**Introduction to Geographic Information Systems**
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Lecture – 01
What is Geographic Information Systems?

I welcome to this introduction of a GIS course. In this course we will have a twenty lectures, and we will be discussing starting from basically what is GIS, and we will go through that definition of GIS, different components, and then later on all integrates is and the analysis part of GIS ,which is the main important part. As you can see that on the screen that GIS is made from three terms; one is geographic, another one is information, and third one is systems. I would like to spend few minutes on the word term which is geographic. A geographic basically does not mean it is geography, but geographic means is a location with specific data.

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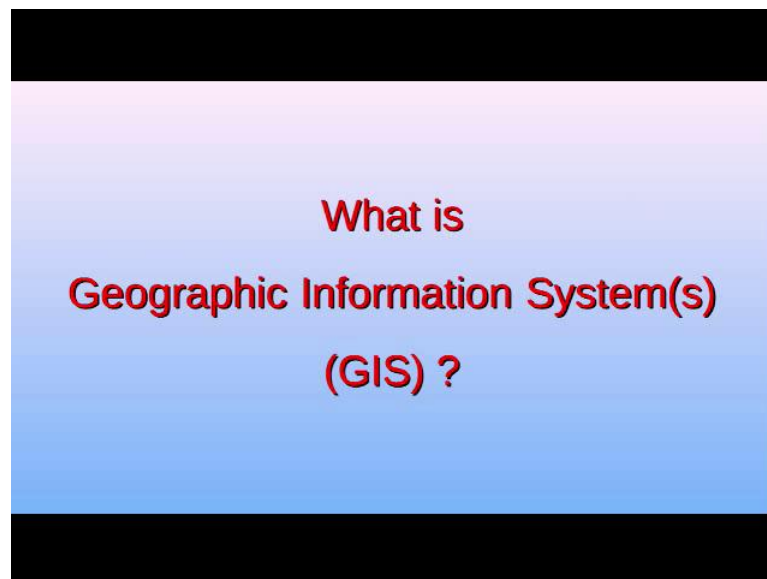
And any object on the earth can be defined, or can be associated with geographic coordinates, which we know as latitude longitude. As we know that the entire earth is having, we can have imaginary grade of latitude longitude; and therefore, each object on the surface of the earth, can be assign these coordinates. And the advantage with a geographic system is that, we can not only assign the coordinates, but we can handle very well all kinds of maps, and all kinds of data which is associated with geographic

coordinates, and also a another term is used for geographic is a special. Most of us are aware about the coordinate system, which is called geometric coordinate systems and we have studied a coordinate geometry as well.

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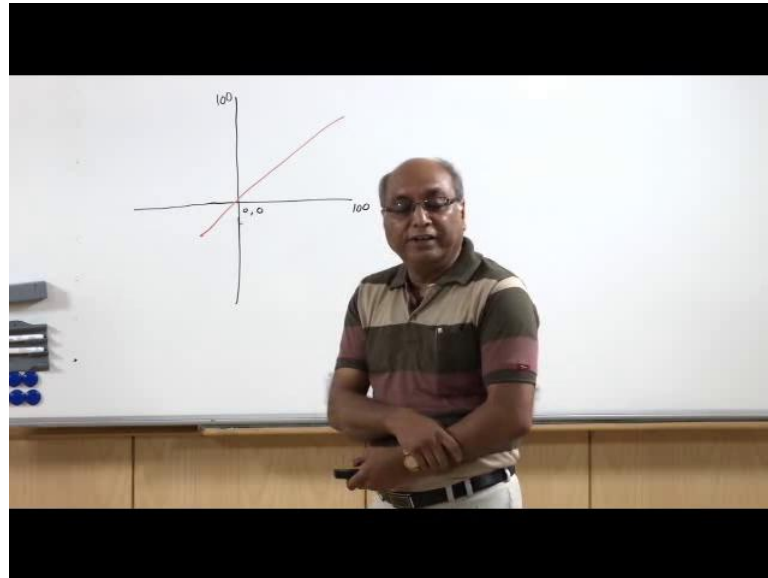
What happens in coordinate geometry that, generally you are having zero zero here, and then you are having say hundred here, and hundred here. But once if I want to do something, if a there is a line which I want to, which is which is going through something like this, and if I want to measure the length of this line, then some part of this line will go in the negative coordinate system, and later on it will be you very difficult to calculate, even the length or we have to take care. Let us take care about the length of the line. Same would also happen in case of area, but if we handle such data; like point line or polygons, in geographic coordinate systems, then the handling becomes much easier. And therefore, this system has been come into picture and little bit we will spend some time on the history of a GIS.

