Modern Surveying Techniques

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Lecture – 1

Geographic Information System an Introduction

Geographic information system an introduction: Man has been devoting lot of time in the preparation of maps ever since in time immemorial. Through navigators, geographers and surveyors has been documenting the earth surface to collect information regarding the special distribution of significant objects. These maps can be categorized as topographical maps which are general purpose maps or as thematic maps which provide information regarding the natural resources so that one can understand the distribution of natural resources for specific applications.

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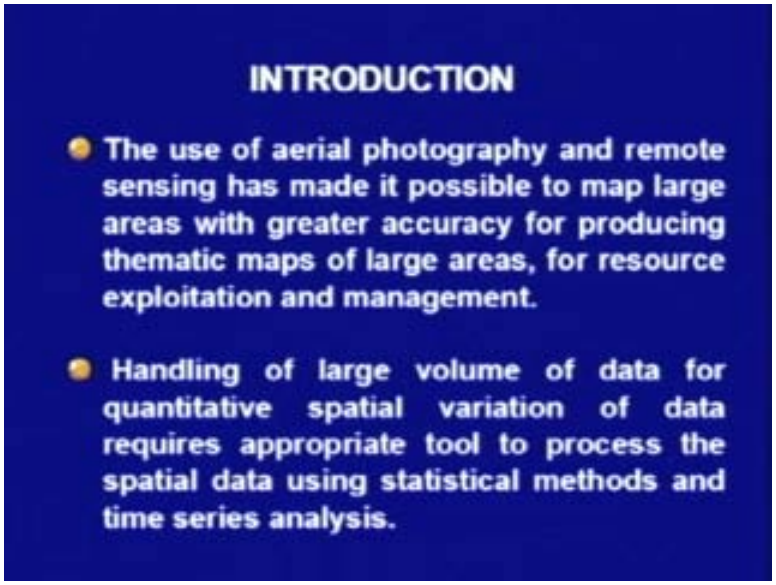

Another source which man has been very recently using is the aerial photographs and remote sensing data set to map large areas with greater amount of accuracy. In order to handle such large volumes of data for quantitative spatial variation; the data requires to be processed, the data requires an appropriate tool for processing the information either with the help of statistical methods or with time series analysis approaches.

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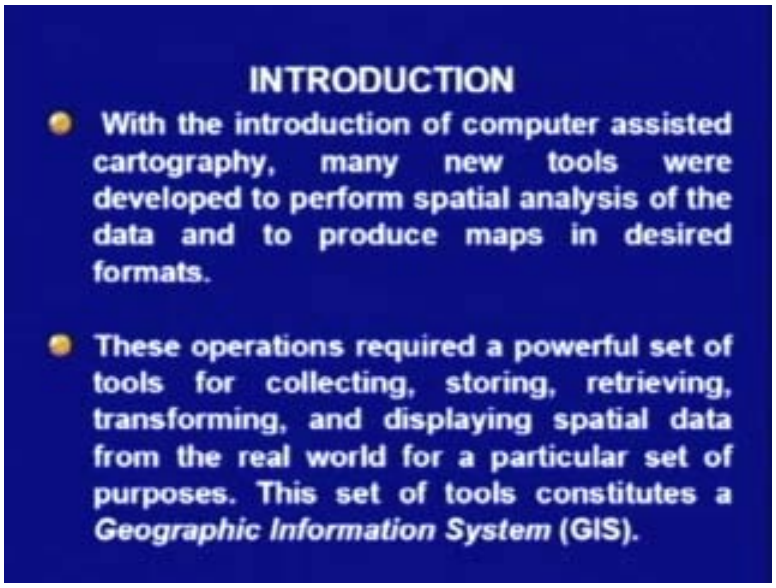

With the introduction of computer assisted cartography, many new tools have been developed to perform spatial analysis and to produce maps in desired formats. These operations require a powerful set of tools for collecting, editing, retrieving, transforming and displaying spatial data for the real world for a particular set of purposes. This set of tools constitutes a geographic information system; in short known as GIS.

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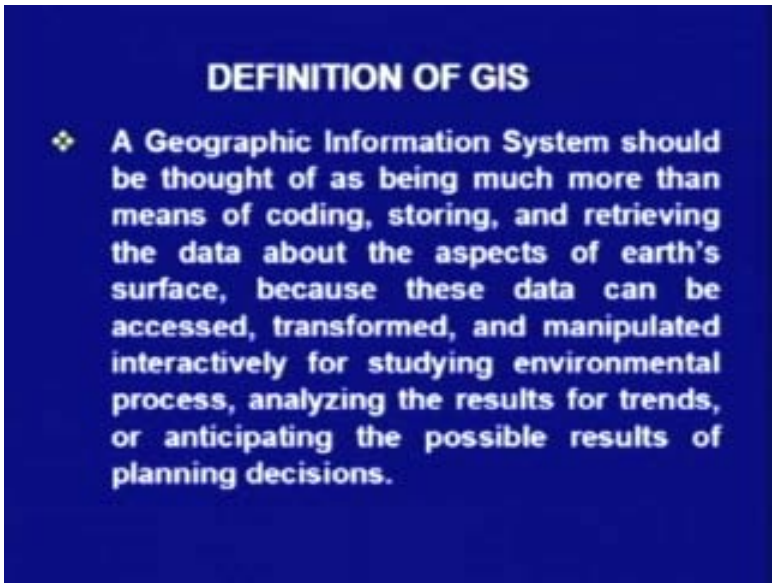

Now, let us look at the definition of GIS. Before we go on to the definition, let us look at the background so that the definition of GIS is much more clear. A GIS system should be thought as being much more than a means of coding, storing, retrieving the data about the aspects of the

earth's surface because these data can be assessed, transformed and manipulated interactively for studying environmental processes so that one can analyze the results for trends or anticipating the possible results of planning decisions.

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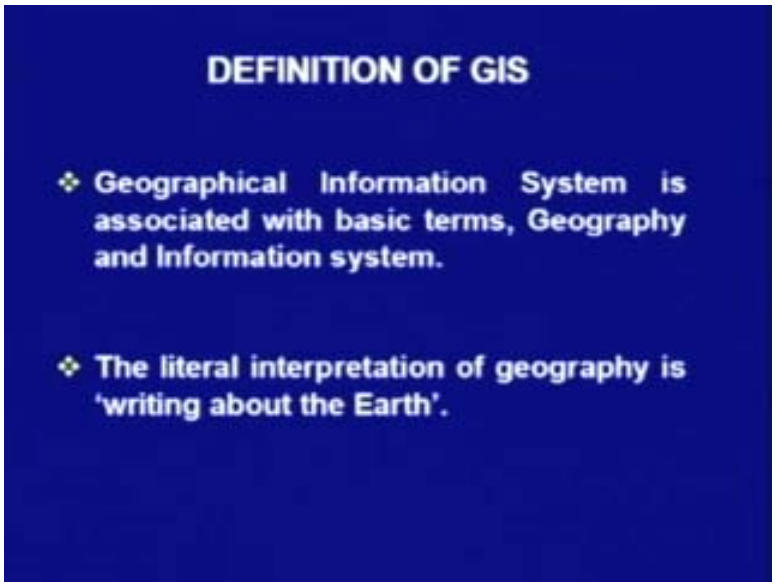

In GIS there are two key words; one is geography and the other is information. So, let us look at the literal interpretation of this particular terminology. First of all, let us look what geography means. Geography, in the shortest and simplest way is nothing but writing about the earth itself.

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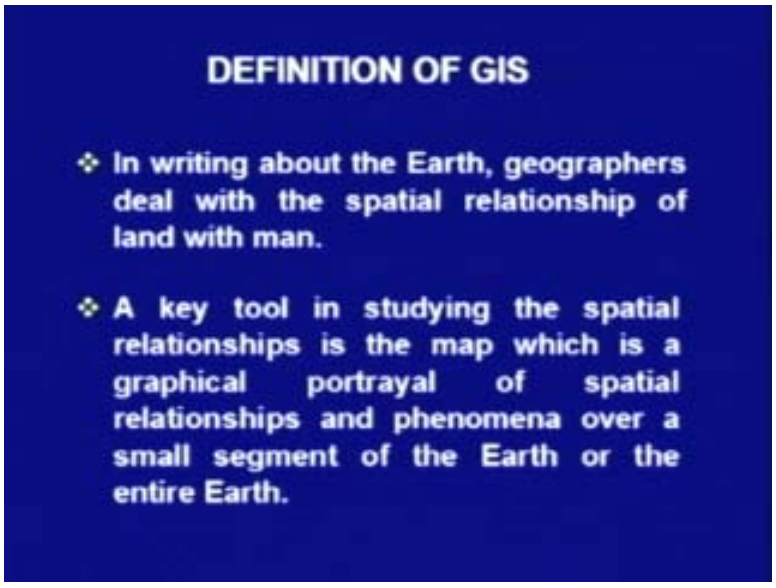

In writing about the earth, the geographers deal with the spatial relationship of land with man. A key tool in studying the spatial relationships in the map which is a graphical portrayal of the spatial relationship and the phenomena over a small segment of the earth or the entire earth itself.

