which different applications with the different data requirements can be retrieved. So, in an efficient DSS system, there will be a database. Using that database, we can retrieve the data or we can give the input data, and then we can get the output in various formats, so that it can be directly utilized in the particular computer model.

As far as database is concerned, major categories of data can be the spatial variations in 3 dimensions x, y, z and then temporal data like time varying data, then relation data and attribute data. Like that various data sets for the particular problem can be there within the database of the DSS, which we consider.

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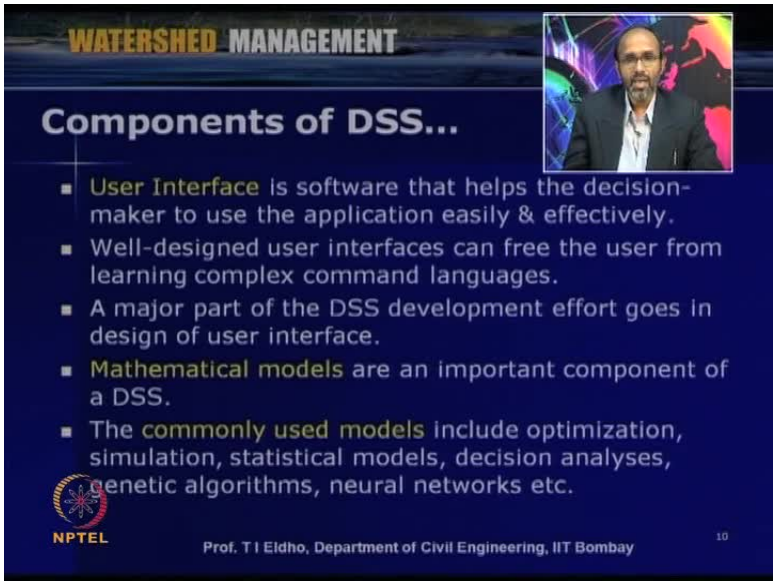

Then, the other most important component is so-called user interface. User interface is software that helps the decision maker to use the application easily and effectively. As I mentioned, it is not essential that the decision maker should understand all the aspects of

the problems or all the modeling what is happening within the system. So, the user interface is what is interacting with the decision maker. So, this helps the decision maker to deal with the problem or to understand the problem, and then take decision easily and effectively. Well-designed user interfaces can free the user from learning complex command languages. Earlier, when we used to have DOS-based system, we have to use very complex commands, but now, with a graphical user interface, there is no need of such commands; by just clicking the button, we can get various things. So, that way now, the graphical user interface plays a major role in the most of the decisions support system.

A major part of a DSS development effort goes to the design of appropriate user interface. This word appropriate is very important. So, depending upon the problem, we have to design the DSS interface; like various questions or various outputs – all those things should be there within the interface, so that the data input can be given easily, the output can be taken easily, and then the decision maker can easily understand the system. Other important component of the DSS is the mathematical models. Actually, mathematical models are important component of DSS. As I mentioned, it can be simulation models or optimization models, which helps to understand particular scenario is implemented or particular plan is implemented, what happened within the system. So, that is what the mathematical models predict as a simulation model or an optimization model.

The commonly used models include optimization, simulation, statistical models, decision analyses, then artificial intelligence techniques, genetic algorithms, neural networks, etcetera. So, number of mathematical models or computer models are used nowadays. So, that way when we looking to decision support system, we can see that it is actually a semi-structured system. That means it is not fully computerized, so that the computer take the decision; no, it is a decision maker is there. So, it is actually a system, which helps the decision maker to take the decision.

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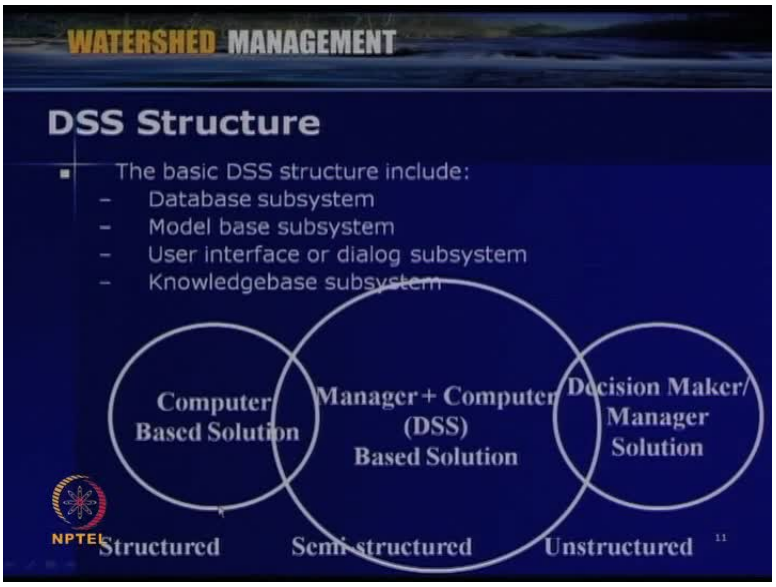

Here in this slide, I have shown for example, an unstructured system, where the decision maker manager has to find the solution on his own; there are no support systems. Here there is a computer-based solution. So, the entire solution is through the computer models. So, there is no role for the decision maker or manager. However, generally, most of the time, decision support system means it is a semi-structured system, where the manager or decision maker and computer come together, and then take the decision. So, that way it is a semi-structured system. So, as I mentioned, the basic DSS structure include database subsystem, model base subsystem, user interface or dialog subsystems and then knowledge subsystems. So, the subsystems are database, model base, user interface and knowledgebase subsystems.

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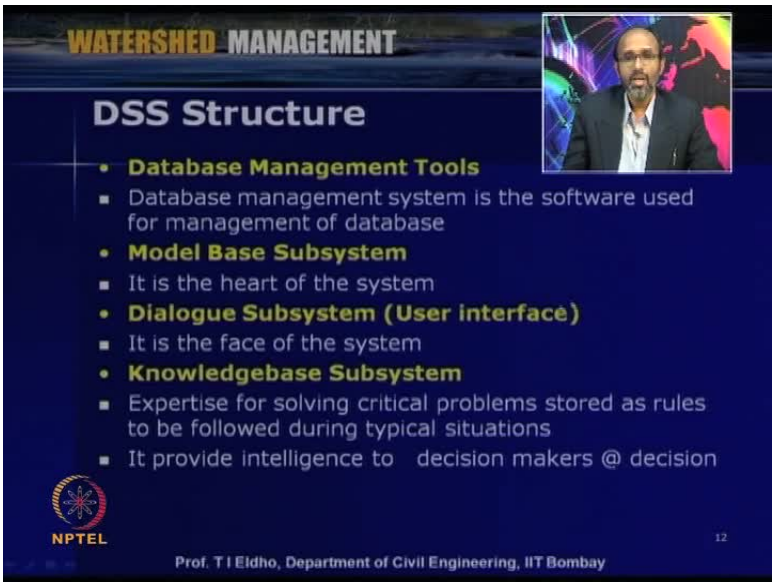

Let us look into some of the important aspects of these subsystems. The database management tools or the database system software is used for the management of database. This includes the data input, then its processing to appropriate format and then the output. Then, model base subsystem, which is actually the heart of the system, where various models will be running. So, we can say that this model base subsystem is the heart of the system. Then, as far as user interface is concerned, this gives the dialogs to understand the system or understand the problems. So, that way we can that it is the face of the system.

Then, the knowledgebase subsystem that gives the expertise for solving critical problems stored as rules to be followed during typical situations – if, then or what will happen. So, like that to the knowledgebase subsystem. So, this system provides intelligence to decision makers, so that particular decision can be made by the decision maker. So, that way we can see that all these – database subsystem or model base subsystem or the user interface subsystem or knowledgebase subsystem – are important in decision support systems in its own way. However, the heart of the system – we can say as the model base and the face of the system – we can say as the dialog subsystem or the user interface.