Geographic Information Systems

Roger Tomlinson ("The Father of GIS")
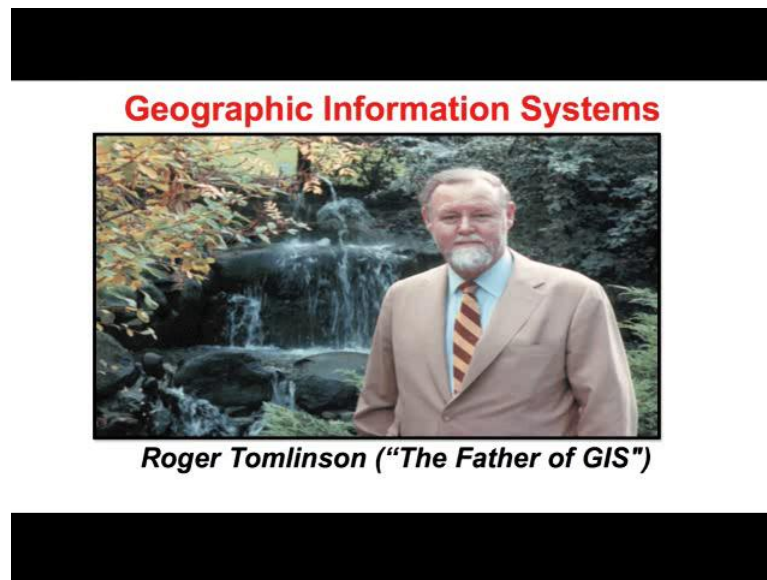
This was the term which was given by a person, whose name is Roger Tomlinson, who is also known as now a day as father of GIS. He is a computer scientist, because he is still alive ,and he used to work in the (Refer Time: 03:30) center which was looking after the Municipal Corporation of Ottawa, and they had lot of networks, of say guest pipelines or telephone lines, power lines, and room network. So, whenever somebody used to go to dig a say gas line, then the same time you might damage the telephone line, or electricity line. So, the task was given by the Ottawa Municipal Corporation to this computer engineer that, can you develop a computer system by which, when a person is assigned such repair work he should know, that at what time, at what depth, at what location he will encounter another network, and for that then he started working on this kind of concept, and he developed this geographic information system.

There are different terms nowadays are there, like a many people would like to call as a Geo Informatics, which involves not only GIS, but also remote sensing G P S, and overall computer technology. Some people call as a spatial information system, but all will converge on one concept, the basic is that handling the data in geographic domain, rather than in geometric domains; that is the main difference here. As we know that earlier there are still exist some cad cam systems, in which a geometric coordinate system is used, not geographic coordinate system. And therefore, there are some difficulties people encountered. Especially when I want to, if I am having a map of this

portion, when I want to add another map of adjacent portion, I might have difficulty in a geometric coordinate system.