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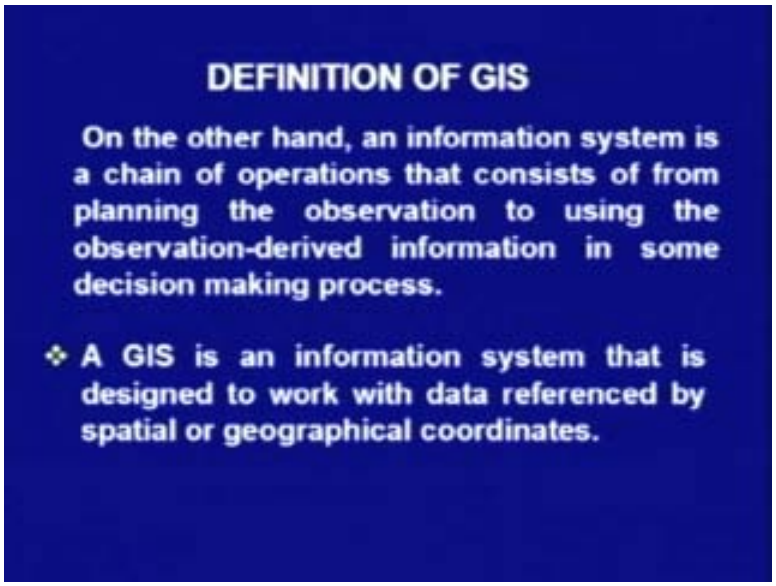

On the other hand, an information system is a chain of operations that consists of planning the observation to using the observation - derived information in some decision making process.
A GIS, in fact is an information system that is designed to work with data referenced by spatial or geographical coordinates.

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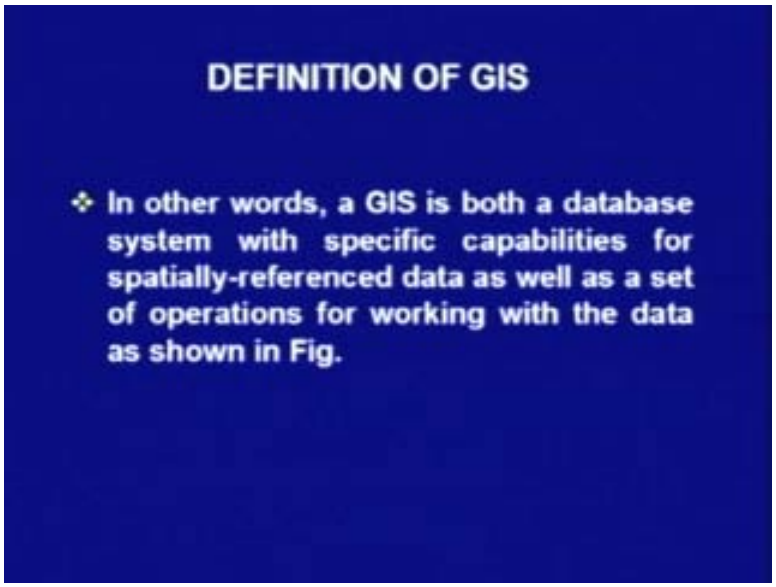

So in other words, we can say GIS is both a database system with specific capabilities for spatially - referenced data as well as a set of operations for working with the data which we can see now in the next figure.

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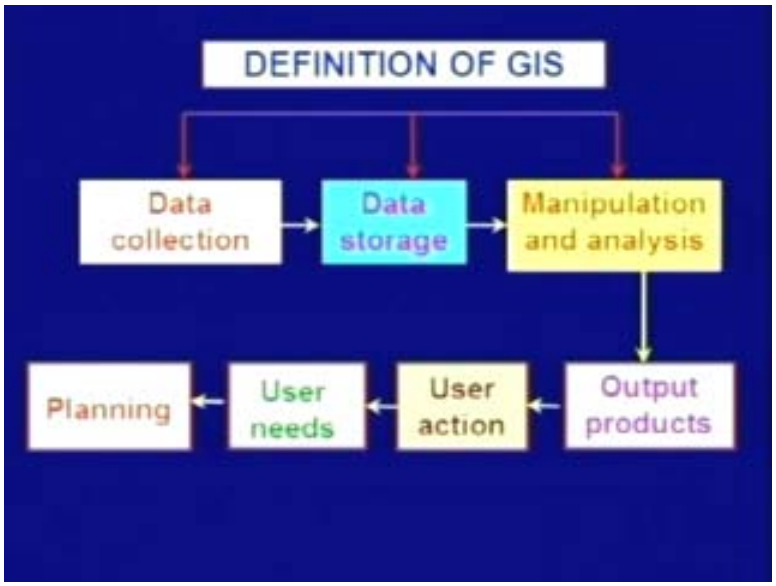

So, it is a data collection procedure, it is a data storage procedure, it is it can allow manipulation and analysis of information. From these analyses, we can have output products which can be used by the user to identify the user needs and perform planning. And, this planning subsequently will require more inputs for data collection as such.

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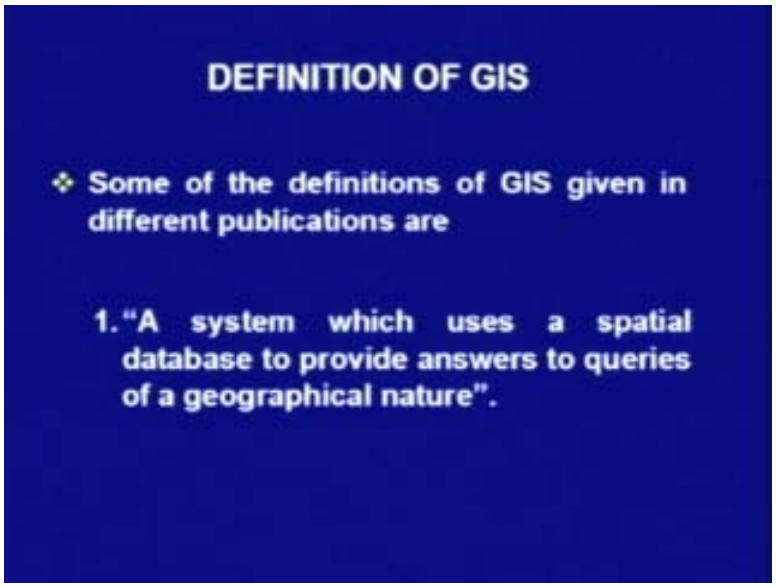

So, let us look at some of the important definitions which have been given in by different sources. First of all; a system which uses a spatial database to provide answers to queries to a geographical nature.

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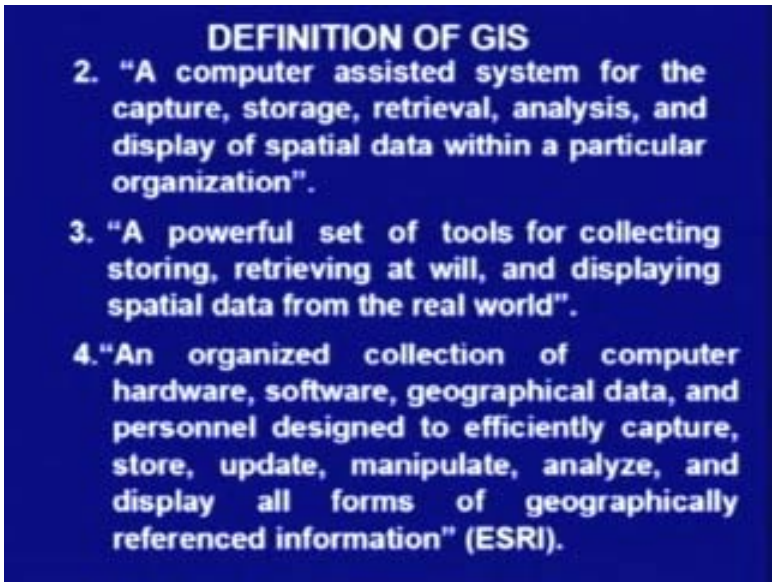

Another definition could be "a computer assisted system for the capture, storage, retrieval, analysis and the display of spatial data within a particular organization'. Another definition could be "a powerful set of tools for collecting, storing, retrieval at will and displaying spatial distribution with the real world.

However, the next definition probably seems to be the best fit. "An organized collection of computer hardware, software, geographical data and personnel design to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information": a definition which has been given by one of the leading organizations in the GIS world ESRI.

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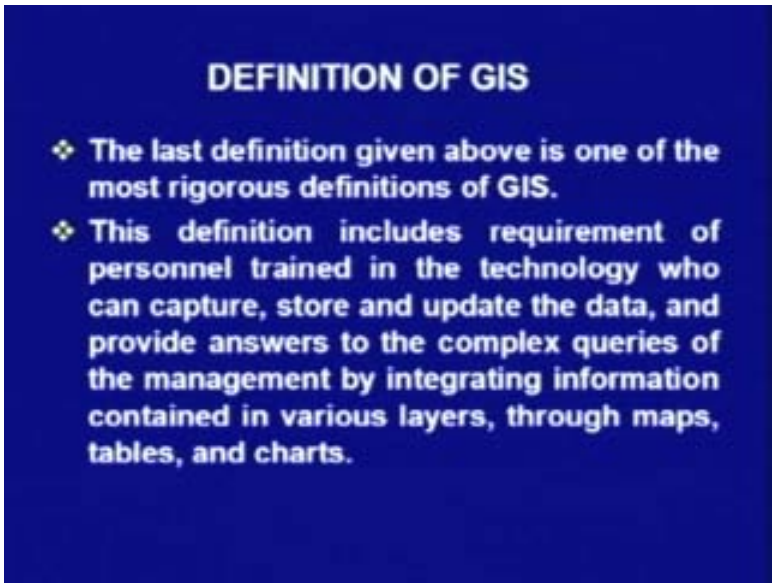

So, we can see that the last definition is the one which gives a very rigorous definition to GIS. This definition includes the requirement of the personnel trained in the technology who can capture, store and update the data and provide answers to the complex queries and provide queries of the management by integrating information contained in various layers through maps, tables and charts. GIS is also a result of linking parallel developments in many separate spatial data processing as shown in the next figure.