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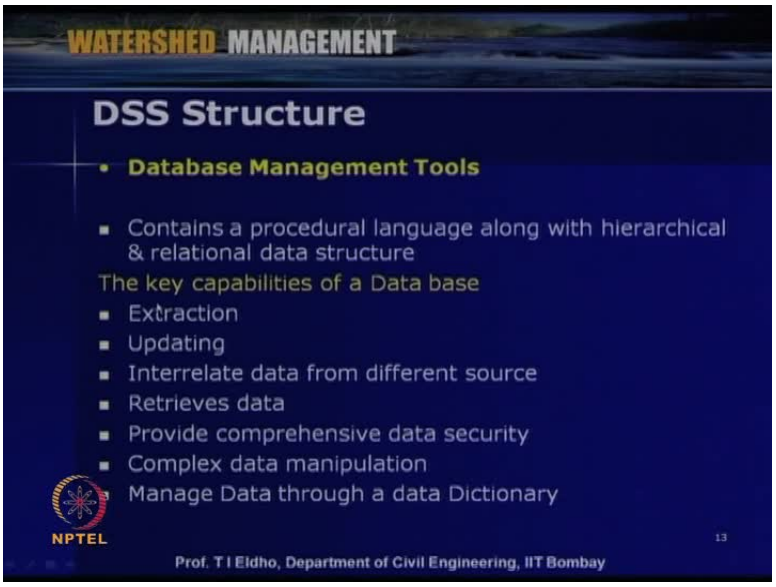

Now, as far as the DSS decision support system structure is concerned, when we deal with database management tools, these database management tools contain the procedure language along with the hierarchical and relational data structure. So, the key capabilities of the database, which we consider as database subsystem include extraction, updating, interrelate data from different source, retrieve the data, provide comprehensive data security, complex data manipulation, manage the data through a data dictionary. So, these are some of the key capabilities as far as particular database within DSS. So, there should be option for inputting the data, extracting the data, updating the data, retrieving the data and then various manipulations of the data. So, all those things should be there in the database subsystem of the DSS, which we consider.

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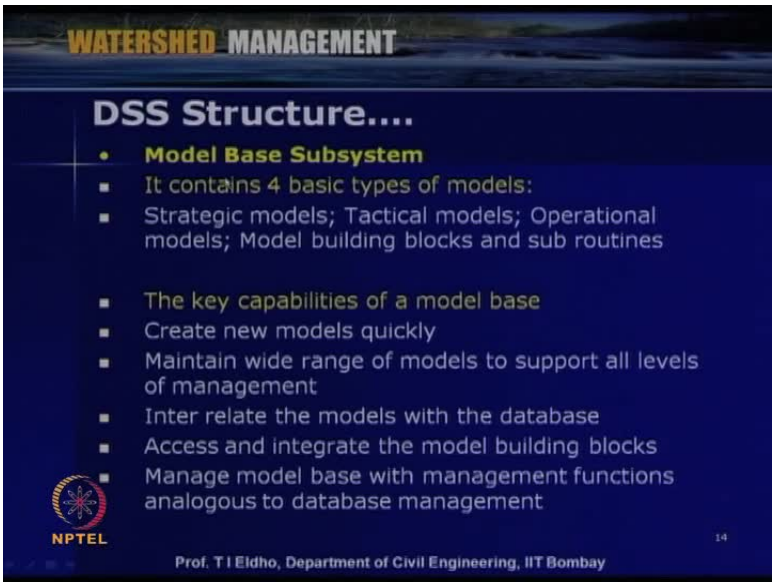

Now, the model base subsystem as concerned, the details are listed here. It contains four basic types of models as we have already seen: strategic models, tactical models, operational models, model building blocks and sub routines. So, these are some of the important components of the model base subsystem.

The key capabilities of a model base include: it creates new models quickly. If a particular scenario is selected or particular plan is selected, this model base subsystem create new models quickly; maintain wide range of models to support all levels of management. Then, it inter relate the models with the database. Then, access and integrate the model building blocks So, we can say that from one building block to another block connectivity should be there. So, all those things should be there in the model base subsystem. Then, manage model base with the management functions analogous to database management. So, management is very similar to what is there with respect to the database management. However, in model base subsystems, as we have seen, it is actually the heart of the system, which has to run for various scenarios or various alternatives. Then, the output should come and then based upon that post-processing should be done to understand the system behavior.

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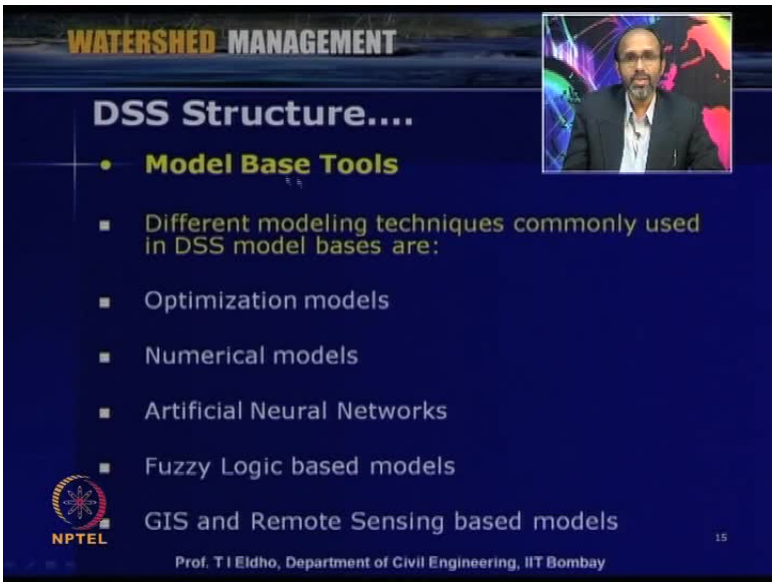

The model base tools as I already mentioned: different modeling techniques commonly used in decision support systems include optimization models like linear programming, dynamic programming and like that. Then, numerical models like finite element method, finite difference methods, mainly for a simulation purpose. Then, artificial neural network or artificial intelligence techniques like artificial neural networks, genetic algorithm. Then, Fuzzy logic based models. Then, geographic information system and remote sensing based models also are nowadays used when we have to deal with a large database or larger area like a river basin or a watershed larger area, which we have to deal generally.

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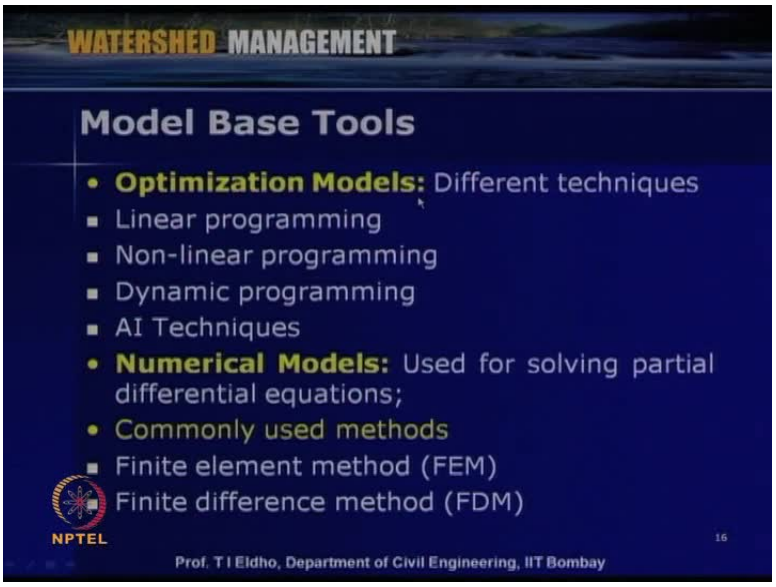

Let us have a brief look into various model based tools. As I already mentioned, the optimization models are generally used in the DSS support systems. Actually, optimization is done to either minimize the cost or maximize the benefits. So, that is very important in most of the decision making process since most of time, the decision maker wants to reduce the cost or minimize the cost and maximize the benefits with respect to various scenarios or with respect to various cases. Depending upon the problem, we can have various models like linear programming, non-linear programming, dynamic programming, then, artificial intelligence techniques like genetic algorithm. So, these are all optimization models depending upon the problems. For example, if the objective function and the constraints are linear in nature, then we can go for linear programming; if the constraints or the objective function non-linear, we can go for non-linear programming; if it is stage-wise, then we can go for dynamic programming; depending upon the data and the problem, we can also go for artificial intelligence techniques like genetic algorithms.