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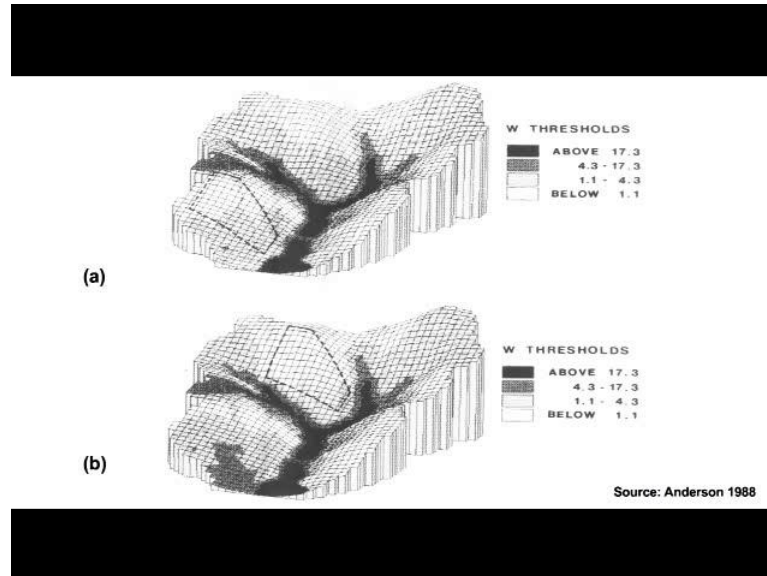
But in geographic coordinate system such difficulties will not arise; that is the advantage, one of the advantages. Because the main purpose of GIS is not to store the data or keep the data, but provide analysis and finally, as most of the system they provide the platform too and model the data, or to use these systems to predict something, which has not happened yet on the ground. So, here I am showing the same water shade in a, in to up and down, and this water shade as you can see the boundaries here; say showing in a grid form. And some, this water threshold or in simple terms we can say, the soil moisture here. So, what we are saying that they are at different shades here, and one this dashed bracket, or an area is marked here. In the same water shade at another location, having the same area is also marked, but it is basically indicating that if in this particular water shade.

The forest of this part of the water shade is removing, and then this is going to the scenario of soil moisture conditions. And if same area, but at different location within the same water shade, if the forest cover is removed, this is going to be the change in the soil moisture condition. As you can see that here this is bringing all together a new scenario, which is not there in this case. So, what basically GIS is providing us, to predict something, which has not really happened on the ground; that means, you can simulate

lot of real thing, real scenarios, real problems which are related with nature, or an a complex processes of nature, within the computer, before anything really happens on the ground; that is by it has become a very powerful tool for modeling, and also for prediction

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So, as I mentioned already here, that the geographic means it relates to the places on the Earth's surface, and in geographic coordinate system, not in geometric coordinate system. And the then we start answering questions, that where something is, because once a location is attached to your object, then we can answer where it is. Like now a days we know that a with mobiles, and with coordinate systems, we can find out, or very soon we will be able to track each and every mobile, through the g p s, because g p s provides the information, which is the location which is latitude longitude of that particular mobile.
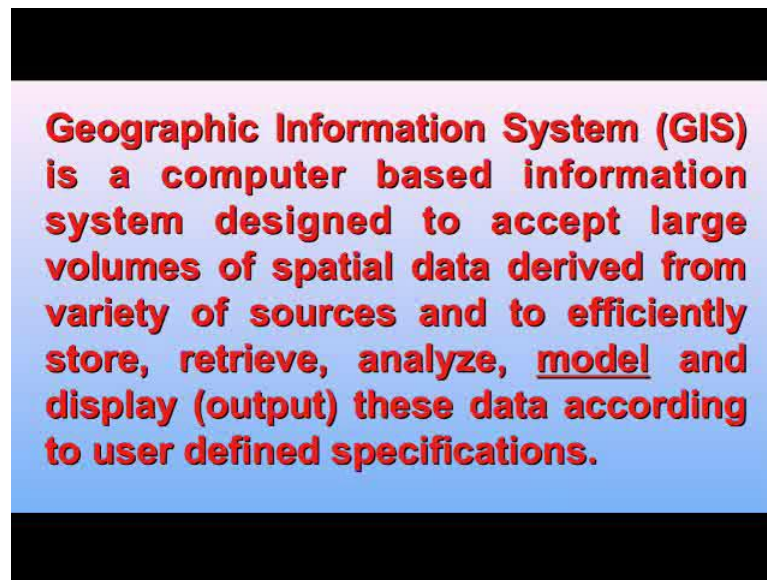
So, similarly here that in GIS, we get the information or answer of a question, that where is something, and also another question that what it is given location. So, once we have attached information, let me give you one very interesting example; like every year there are JEE examination is conducted, when we keep all this data in a data base. We do not keep this data in a geographic data base. Suppose tomorrow we start keeping, the coordinates of each candidate who is appearing for JEE in a geographic coordinate systems or in a GIS platform what would happen. Once the students are selected then we