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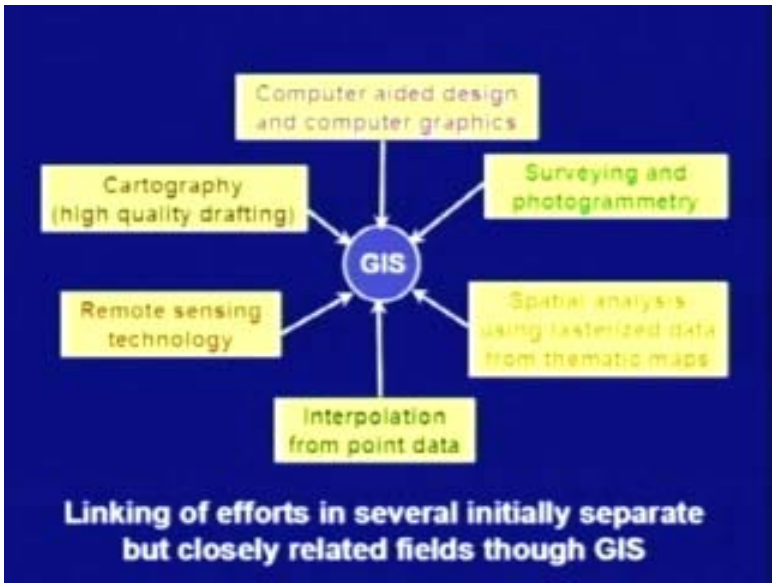

If you look at this particular figure; GIS as a matter of fact is assisted by computer added design and computer graphics. It requires inputs from surveying and photogrammetric data collection techniques. It performs spatial analysis using rasterized maps from thematic maps. It performs the interpolation from point base data. It uses remote sensing technology inputs and the final output is produced by cartography which is a high quality drafting technique.

Now, let us look at what are the components of a GIS. The components of a GIS can be defined in various ways. But very comprehensively, it can have the following components.

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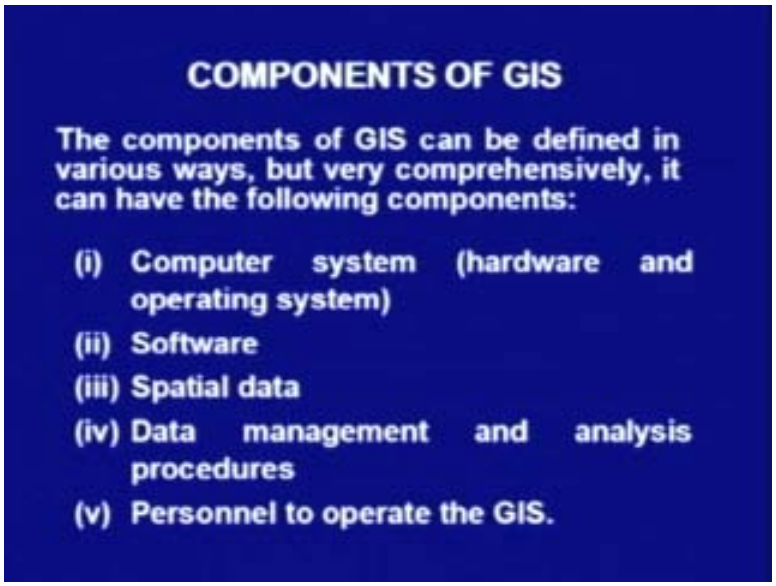

First: a computer system which will consist of the hardware and its operating system. Second is the software which will run the data. Next is the spatial data set that is the input information which would be acquired from different sources. These data's will then have to be manipulated so that their result can be obtained. So, we have a data management and an analysis procedure and finally personnel to operate the GIS.

Now, let us look at these components in a detailed manner. What are the hardware components and the operating system requirements?

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The hardware components of a GIS comprise of a central processing unit; in short we call it as the CPU, a disk drive, a tape drive, a digitizer, plotter and a visual display unit, in short we call it as VDU. The disk drive and the tape drives are basically data storage devices. The data can be used for communicating with the other systems. The disk drive and the tape drives are basically data storage devices. The tape can be used for communication with other systems.

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Now, let us look at the graphical display of the major hardware components that we need in a GIS. The core of the GIS is a CPU system which will have a video display unit. A mouse for interactively displaying, interactively sending commands. A digitizer for sending an input data

from maps and all. A scanner to scan the maps. A plotter to plot the output maps. A printer to print all the textual information. A tape drive to store the information, a disk drive. Again, a storage accessory and finally a keyboard to send in all the commands to run the software.

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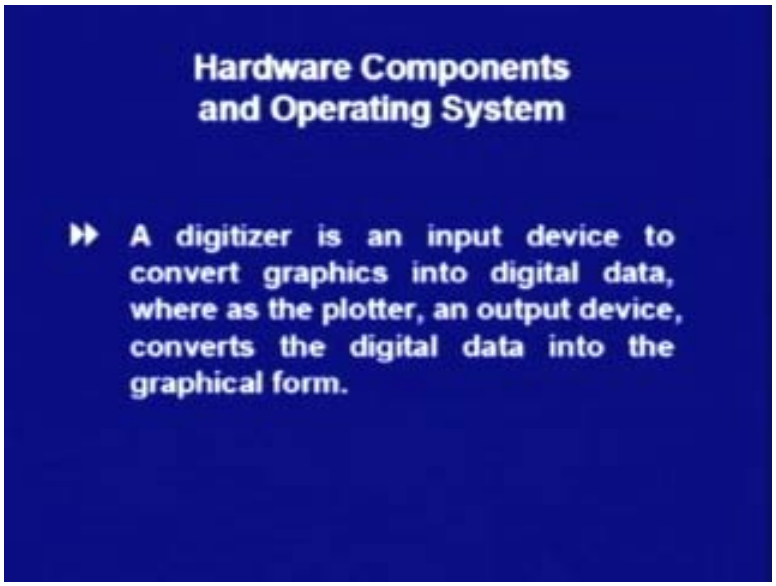

Now, look at let us look at some of the individual components of the hardware that we have.
A digitizer is an input device which converts the graphics into digital data. Whereas, the plotter is an output device which converts the digital data into a graphical form.

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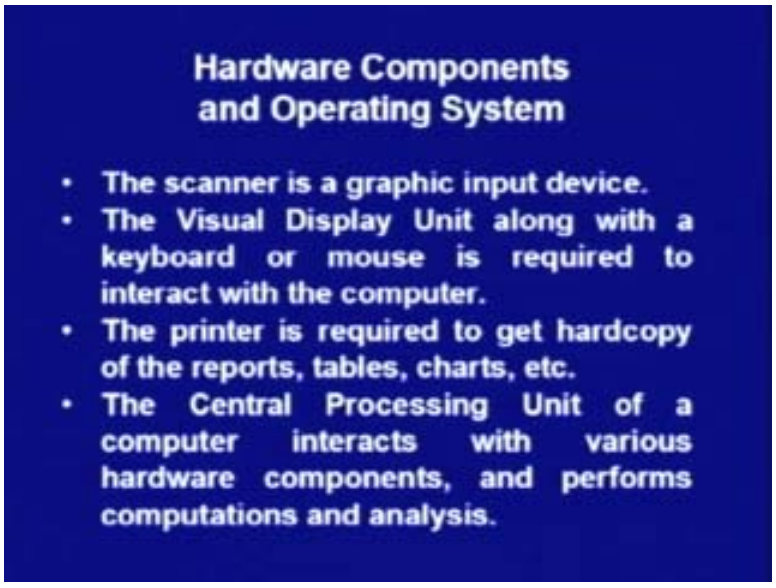

A scanner is basically a graphical input device. The visual display unit along with the keyboard and the mouse is required to interact with the computer. The printer is required to get hard copy of the reports, tables and charts which may be prepared after the analysis had been carried out. And finally, the central processing unit is the one which interacts with the computer with the various hardware components and performs the computations and the analysis.