Other type of model base tools like numerical models; especially to solve partial differential or differential equations, we use a numerical model especially for simulation purpose. So, this simulation is very important. Once a particular plan or particular scenario is not, then we can run that scenario and then see what will happen. So, most of the time, numerical models or different types of models will be very useful. Then, that gives the simulated results for that particular scenario. Especially since water-related or

watershed-related problems are very complex, we have to solve partial differential equations like Saint Vincent's equations or Navier-Stokes equations. In those cases, there are no analytical solutions available. So, we have to use the numerical models like finite element method, finite difference methods, as we have seen in some of the previous lectures. So, we can use these techniques as a simulator or simulating tool and that can also be part of the decision support systems.

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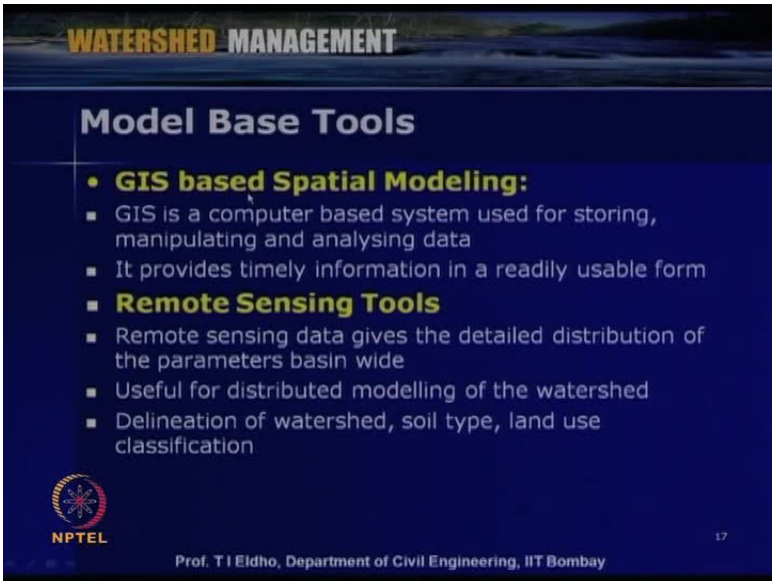

When we are going for special modeling – geographical information systems as I already mentioned earlier, we can utilize GIS based systems. As we discussed in one of the previous lectures, GIS is a computer based systems used for storing, manipulating and analyzing the data. It provides timely information in a readily usable form. So, based upon the data, we can manipulate the data and then generate different maps like topographical maps, land use map or land cover map, soil map, digitalization models. So, we have seen all these aspects. So, GIS is very helpful especially in the case of watershed management or water source management. So, that way GIS can be effectively used as a part of the decision support system.

Remote sensing tools – wherever huge data is needed and then the temporal variations to be considered, then we can use the remote sensing. Remote sensing data gives the detailed distribution of the parameters basin wide like river basin or the watershed basis. It is useful for distributor modeling of the watershed. So, if we are going for physically

based models, then remote sensing data is very useful especially land use, land cover and then these special variation. Delineation of watershed, soil type, land use classification, etcetera – in all these cases we can use remote sensing tools as a model based tool.

What we are discussing about is the components of the decision support systems. Now, most of the time, especially related to watershed management or water related issues, we have to deal with spatial variation either a watershed basis or river basin scale, catchment basis or the state wise or the country wise. So, that way we have to see the spatial variation. Then, when we can generate a decision support system based upon the spatial variation specifically, then we can call that type of system as spatial decision support systems.

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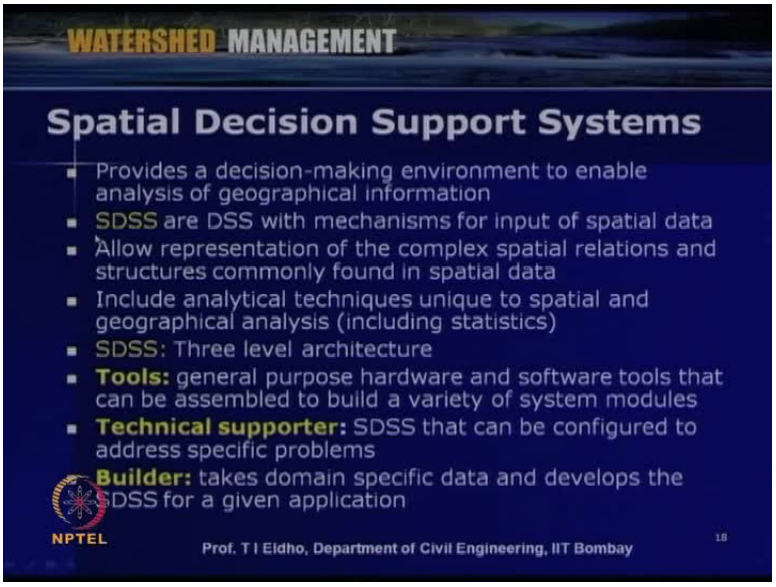

Spatial decision support systems provide the decision-making environment to enable the analysis of geographical information specifically. Spatial decision support system or SDSS are DSS with mechanism for input of spatial data. SDSS allow representation of the complex spatial relations and structures commonly found in spatial data. SDSS include analytical techniques unique to spatial and geographical analysis including the statistics. Generally, GIS is also a part of this SDSS or spatial decision support systems.

SDSS is very similar to the DSS. In SDSS, generally three levels of architecture will be there. First one is the tools; general purpose like hardware and software tools that can be

assembled to build a variety of system modules very similar to what is there in the DSS. Then, technical supporter – SDSS that can be configured to address specific problems through modeling; so, that is the technical supporter. Then the builder – builder takes domain specific data and develops the SDSS for a given application. So, for particular application whether the water-related or soil-related, then we can have the spatial decision support systems.

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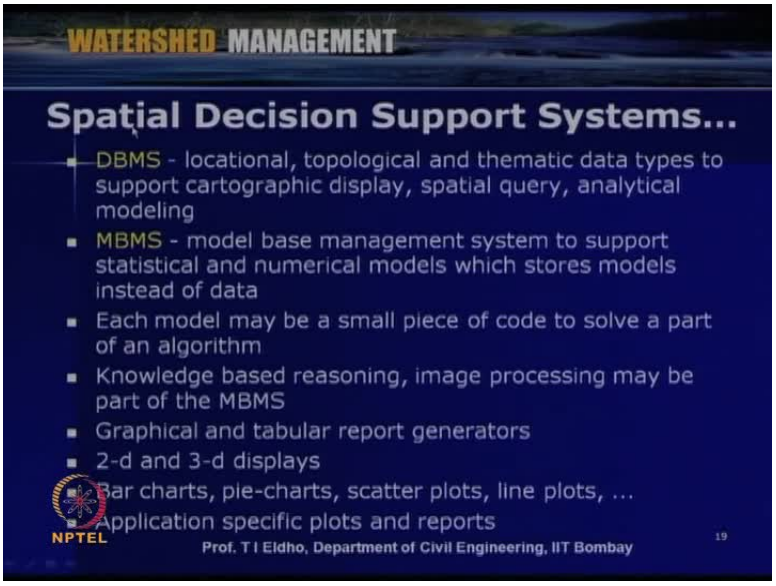

Very similar to DSS, any type of DSS, spatial decision support systems, we have the database and then model base, like that. Here again in this slide, the various components of spatial decision support system are described. DBMS or database management systems like locational, topological and thematic data types to support cartographic display, spatial query, analytical modeling, etcetera. So, DBMS will effectively be a part of most of the SDSS. Then, MBMS or model base management system as we have seen for DSS; very similar to that; we have spatial decision support system also; we will be having the model base management system to support statistical and numerical models, which stores the models instead of data. Each model may be a small piece of code to solve a part of particular algorithm. So, that way we can plan in the DSS or SDSS.