would then we will plot this you know appeared student versus selected student. We should get a very interesting plots or distribution of the data, and I am sure we will also find some clusters.

So, clusters will raise the question, why it is happening, why not throughout this distribution of selected candidates, throughout India is same, why it is happening in a cluster form. Might be because of good coaching, might be the intelligent level of people are higher, or is it related with the, you know economic things, or is it related with the schooling. All kinds of questions will come and then we will be able to answer, if we get few more data, like economic data set, or may be schooling data set climate data set. If we start adding in (Refer Time: 09:46) in geographic system or GIS system, we should be able to answer that why there are clusters. So, similarly lot of such phenomena's can we understood very nicely, once we assigned the location to certain objects. So, that is why geographic word is very important.

The other two terms which are used, which most of us are filled here, is about the information and systems. That information and systems which we; because the data is converted into information through computers, and which GIS platform allows us to manipulate summarize. Also we can raise the questions to the system, we can edit, we can visualize. Visualization is very important thing. In the previous slide when I have showed the water shade, that is also visualization, and visualization before really anything happens. And we work on the information or data which is stored in the computer data base. We say it is a kind of integrated system, which is having not only in the geographic data, but in a data base systems. So, all the qualities of database systems DBMS systems are there and all your cads' systems capabilities are also there, so say kind of integrated systems. Slowly we will learn how it is progress, when we progress in this course.

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Geographic Information System (GIS) is a computer based information system designed to accept large volumes of spatial data derived from variety of sources and to efficiently store, retrieve, analyze, model and display (output) these data according to user defined specifications.

So, let us have a look on the definition of a GIS. There is a most modern definition of GIS in different books, literatures or internet. We will go and find little varied definition, but if we hear each and every word is very important, and therefore, I will go one by one through all these terms, or words which are mentioned in this definition; that GIS is a computer based information system; that means, that can we have an (Refer Time:11:40) GIS system.

No, very difficult, because earlier when we did not have a good computers, there are people who are having some maps or data, in a transparent sheet or tracing papers. It was very difficult. So, manual system of GIS is not really possible, or that is not really truly a GIS, which present day which we are having. So, computer wave, it has to be computer based, and it is design to accept large volume of spatial data. Spatial or geographic data I have already explained to you, that the data which is location specific data, and which is designed to accept large volumes; that means, a large data sets can come into our GIS data base, and then we can analyze in a very easily manner, and throughout this course we will learn how the analysis can also be formed. And this data can come from variety of sources.

So, this data is derived from variety of sources. May be the data, may be the remote sensing data coming from satellites, and remote sensing, may be data from field, may be data from coming from internet sources, or various instruments that data can directly

come into GIS, given that it fits in the format, which is required in a GIS data base. Then the other purpose of GIS is to efficiently store. If data is not a stored properly in a organize fashion, in a formatted fashion, then the retrieval of the data really becomes very difficult. For example, if in a office there are room or store which is having hundreds of file, we know that the information is there, or data is there, but when I ask a specific data or information from that office, then the answer may come, sir the data is inside the room, or inside in this store room, but we do not know in which the file the data is; that means, it is not efficiently stored. Whenever I ask a question or data or information, from that particular office, and if they are able to retrieve very efficiently that information to me, then we call as efficient.