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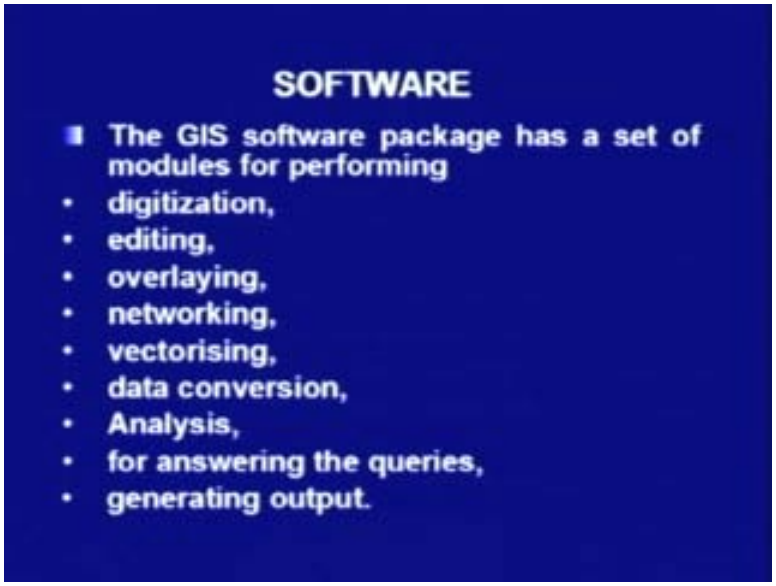

The heart of a GIS is the software which performs all the tasks. Now, which are these tasks which the software will be required to do? First is input of information which is required and this would be carried out with the help of digitization. Digitization of maps: once the digitization has been carried out, any error which has come during the process of digitization will have to be corrected and this would be done through editing.

Once the editing of the data sets have been carried out, the over link between individual layers of information will have to be done. Then the networking of the data set of different layers will have to be carried out. And, vectorisation of the information followed by conversion of the data set so that it can be manipulated and analyzed and subsequently one may have modules for answering the queries and generating the desired output.

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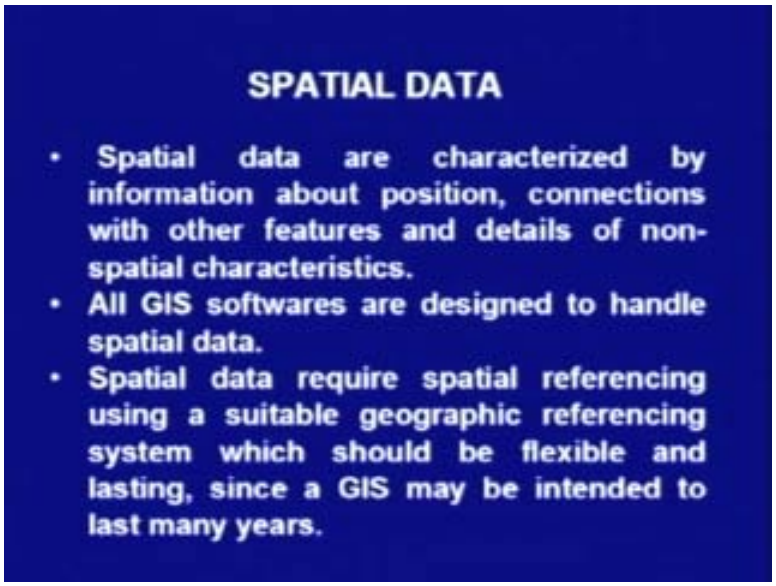

The first and fore most important thing is the spatial data. Spatial data are characterized by information about the position, connections with other features and the details of non spatial characteristics. All GIS softwares are designed to handle spatial data. Spatial data require spatial referencing using a suitable geographic referencing system which should be flexible and lasting. Since, a GIS may be intended to last for many years.

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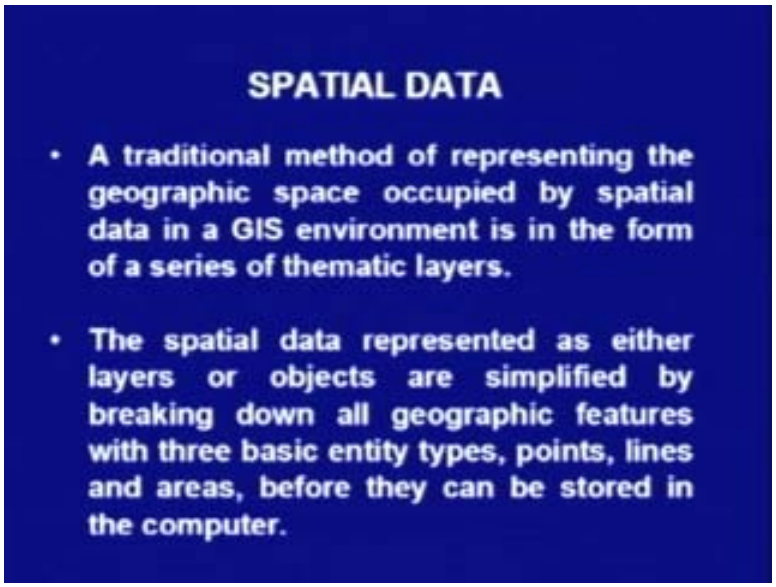

A traditional method of representing the geographic space occupied by spatial data in a GIS environment is in the form of thematic layers. The spatial data represented as either layers or

objects are simplified by braking down all geographic features into 3 basic entities. That is points, lines and areas before they are stored into a computer. So, let us look at the data management and analysis procedure. Input data in the form of spatial data and non spatial data and the information about their linkages and updating of data are most expensive and time consuming part of any GIS project.

The data input is the process of converting the data from its existing form to one that can be used by a GIS. Once the data has been stored, naturally this data has to be managed and this requires the use of a database management system or in short we call it as the DBMS.

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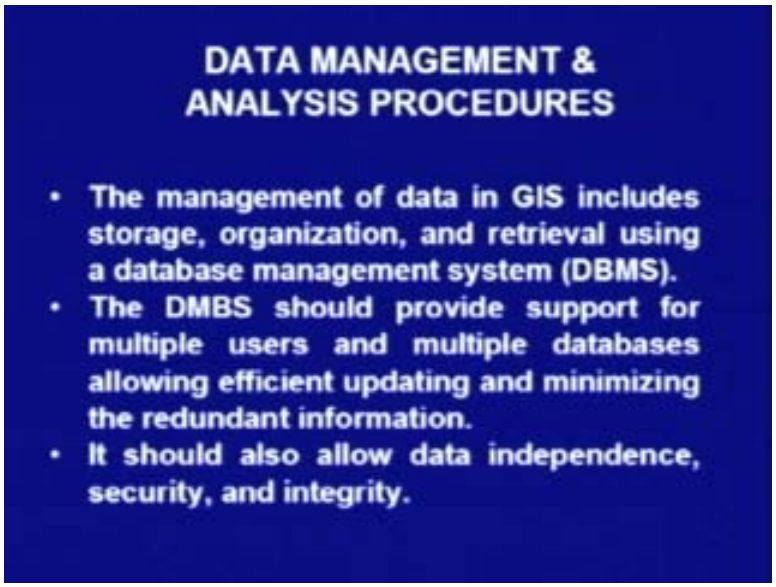

The DBMS should provide support for multiple users and multiple databases, allowing efficient updating and minimizing the redundant information. Further, it should also allow for data independence, security and integrity.

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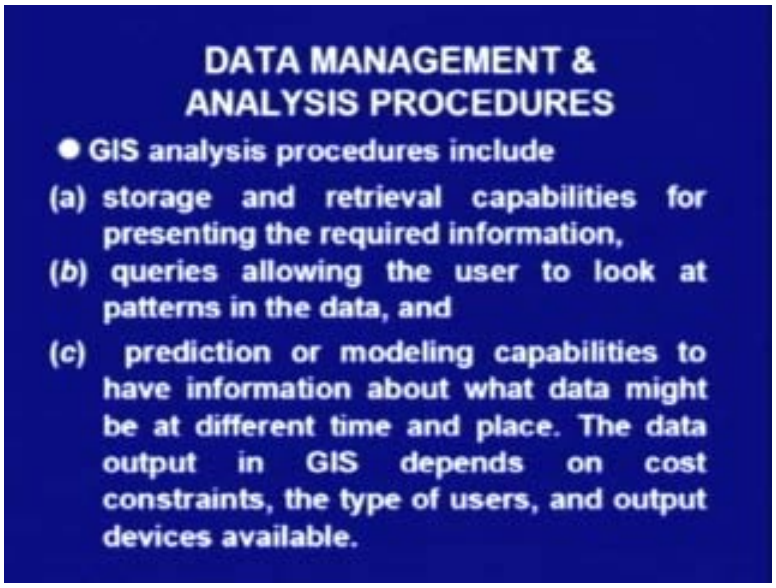

GIS analysis procedure may include; storage and retrieval capabilities for presenting the required information, queries allowing the user to look at the patterns in the data set and predicting and modeling capabilities as such. The data output in GIS depends on the cost constraints and the type of users and the output devices which are available to us.

However, the next component is a human based but the most important part of it and that is the personnel who is operating the GIS. A GIS project requires trained personnel who can plan, implement and operate the system. These people should be capable of making decisions on the basis of the output. The success of any GIS project depends upon the skill and the training of the personnel handling the GIS project.

Before we go further, let us look at some of the geographical concepts which are important and need to be understood. As already pointed out, all geographic features can be represented by 3 basic entities; point, lines and areas. A spatial object represents a geographical area having a number of different kinds of associated attributes or characteristics.