Knowledge based reasoning, image processing can also be part of the management, or model base management system or MBMS. Graphical and tabular report generators very similar to DSS are there in the case of SDSS also. The displays can be in 2 dimensions or

3 dimensions. Also, we can choose either bar charts, pie-charts, scatter plots, line plots, etcetera within the SDSS, very similar to DSS. Then, also application specific plots and reports can be generated within the SDSS. So, that way SDSS or spatial decision support system is DSS only, but generally, when we deal with either watershed or river basin scale, then we have to deal with lot of spatial data. That why we call this DSS as spatial DSS or spatial SDSS.

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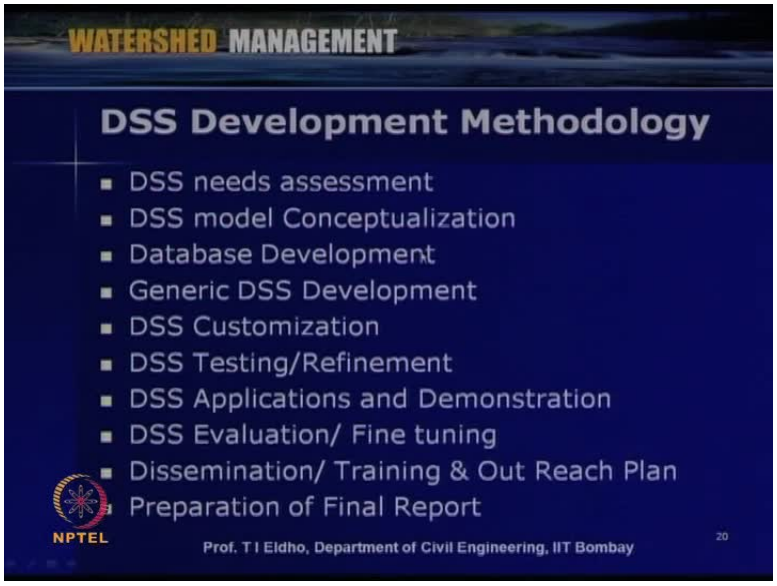

Now, before going to discuss the various aspects of water resource management or watershed management related to DSS, let us look into the development methodology as far as decision support system is concerned. Various steps I have listed here. Before we develop a DSS, we should assess the needs – what are the things that are expected from decision support systems, what are the things that should be there within the systems, and what will be the input, what will be the output from the system? So, that way we have to do needs assessment when we develop a DSS. Then, DSS model conceptualizations – similar to we conceptualize a model, we have to conceptualize the various components of the decision support systems. Then, as given in this slide, database development; we have to develop the database. So, that is one of the essential component of the DSS.

Then, next step is generic DSS development. Based upon all these aspects, we can have a generalized DSS system. Then, for particular problems, to deal with particular either

water related, soil related or land related issues, we can customize the system. So, that is so-called DSS customization. That is the next step. Once it is done, the system is ready. Now, we can go for testing, further we can define and then see how the system is working. So, that is the next step as shown in this slide; DSS testing and refinements. Once the testing is done, if it is working properly, then we can go for typical applications. So, that is, DSS applications and demonstrations; for particular area or particular system or particular plans, we can have the DSS applications and then demonstrate. Then, we can evaluate the system and fine tune it. Then, once it is ready, we have to train the people, who are going to use it. So, that way we can prepare dissemination training and outreach plans. Then, based upon the needs, we can prepare a final report also. These are some of the essential steps as far as the DSS development is concerned. So, we can follow a systematic approach as far as DSS development is concerned.

Now, we will discuss water-related issues. Whatever we have discussed so far were related to general aspects of decision support system or SDSS – spatial decision support systems; various components, structures and then various subsystems – like that. Now, when we deal with water-related issues – we have seen in many of our earlier lectures in this course – the water-related like rainfall to runoff or various things including the climate, the changes are drastic from one location to another location; spatial variation is too much and then temporal variation, time-dependent variations are also there. So, that way the main need of decision support system. Due to all these changes, decision support system is very essential when we deal with water-related issues or water-resource plans or watershed development plans.

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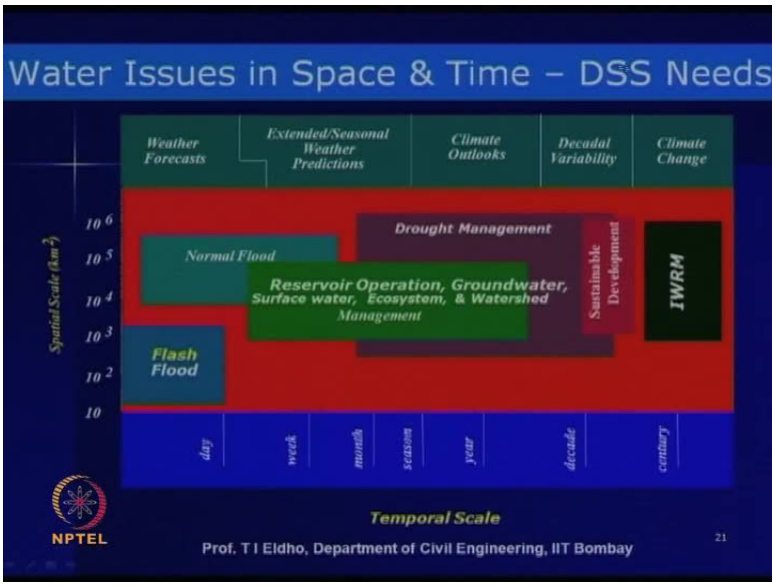

Here the temporal variations can be either daily variation, weekly variation, monthly variation, or season variation, or yearly variation, or decadal variation, or century variation, where especially climate change issues are there. Especially when we deal with water-related issues – how is the rainfall variation, temperature variation, drought pattern, the weather forecast is very important. The spatial scale can be either few square kilometer or large area like 1000 square kilometers or even million square kilometer, like that.

This is temporal variation, (Refer Slide Time: 44:08) spatial variation. Then, the issues are concerned like either whether forecasting or extended seasonal weather predictions, then climate outlook. If it is long-term prediction or long-term effects, then decadal variation, decadal variability or climate change; we have to consider century variations. Especially various problems like flood problem or drought problem or water availability problem we will be considering. Then, within the area or river basin scale or watershed scale, the reservoir is there – how to operate the reservoir or reservoir operation. Then, surface water management, ground water management, then eco-systems management, then watershed-based management system – all these things we can consider within a decision support system. In an axial, we can say that when we deal with especially water-related or watershed-related problems, decision support system is very essential since we have to evaluate various plans, various scenarios, and then we can come up with

appropriate outcome. So, that way decision support systems will be very useful to deal with a water-related issues, water resource management or watershed management plans.

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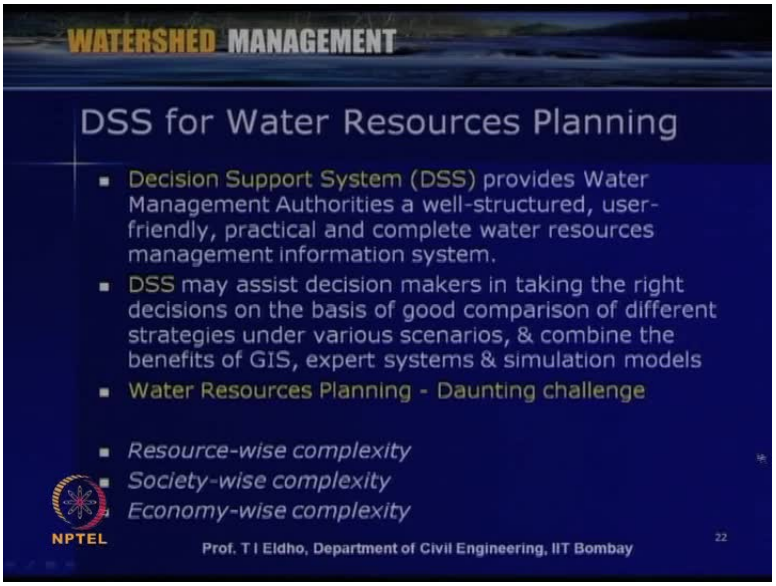

Now, DSS for water resource planning; decision support system provides water management authorities a well-structured, user-friendly, practical and complete water resources management information system. So, that way a number of software, number of packages are available nowadays. So, we can have user-friendly, practical and complete water resource management plans. DSS may assist decision makers in taking the right decisions on the basis of good comparisons of different strategies under various scenarios, and combine the benefits of genetic information system, expert systems and simulation models. So, we can combine various things together within DSS, decision support systems. So, that way DSS is very essential in water resource planning and management, and also within the context of watershed management.