So, in GIS we can have efficient storage, once we are having efficient storage, that allows us to efficient retrieval, and of course, analyze which is the heart of GIS. the main purpose of GIS is in these two terms; analyze, and model. Model I have given one example of, ultimate aim of the model is to predict something, which has not really happened on the ground. We will also see a demo, in which a through a GIS software I will show that how on a terrain, a reservoir can be simulated, before really it happens, and we can calculate all required parameters, which are required for the construction, or even planning phases, pre fragility stage. So, the model can be then and various then, once you are having everything on computer, then you can play with that, or you can change the scenario, you can change the constraints and condition, and can bring a very good you know options, or scenarios which you can present to the decision maker. So, ultimate aim of GIS is also, is a decision support system.

So, it will provide different scenarios through the analysis, through the modeling which you can present to the decision makers, and then they can make the appropriate decision. And finally, the other purpose of GIS to display or bring output. It is not just keep everything on the computer. No, you can create output in form of maps; you can create output in forms of models, even 3 d models and so on so forth, or even simulations animations. So, all these things can be done at the end of this you know development stage of GIS, according to user defined specifications. There is another very important thing, not as per the GIS expert, but as per the persons who is going to use the GIS data or output. So, decision makers will ask something, this is very interesting related with GIS is; more you deliver through GIS, more you are asked to deliver, and this thing has

really compelled us to develop GIS more and more. and this is how the Roger Tomlinson developed, because he was asked to do something using computers.

Once he developed the GIS, then he was asked few more things to do in the and slowly, this GIS has been developed. So, let us go through one quickly through this definition, if the geographic; GIS is a geographic information system, which is a computer based information system, designed to accept large volumes of a spatial data, and derived from variety of sources and to efficiently store, retrieve, analyze model, and display these data according to user defined specifications. So, users are very important. Later on in the next lecture you will be seeing the different components of GIS, where you will see the user or people are very important. So, not only computer software, but the users are equally important in a GIS system.

Now, I have been using these two terms, generally many people uses these two terms interchangeably, which is not really accurate. Data is something information is something, and then third which GIS place major important role, to convert all these into knowledge. So, far we know that by data itself, as if there is a register or a file which is having just data. It does not have any meaning. So, it is having a rain fall data, it is does not having any meaning, unless it is analyzed. And once you do the analysis, perform analysis on GIS platform then it becomes information. So, using simple computer, even without using GIS, you can convert data into information. So, data itself generally differs from information.

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And data of little use as I have already mentioned, that if it is there in the file or in excel sheet, or in table, or in a register, it does not have any meaning, unless it has been analyzed or convert a transform into information. The best thing which GIS does is even convert this information into knowledge, and I will give you some examples also. So, information is an answer to the question based on the raw data, whereas GIS can be transformed data into information.

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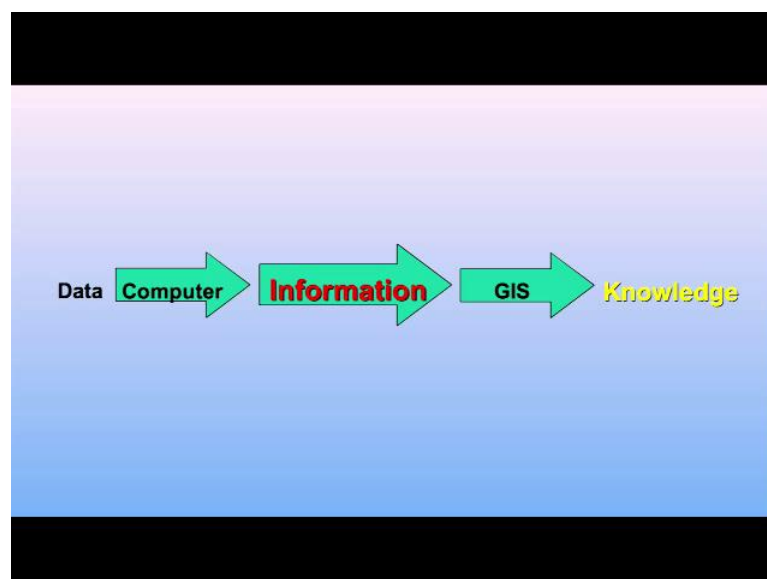
So, how it happens, very simply through a small flow chart, if the data once you involve the computer, you can convert data into information, but when this information goes through the GIS, then it becomes the knowledge. We have seen one water shade scenario, where the forest was not yet cut, but we knew that what would happen to soil moisture condition and that is the knowledge. So, if GIS could not have been there, then such scenarios cannot be prepared or presented, and that is the advantage having GIS.