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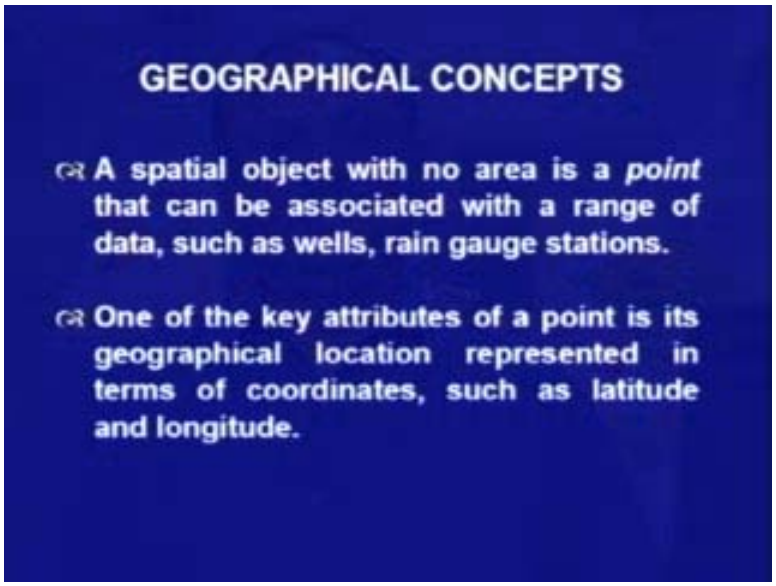

A spatial object having no area is a point. That can be associated with a range of data such as wells, rain gauge stations, etc. One of the key attributes of a point is its geographical location represented in terms of coordinates, such as latitude and longitude.

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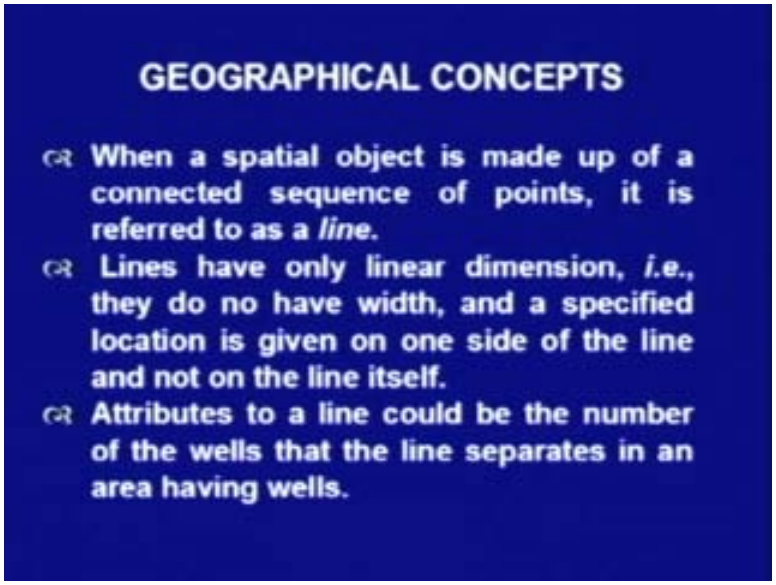

The next geographical concept which is very important and that is the line. A spatial object which is made up of connected sequence of points is known as a line. A line will only have a linear dimension that is it will have no width. And, a specified location is given on one side of the line and not on the line itself. Attributes to a line could be the number of wells that the line separates in an area having wells.

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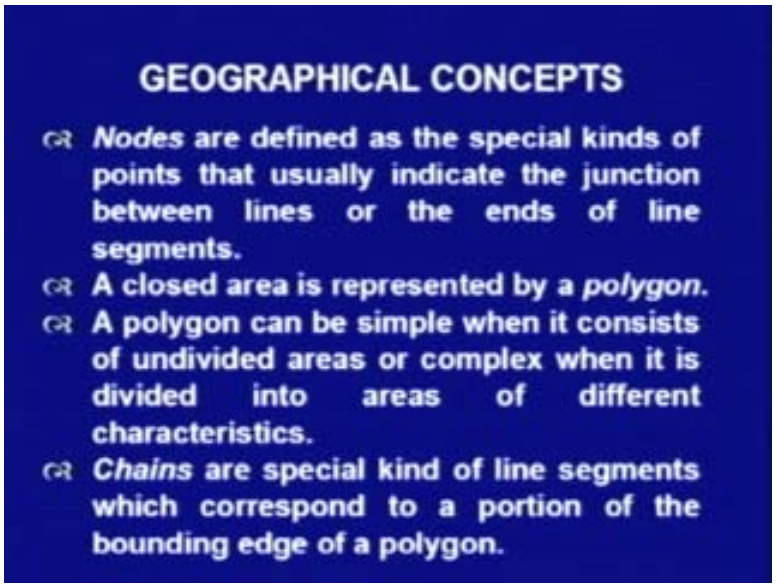

The next concept is the nodes. Nodes are defined as the special kinds of points that usually indicate the junction between the lines or the ends of line segments. A closed area is represented by a polygon. A polygon can be simple when it consists of undivided areas or complex when it divides into areas of different characteristics.

Another special type of line segment which is of important and that is chains. And, these correspond to a portion of the bounding edges of a polygon.

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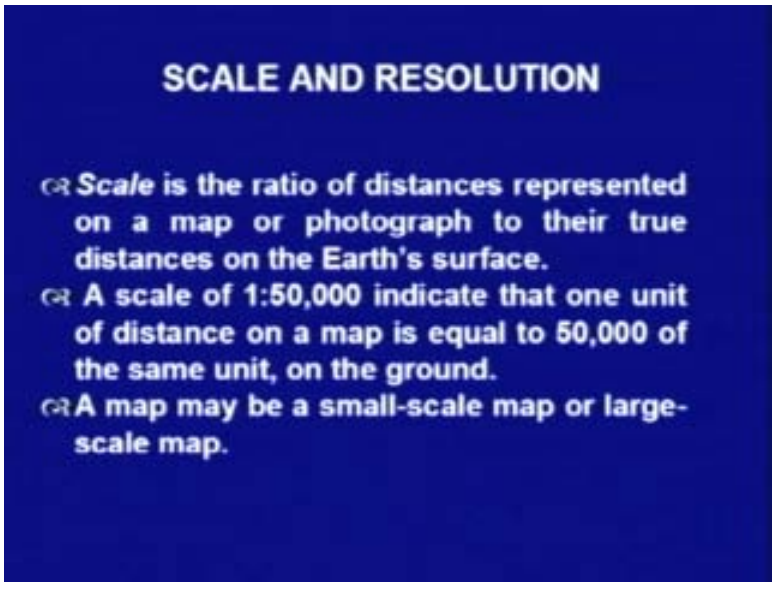

The next concept is the scale and resolution. Scale can be defined as the ratio of the distance represented on a map or photograph to their true distances on the earth surface. A scale of 1 is to 50,000 indicates that one unit distance on the map is equal to 50,000 units on the ground. A map may be a small-scale map or it could be a large-scale map.

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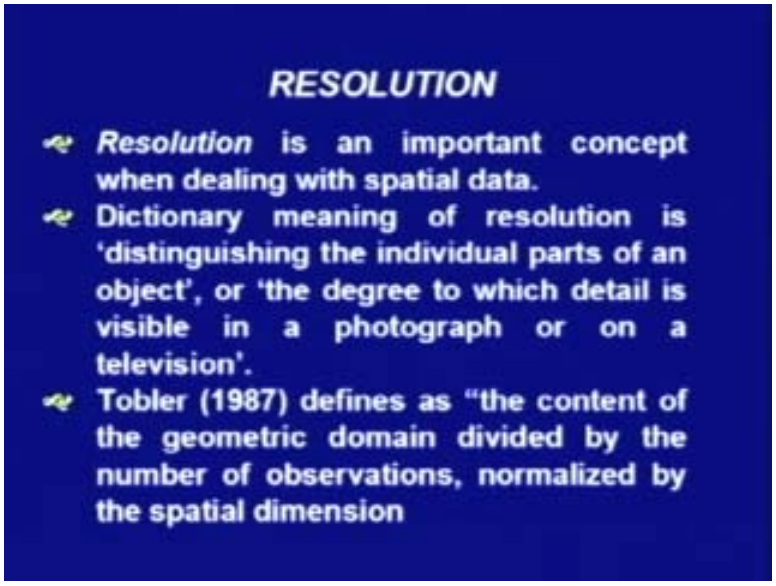

The next is the resolution. Resolution is an important concept when we are dealing with spatial data sets. The dictionary meaning of resolution is distinguishing the individual parts of an object or the degree to which detail is visible in a photograph or on a television cap. Tobler in 1987 defined resolution as the content of the geometric domain divided by the number of observations normalized by the spatial dimension.

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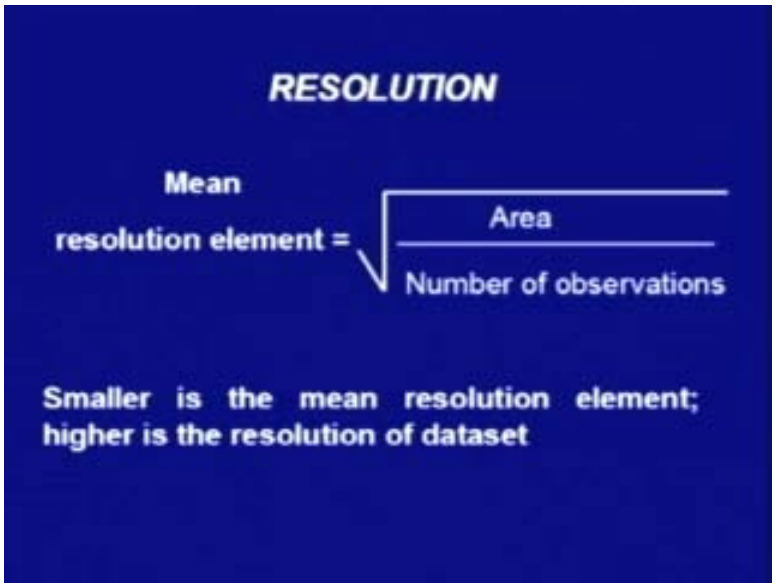

And, this can be translated into a very simple equation. That is; the mean resolution element, it is equal to the square root of the function area divided by the number of observations. So, resolution can be expressed by a mathematical relationship. That is; mean resolution element, it is equal to under root of the area divided by the number of observations taken. Thus smaller is the mean resolution element; higher is the resolution of dataset.