Water resource planning problems are generally resource-wise complexities, too much society-wise complexities, too much economic-wise complexity also there. So, water resource or watershed planning and management that way is a daunting challenge. So, that way DSS decision support system will be a very useful to deal with water resource plans or watershed management plans.

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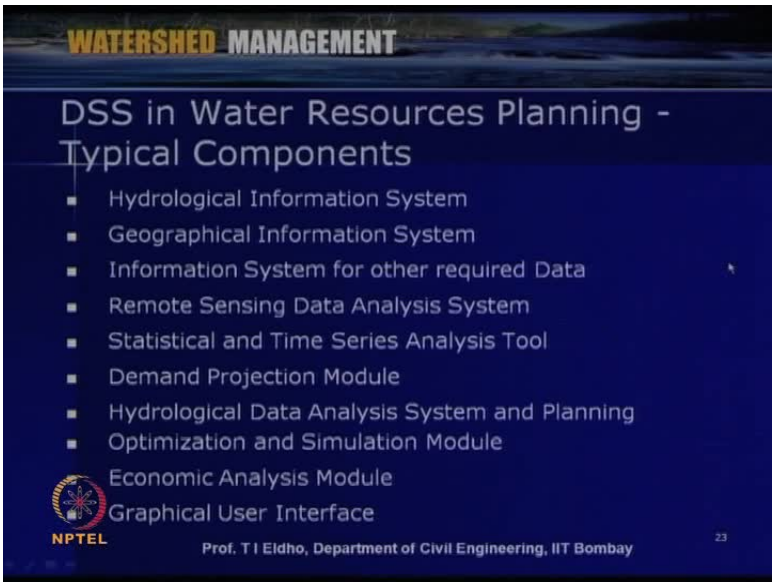

Typical components of a DSS related to water resource planning, the various components I have listed here. The basic components as we have seen earlier like in database management system, management base, model systems, then the user interface, these are all essential components. However, various other components related to hydrological aspects or modeling aspects, these are listed here like – hydrological information systems, geographical information systems, information system for other required data, remote sensing data analysis systems, statistical and time series analysis tool, demand projection module, hydrological data analysis system and planning, optimization and simulation module, economic analysis module, graphical user interface. So, like that many of these components can be there depending upon the problem, depending upon the river basin or watershed, for which we are developing the decision support system.

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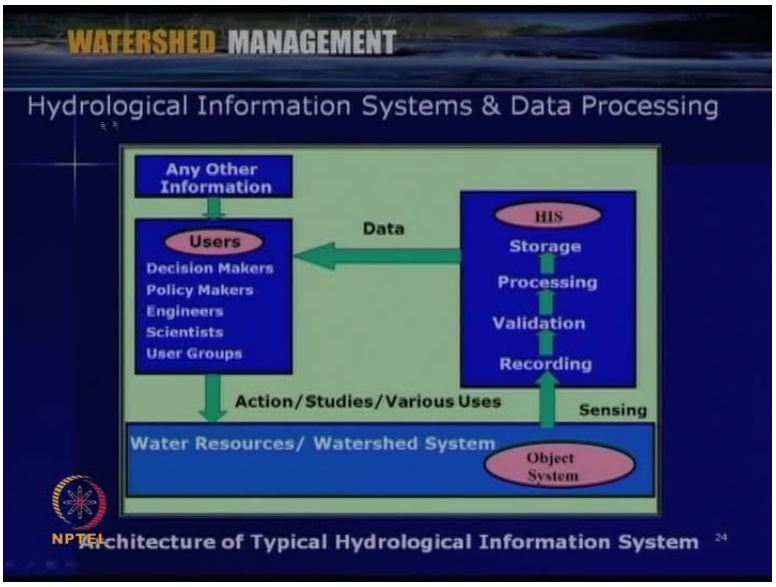

Typically, when we consider hydrological information system and data processing like water resource or watershed system is concerned, we can set the objectives; we can have the various data from the various agencies; we can record it by related process and store it; the users like a decision makers can use it. Policy makers, engineers, scientists are user groups. So, various users can utilize it. So, that way we can develop the systems.

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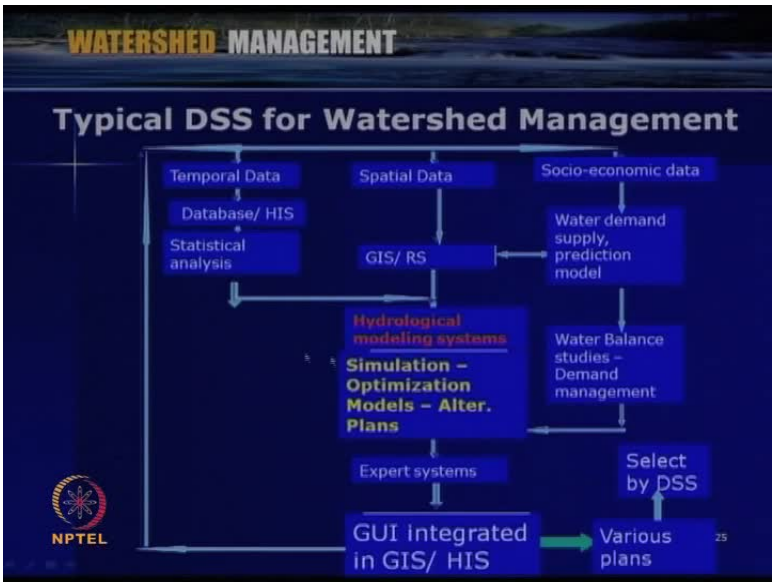

Now, here in this slide, a typical decision support system related to watershed management is shown. As I mentioned, the temporal data, spatial data, socio-economic

data – all these data we should have within the DSS system. Then, we should have database or hydraulic information system. Then, various tools like a statistical or optimization tools can be there. Since very much data intense is the process, we can integrate geographical information systems and remote sensing. Then, related to the various… For example, if the problem is related to water, then we can assess the water demand for the particular watershed, water available, water supply; then, we can have the prediction models; then, we can find out water balance studies using the models; then demand management; then, we can have the hydrological modeling systems, where we can run various models; then, using simulation models or optimization models, we can generate the alternative plans depending upon the problems, and then we can have the expert systems for that depending upon the problem. All these things will be represented in a graphical user interface integrated in GIS or hydrological information systems. So, GUI integrated in GIS or HIS. So, that way finally, various plans are available and then the decision maker can use that water systems to select particular alternative or particular plan or particular scenario. So, this shows a typical decision support system related to watershed management.