The GIS not only converts data into information, because it is a computer based. So, it can convert data into information, but information to can be converted through modeling, through analysis in GIS into knowledge which is very important, and that is the, basically what I would say the ultimate purpose of GIS, is to covert data into information and then finally, to the knowledge, and knowledge which can really help in all kinds of scenarios, which we will see it in later. Now I have also mentioned to aware technologies one is GPS, another one is remote sensing in GIS, we are we are already discuss here, that there are three common things with these three technologies very important and that is why, because of this these commonalities among these three technologies, the integration of this technologies have become very much possible, and therefore, new products, new applications are coming through this, which will we see in some examples.

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So, GIS GPS and Remote sensing which is satellite based remote sensing I am talking, are generic I will explain spatial, and digital technologies. As a spatial or geographic technology which we have already said, but because GIS handles the data in geographic domain, GPS provides the geographic coordinates on any part of the globe, any time, and the remote sensing data is also represented, can be represented in a spatial domain or in geographic domain. Now about the word generic, generic means here that it can be applied for various things; like computers you know.

Computer are being use for accounting, computer are being use for creating videos, computer are being use to modify you know ordinance. For all kinds of purposes, nowadays people are employing computers. So, computer technology is a generic technology. So, these three technologies, which are like GIS GPS and remote sensing, are generic, spatial, and digital technology. Since these are digital technologies; therefore, the integration of these three technologies, being computer technology has become very much possible. And as we have seen nowadays on your mobiles, smart mobiles, all kinds of things are coming.

And one of the two best products which people un knowingly, which are not expert of GIS, they do not know what is basically GIS, may not be knowing, but they are using these very popular products which I can name; one is Google map which is on your mobile, anywhere you go for navigations, for car navigations, location identification. For all kinds of things you are using Google maps.