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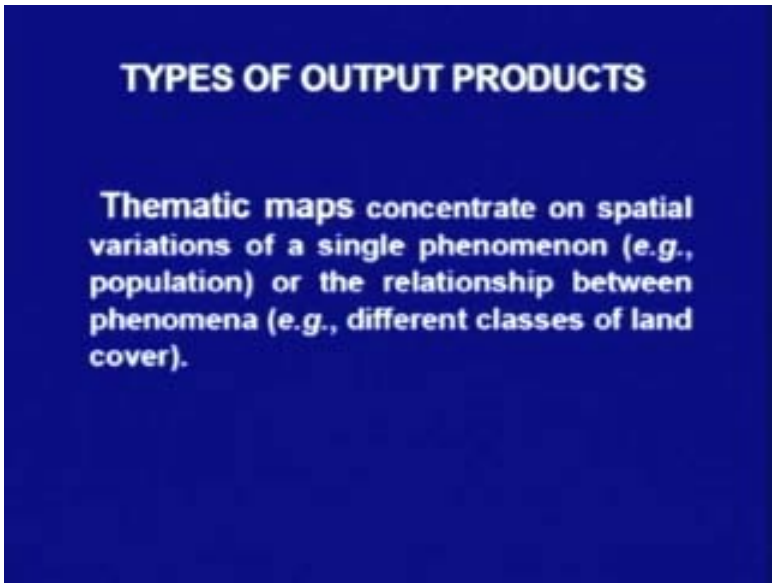

Now, coming to the types of output products which can be had from a GIS; thematic maps are one of the most common maps which are generally made available through a GIS analysis and

they concentrate on the spatial variations of a single phenomena. May be, with the population or the relationship between phenomena's. That is between different classes of land cover.

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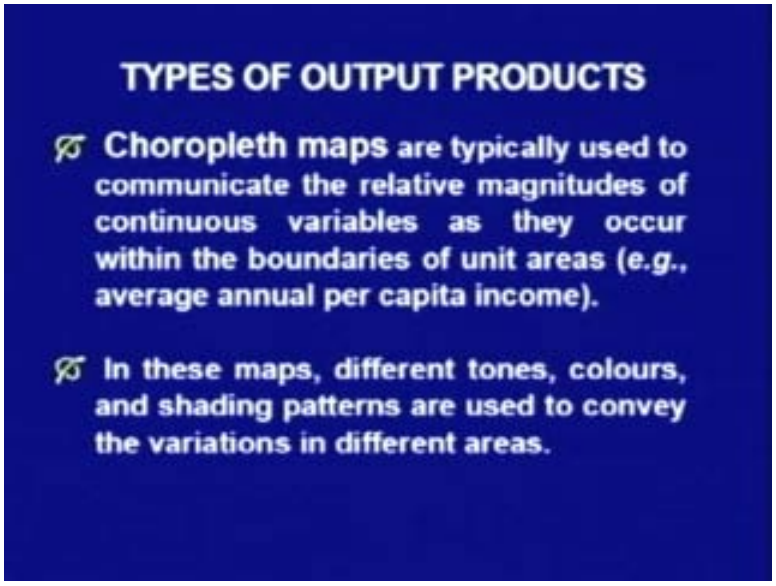

The next could be a choropleth map. These are typically used to communicate the relative magnitudes of continuous variables as they occur within the boundaries of unit areas. That is average annual per capita income. In these maps, different tones, colours and shading patterns are used to convey the variations in different regions.

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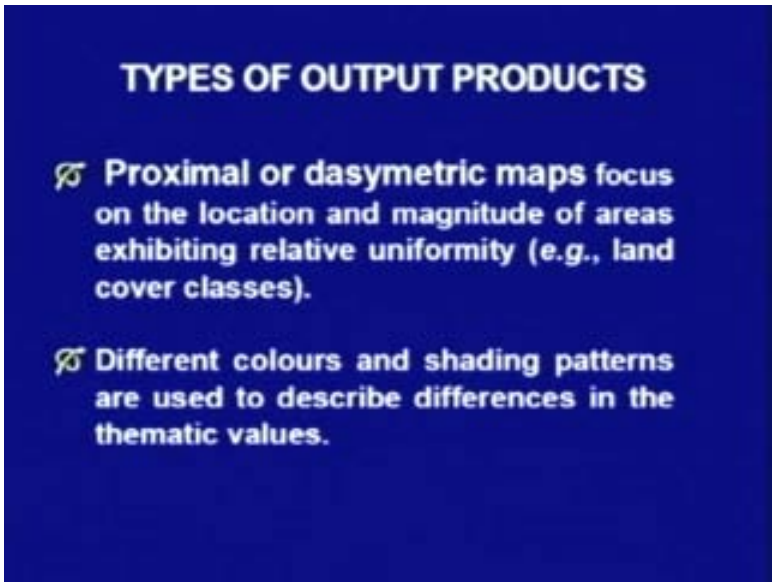

The next type of the output product could be proximal or dasymetric maps which focus on the location and the magnitude of the area exhibiting the relatively uniformity of land cover classes. Different colours and shading patterns can be used to differentiate the thematic values.

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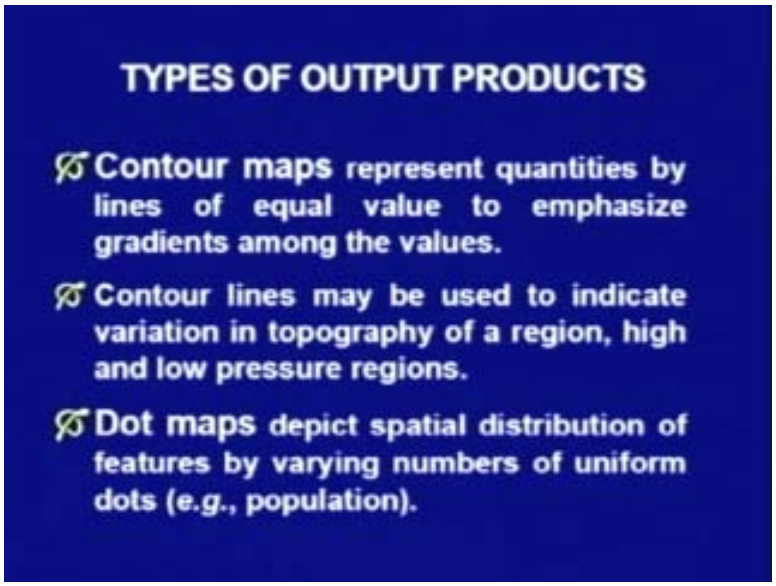

Then we can have contour maps which represents quantities by lines of equal values to emphasize the gradients amongst the values. Contour lines may be used to indicate the variation in topography of a region; high or low pressure regions etc.

Then we can have dot maps which depict spatial distributions of features by varying numbers of uniform dots. For example; to present population ranges, different sizes of dots can be used.

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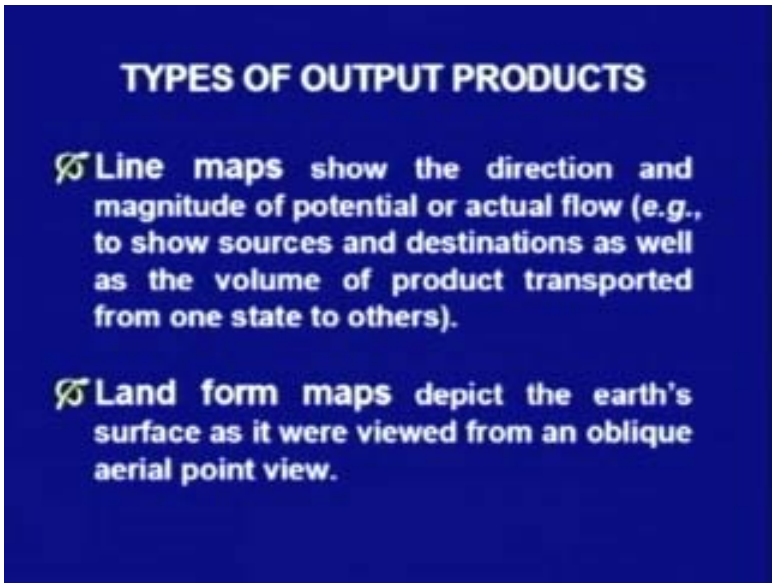

Another type of output which is very commonly used is the line map which shows the direction and the magnitude of potential or actual flow that is taking place; very commonly used to show the flow of transportation from one product one state of product to another state. Then may we have land form maps which may depict the earth's surface as it is being viewed from an oblique aerial view point.