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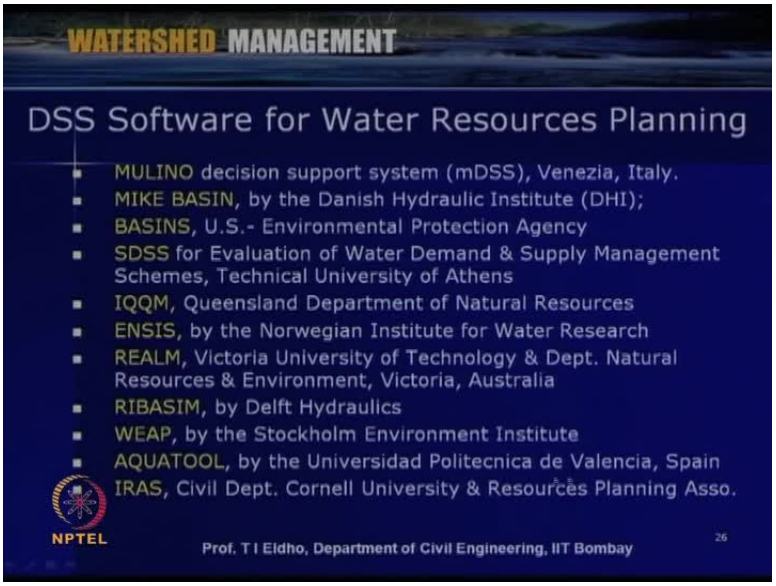

In the literature, if you go through, number of DSS software are available for water resource planning and management. Some of the important software I have listed here like – MULINO decision support system from Italy; then, Mike Basin from DHI; BASINS from US-EPA; Then, SDSS from Technical University of Athens; then, IQQM

from Queensland Department of Natural Resources; then, ENSIS, Norwegian Institute for Water Research; REALM from Australia; RIBASIM by Delft Hydraulics; WEAP by Stockholm Environment Institute; AQUATOOL; IRAS. So, like that number of decision support systems are available. So, depending upon the need, depending upon the problem, we can choose particular decision support systems.

Now, before closing today's lecture, let us look into one specific case study – how effectively decision support system especially GIS based system, can help the decision maker to understand how the scenario related to development of a reservoir and then its flooding region.

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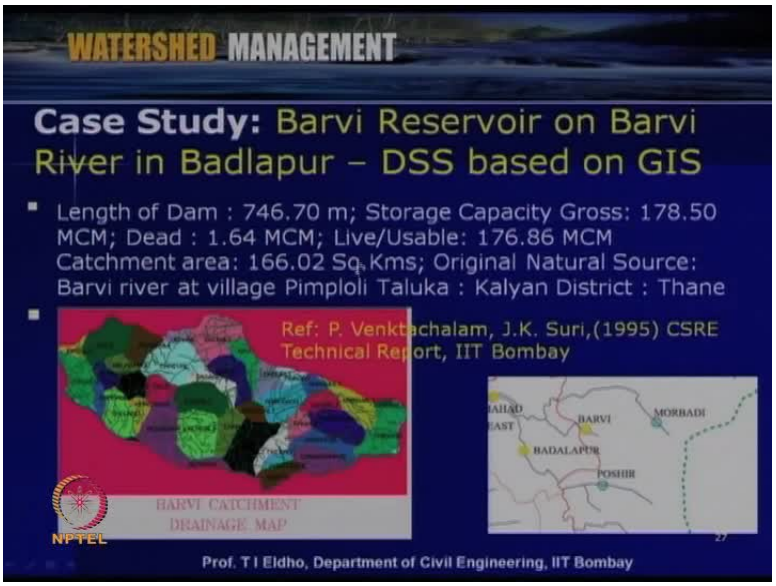

Here the case study is Barvi Reservoir on Barvi River in Badlapur in Maharashtra. This is the area – Barvi river here; this is the reservoir area. These details are taken from a paper and report by professor Venktachalam and J K Suri in 1995. This is the Barvi catchment drainage map. Here the detail of the drainage system is given. The length of the dam is 746.7 meters; storage capacity: 178.5 million cubic meter and then catchment area is about 166 square kilometer. The origin is from Barvi river at village Pimpoli Taluka here; this is the location.

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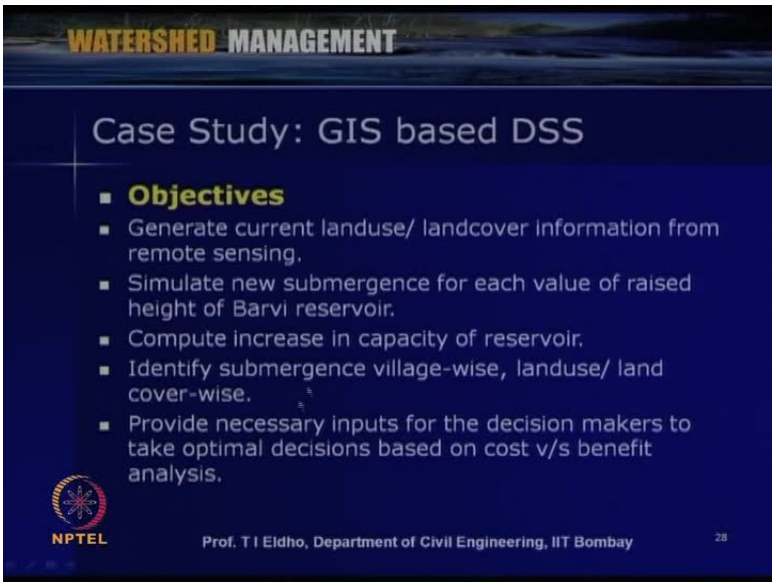

Here the objectives of this study was to generate current land use or land cover information from the remote sensing; simulate new submergence for each value of raised height of Barvi reservoir; compute increase in capacity of reservoir; identify the submergence village-wise, land use or land cover-wise; provide necessary inputs for the decision makers to take optimal decisions based on cost versus benefit analysis. So, these were the objectives of this study.

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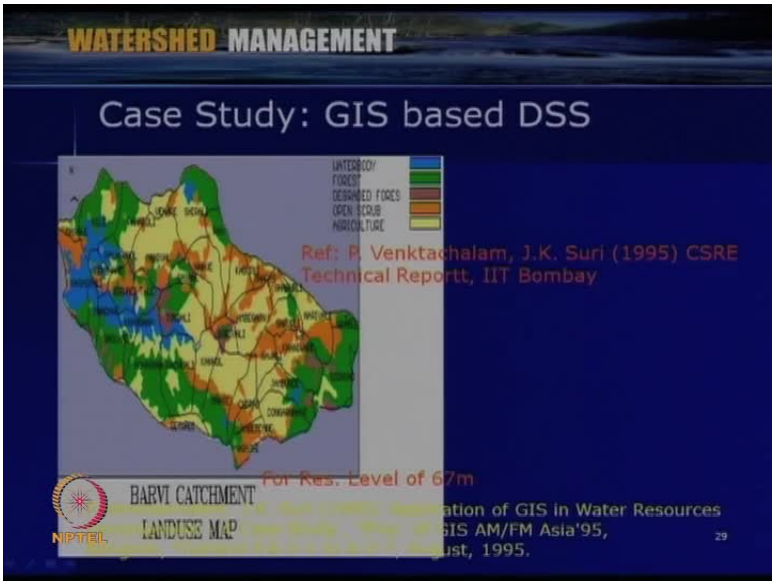

Here the part of the DSS using GIS is presented. Actually, the existing height in this dam was earlier 67 meter. If the 67 meter dam is there, then the water body typically will be like this. Here as I mentioned in the earlier slide, the water spread area and then the capacity is there. The question is – if the reservoir or the dam size is increased, the height is increased and then reservoir area will be increased, then how much flooding can take place, but correspond how much storage capacity will be available. That is what the study has been done here. This is the Barvi catchment land use map (Refer Slide Time: 54:00). Here this shows the water body; then, green colour shows the forest; then, this colour – degraded forest; then, open scrub; agriculture land is the yellow.