So, Google map and Google earth are the custom design, very special products which uses all these three technologies in integrated fashion, and this is how the growth of GIS on these technologies is reaching to the common man, even they are not aware that what kind of integration of technology which they are using, even on their mobiles, but these technologies are being reaching, are reaching to the very common man through such technologies; like a smart mobiles and other things. Now as I have mentioned that even before Roger Tomlinson the concept of GIS in analog form was already existing, but not the present GIS, and had lot of limitation.
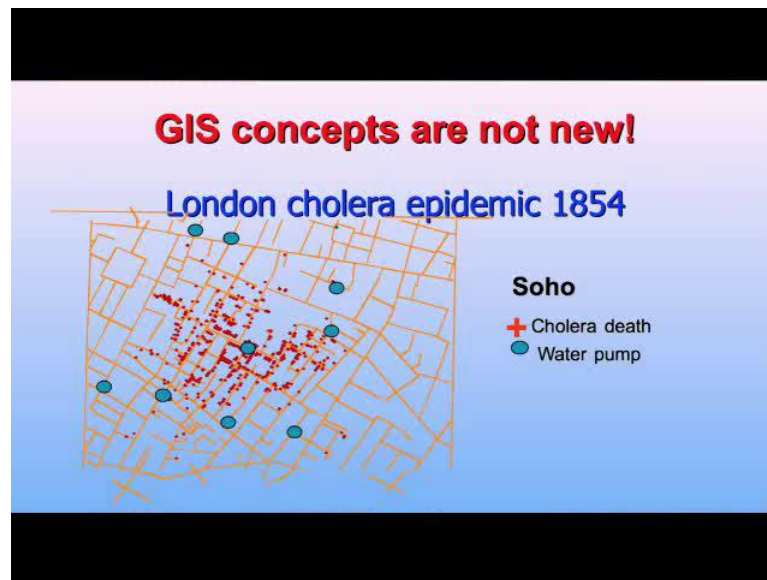
Nonetheless, there is one example of 1854, in London there were cholera epidemic, and they what people analyzed, that there some water supplying tube wells, and there were deaths due to the cholera, and when this plotted, then this deaths we are plotted using geographic coordinates on a road map, and having this location of water supplying tube wells. They found that they are not all wells water is polluted, or having problems which is causing cholera. Only few wells especially the well which is shown in this map in the centre, was the most responsible well, which helped the water which was causing cholera. So, once as I gave the example of JEE selection, similarly in lot of such problems can be resolved, or these challenges a problem can be understood, once we start plotting the data, using geographic coordinates, and as in this example also.

So, once the data is plotted, immediately one can raise the question, that why the deaths are due to cholera are surrounding this area, why not in other parts; and obvious answer, that might be because of, say one layer is not sufficient, as you have see here that the three layers of information, three themes are there; one is your street map, another one death due to the cholera, and third is the tube well locations. In GIS you can have several such layers. This is the analog system example, but in digital systems you can have variety of data, variety of a spatial data into GIS system, variety of layers of all kinds, which we will and learn in this course slowly.