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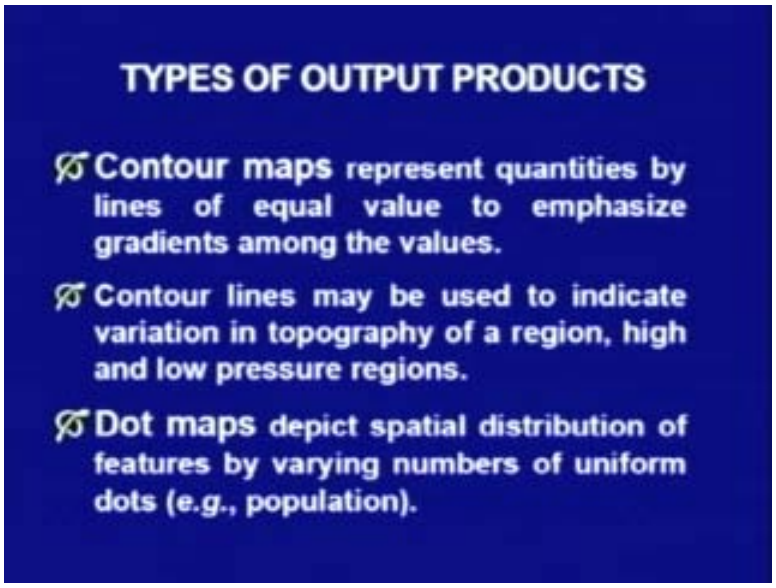

Contour maps represent quantities by lines of equal values to emphasize gradient among the values present. Contour lines may be used to indicate variation in the topography of a region or high or low pressure regions.

Another form of output products could be through dot maps which depict spatial distribution of features by varying numbers of uniform dots, that is population. In order to show different ranges of population, different sizes of dots may be utilized. Another output product very commonly used is the line map.

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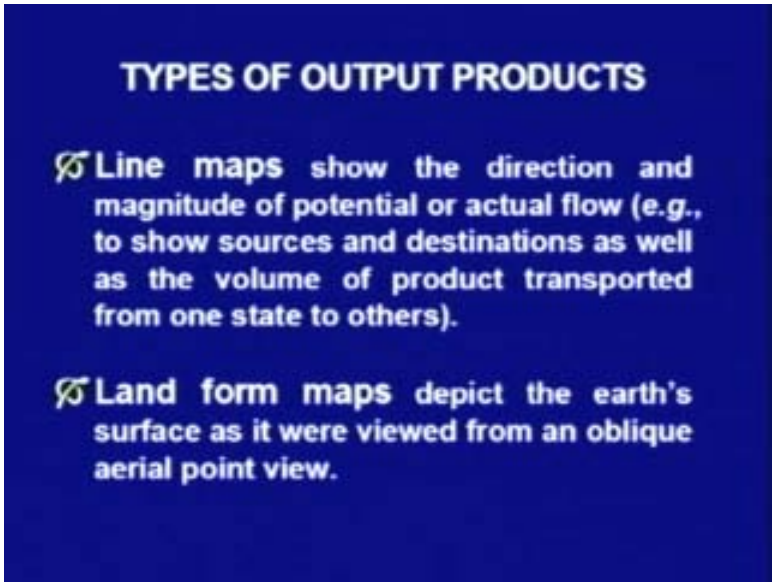

These maps show the direction and the magnitude of the potential or actual flow that is to show the sources and the destination as well as the volume of the product being transported from one state to another. The next type of output product which could be made available from a GIS is the land form maps which depict the earth surface as it is being viewed from an oblique aerial view point.

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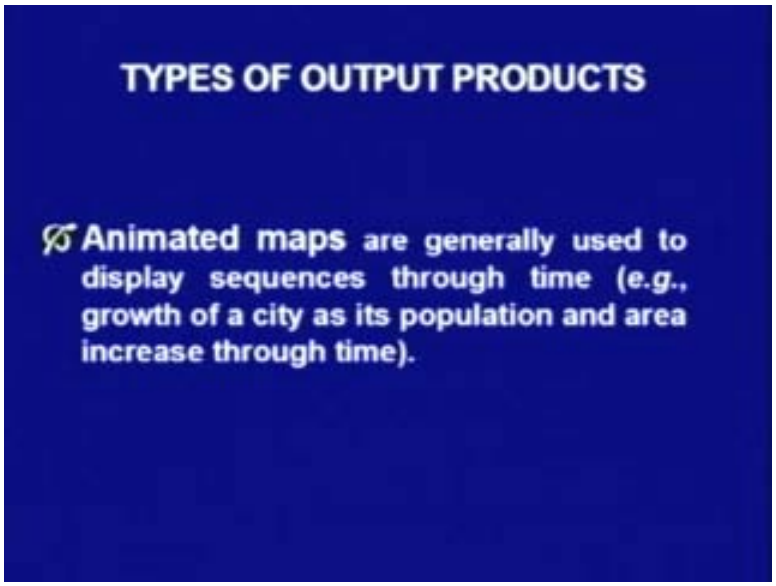

Another common data product is the use of animated maps. When we have is output available through a sequence of time, that is growth of a city as its population and the area increases through the time.

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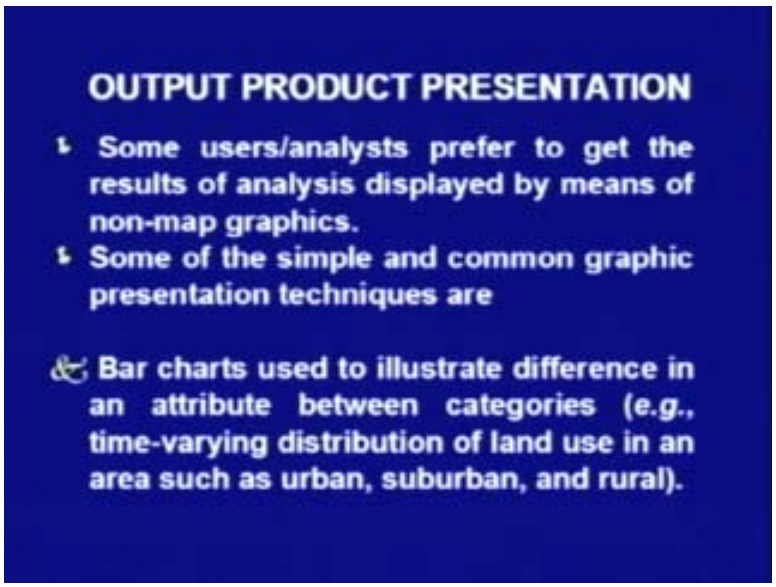

Output product presentation. That is how do we present the out the data? Some users and analysts prefer to get the results of the analysis displayed by means of non-map graphics. Some of the simple and common graphic presentation techniques are bar charts to illustrate differences in an attribute between categories.

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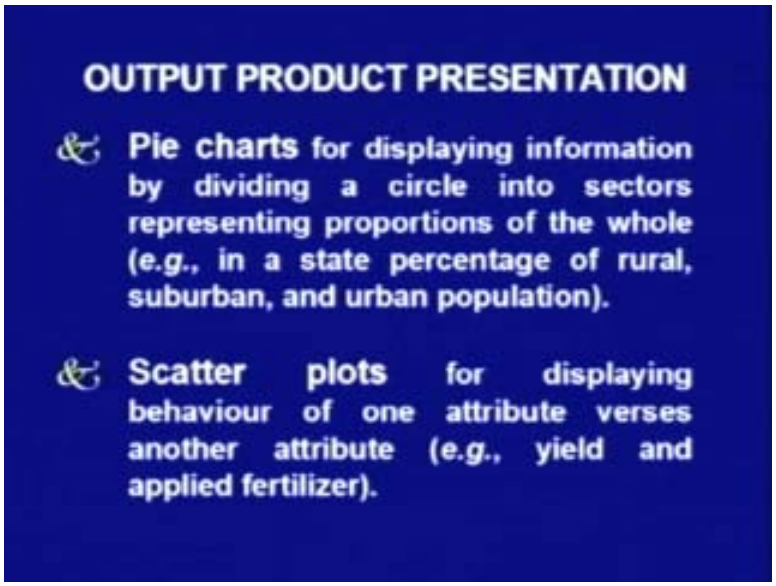

Pie charts for displaying information by dividing a circle into sectors representing proportion or as a whole. Scatter plots for displaying behaviour of one attribute verses another attribute.