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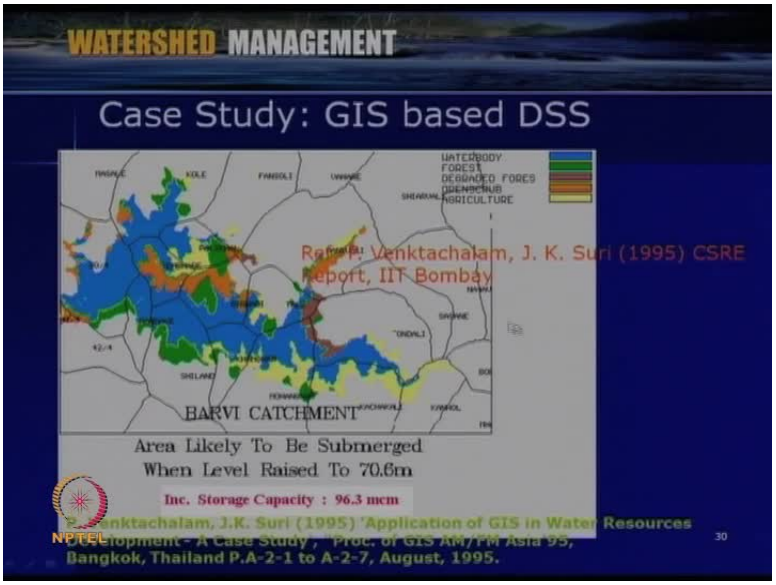

Based upon available data, professor Venktachalam and team studied in detail in a GIS environment, that is, the decision support system in a GIS environment. This shows – if the level of the dam is raised to 70.6 meter from the previous 67 meter, then how much area will be flooded. You can see that corresponding to this (Refer Slide Time: 54:34) – so much area will be flooded. Then, corresponding storage is increased to 96.3 million cubic meters. So, correspondingly, the increase will be this much (Refer Slide Time: 54:52) – will be the storage capacity increase. When the level is raised to 72.6, then how the storage capacity is – gone to 145.6 million cubic meter. Then, we can see which are the areas flooded. Then, again if it is increased to 76 meter, then how much area will be flooded?

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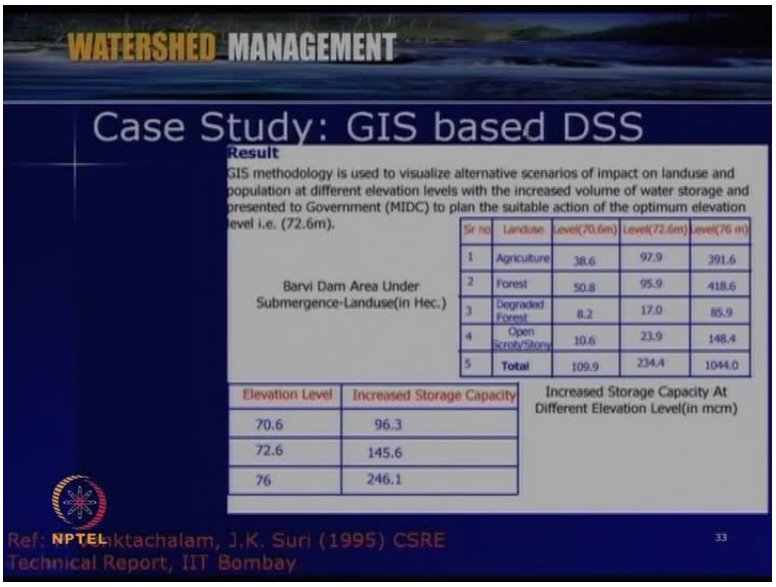

Like that the studies were conducted by the experts. GIS method is used to utilize alternative scenarios of impact on land use and population at different elevation levels with the increased volume of water storage and presented to the government to take suitable action. If the level is this – 70.6 or 72.6 or 76, how much area will be affected in submergence in hector is shown here. The corresponding elevation level and increased storage capacity in a million cubic meter is also shown here.

Using such a system, the decision maker can make a decision – if this is the level, what will be the flooding and what will be the benefits like – how much water can be stored. So, when we put the system in a GIS environment, a decision support system is generated and that can be used by the decision maker.

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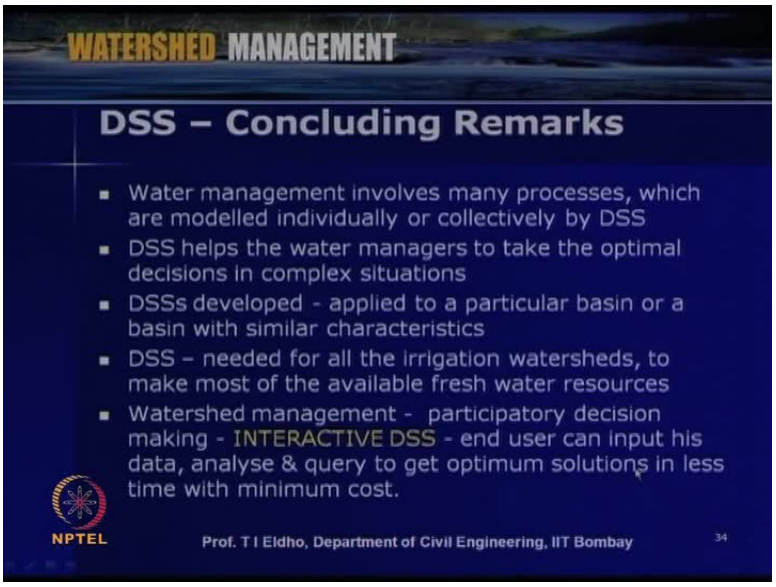

To conclude this today's lecture, some of the remarks like – water management involves many processes, which are modelled individually or collectivity by the decision support system. DSS helps the water managers to take the optimal decisions in complex situations as we have already seen. DSSs are developed – applied to a particular basin or a basin with similar characteristics. So, depending upon the problem, the case, we have to specifically make the DSS and depending upon the needs. DSS needed for all the irrigation watersheds, to make most of the available fresh water resources in an effective way. Then, watershed management is concerned since the people have to interact – participatory decision making we have to do; interactive decision support system is always very effective or always the need of the hour. This interactive DSS – the advantages that end user can input his data and analyze query to get output solution in less time with a minimum cost. So, what will happen then is various scenarios can be generated (( )). So, these are some of the advantages of such a decision support system.

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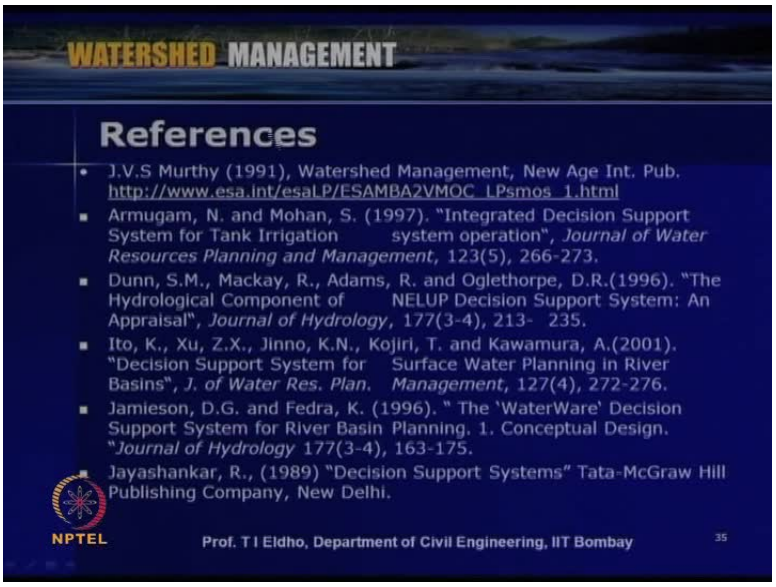

These are some of the references used for today's lecture.

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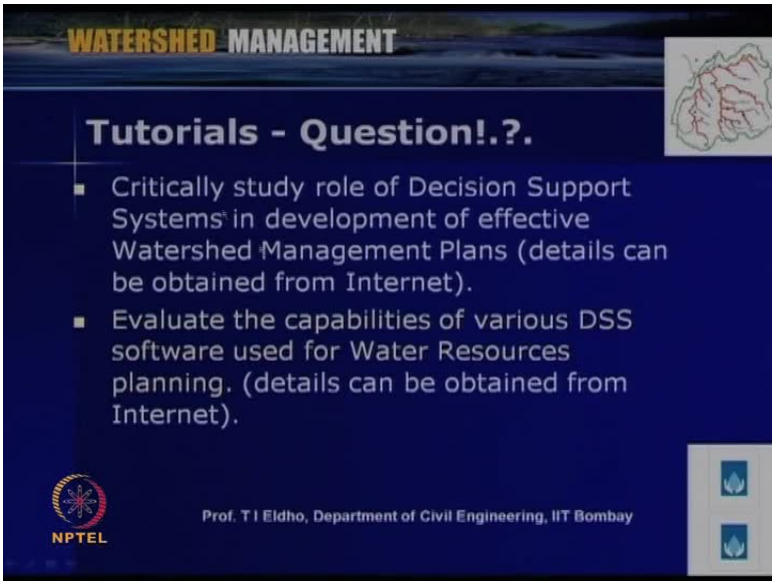

Some of the questions from today's lecture: Critically study role of decision support systems in development of effective watershed management plans – these details you can get from internet. Evaluate the capabilities of various DSS software used for water resources planning as we have seen one of the slide – details you can get from the internet.

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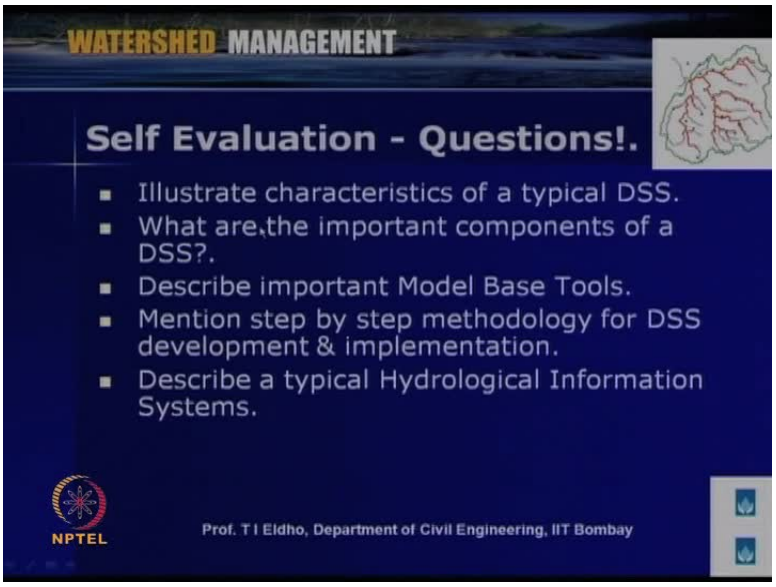

Few other questions for self-evaluation: Illustrate characteristics of a typical DSS. What are the important components of a DSS? Describe important model base tools. Mention step by step methodology for DSS development and implementation. Describe a typical hydrological information systems. These details you can answer based upon today's lecture.

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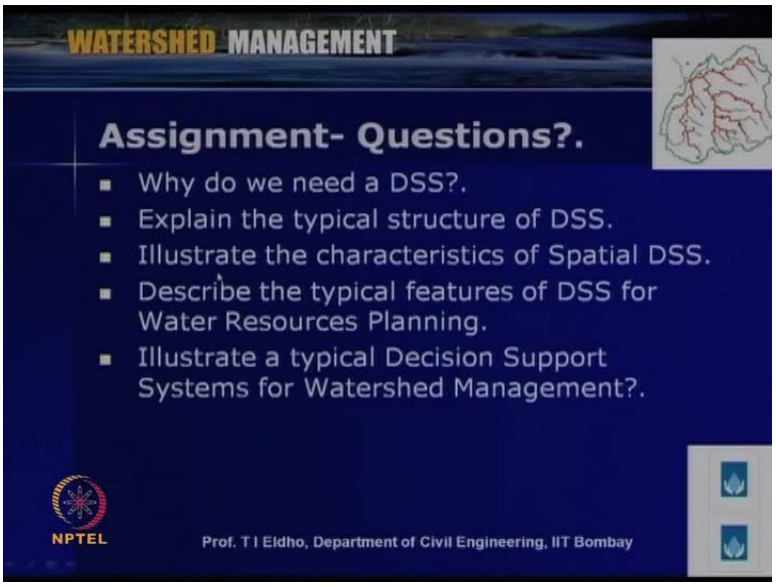

Few assignment questions: Why do we need a DSS? Explain the typical structure of a DSS. Illustrate the characteristics of spatial DSS. Describe the typical features of DSS

for water source planning management. Illustrate a typical decision support system for watershed management. So, if you go through the lecture, you can get answers to all these questions.

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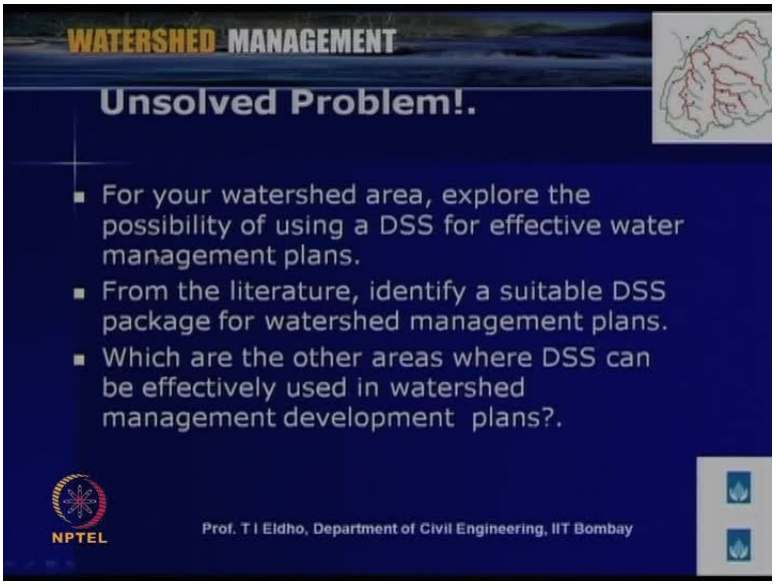

As an unsolved problem: For your watershed area, explore the possibility of using a DSS effective water management plans. From the literature, identify a suitable DSS package for watershed management plans. Which are the other areas where DSS can be effectively used in watershed management development plans? So, we have seen water related issues. Even, soil erosion problem, rain water harvesting, various schemes – we can have the decision support system.

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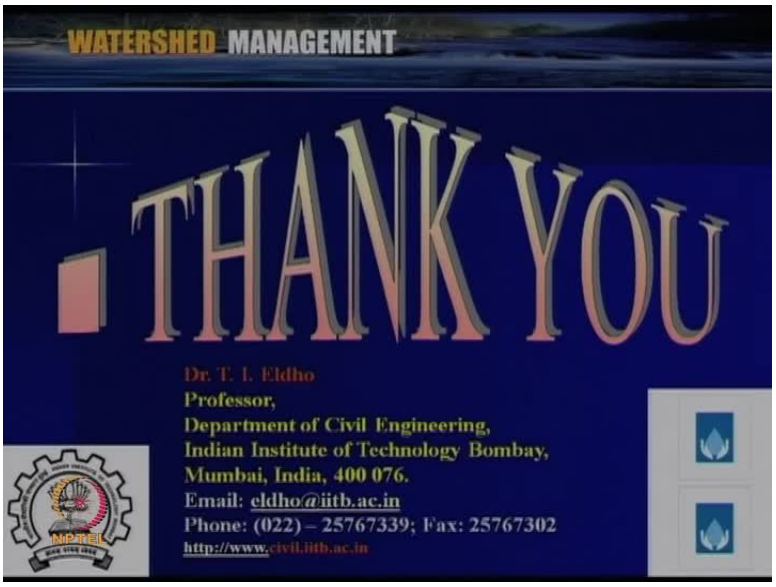

Today, we discussed about the decision support system and its role in water resource management and watershed management plans. So, that is what we discussed in today's lecture. Further, we will see how an integrated system of GIS remote sensing and computer model can effectively utilized in watershed development plans.

Thank you.