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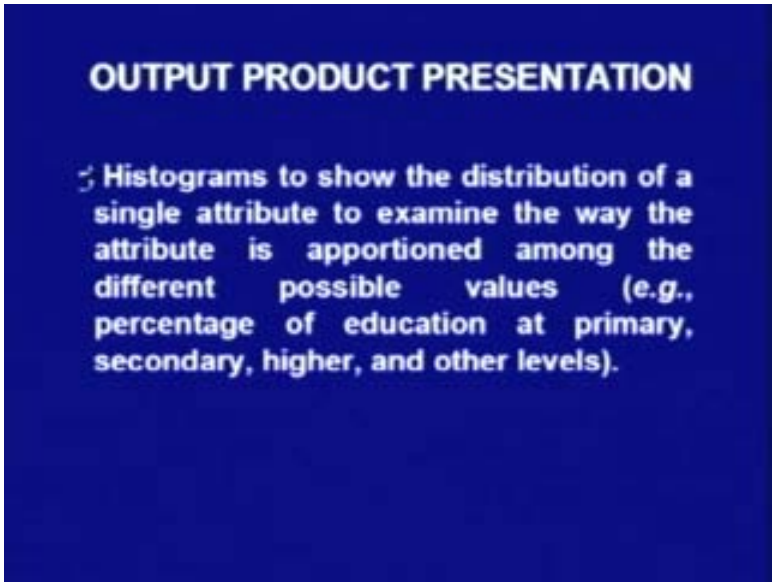

Histograms to show the distribution of a single attribute to examine the way the attribute is apportioned amongst the different possible values

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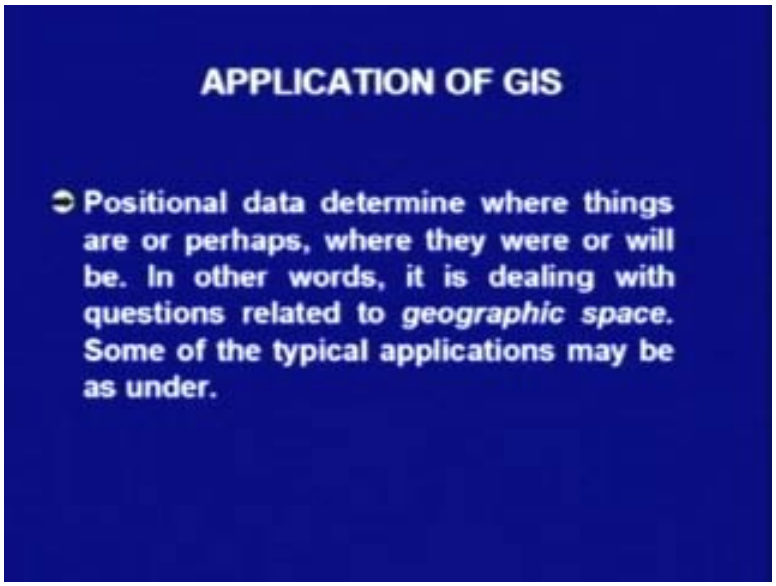

Now, let us look at some of the broad applications of GIS. GIS as a matter of fact, has found its application in those areas where professionals are involved in management and planning, utilizing, analysis of large amount of geographical data that relate to space, typically involving positional data.

Positional data determines whether things are or perhaps where they were or will be. In other words, it is dealing with the questions related to the geographic space. Some of the typical applications may be as under.

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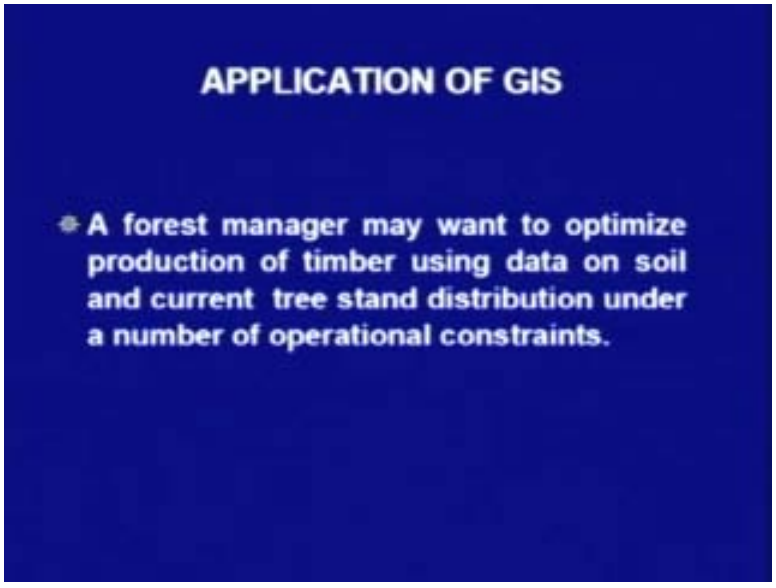

A forest manager may want to optimize the product production of timber using data on soil and current tree stand distribution under a number of operational constraints.

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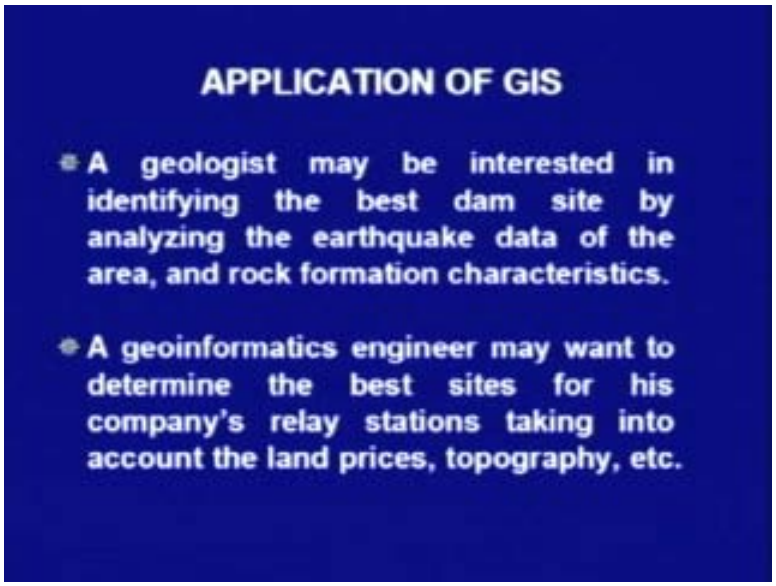

A geologist may be interested in identifying the best dam site by analyzing the earthquake data of the area and the rock formation characteristics. A geoinformatics engineer may want to determine the best site for his company's relay stations, taking into account the land prices and the topography.

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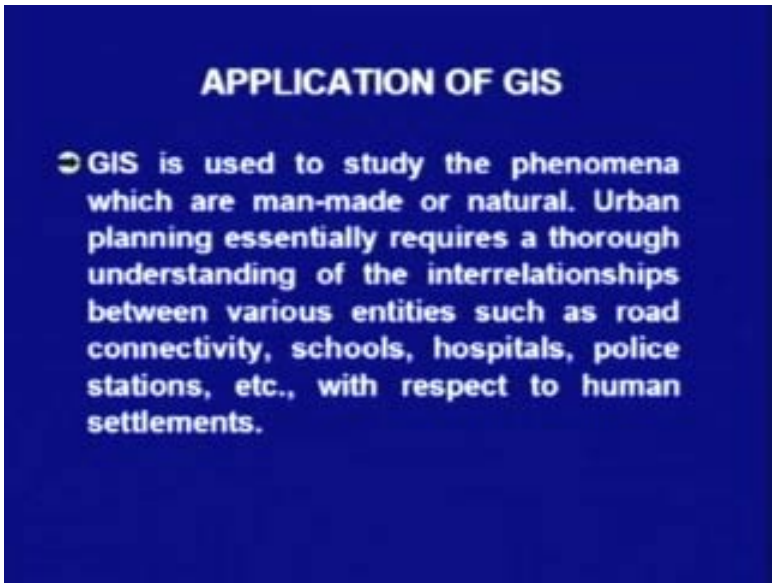

GIS can be used to study the phenomena which are man-made or natural. Urban planning essentially requires a thorough understanding of the interrelationships between the various entities such as road's connectivity, schools, hospitals, police station etc with respect to human settlements.

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On the other hand, in geomorphology, ecology and soil studies; natural phenomena such as rock formation, plate tectonics, distribution of soils are analyzed. GIS application also consists of study of both natural as well as man-made entities together. The study of the human activity on the environment referred to as environment impact assessment involves the analysis of data about both natural and man-made features.

A typical example could be a study on the growing industrial units in an area which is causing a problem of environmental impact assessment.

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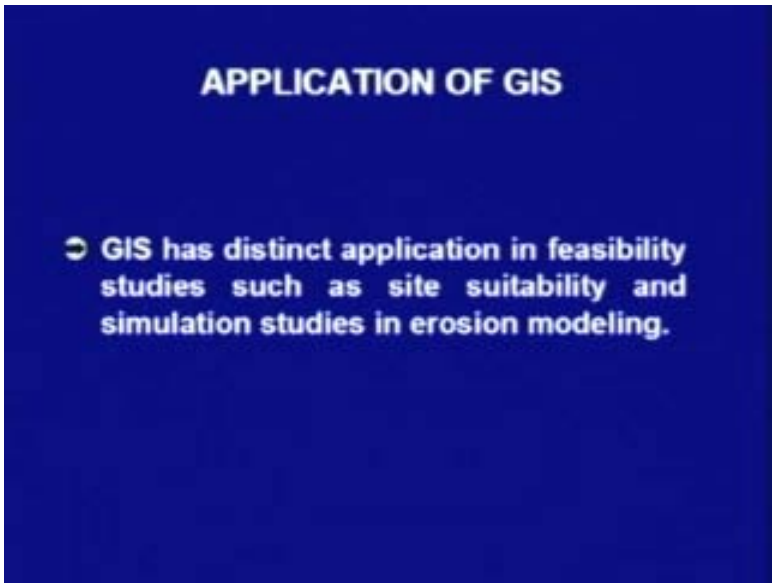

GIS has distinct application in these areas of feasibility study such as site suitability and simulation studies in erosion modeling.

Thank you.