Also it allows us to store the data in tabular form which; that means, this spatial information is attached with a (Refer Time: 25:00) data to be also called as non spatial data. As I have said that GIS is integrated technology, so you are having digital cartography and cad cam tool are all available in GIS plus your database management systems. So all these technologies have been integrated into GIS plus few more things and the basic thing is handling of all this in geographic co ordinate system. So in that way analog GIS systems are not new but only this GIS system is developed in somewhere 1962-63, when Roger Tommlinson started developing GIS. As I have mentioned data in GIS, kept in different themes or we call in simple terms a layers.
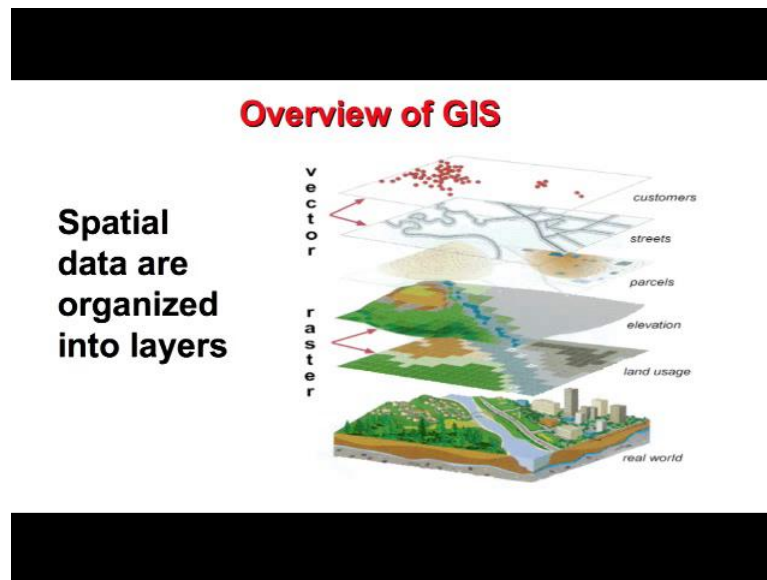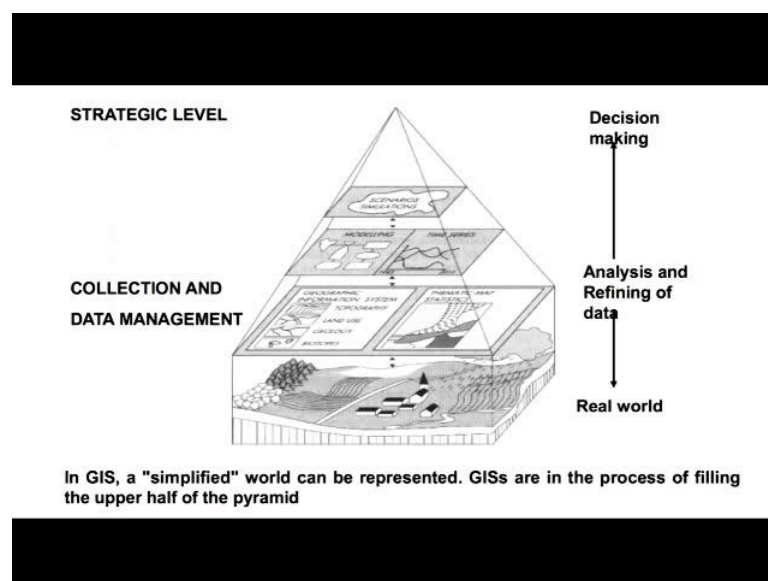
A real word example is given here, that this is real word, which is having you know natural features; like a streams, hills, and forest, and some manmade features like buildings, roads, and other things are there. Three-dimensional information is also shown here what we can do in GIS, that we can keep different information's in different layers. Like here the land uses, how the land is being used can be kept in one layer, which we can call as blend used layer. Then how the topography is changing that we can store in a elevation, or in a raster layer which we call as a digital elevation model, in a elevation layer. Then how these a land records, who owns which part of the land, revenue records can be stored in a polygon layer, which is here it is mention parcels.

So, it is a polygon layer, and then who are having road network or street network, which is nothing, but the line network which you can have in another theme which is the street network. And then you are having locations may be resident, costumers, patient, all kinds of things as a point data you are storing. So, all variety of data as you can see that a, there are point data, there is line data, there is a polygon data, and then these two data sets are different which are a continuous data, which we call as raster data. So, this is raster data, this is vector data. So, vector all three types of vector data is there. Here we have not edit satellite image, you can bring one more raster as a satellite image that will go as a raster data. So, what we see here, that the real world can be divided into several layers.

Now any time we want to use any of layer or combination of these layers into GIS system, it is very easy to use, and that is why this initially that at the data storage level, we go for this disintegrated manner, we store data in a different layers different themes, and later on whichever the theme is required for my analysis I will use. Like in case of that cholera epidemic, three layers were used; the ground water level data, street level data, and then deaths due to the cholera. So, only three layers were used, depending on the problem, or solutions which you are looking, you might use different layers. So, basically as you can say that in GIS, these layers are, the data is organize into different themes or layers, having two or three different types of data models. One is vector raster, and one more data model which we will be discussing in later lectures is the ten, which is triangulated in a regulated network. Now as I have said that the GIS ultimate aim is to support decision making, and this is how is done at strategic level.

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In GIS, a "simplified" world can be represented. GISs are in the process of filling the upper half of the pyramid

So, again the same scenario here that, a real word is segmented into different layers and data is collected then, you create through the modeling analysis, you create the different scenarios, and then decisions are taken. Another very important thing is that these arrows are two directional, and that clearly indicates that at the decision layer, it may be decided your data is required, or the answers which decision level people we are looking, are not getting then we have to come back, and that is why go back to the real word, collect few more data, maybe we have to collect the subsurface data, like ground water data, or may

be the soil type data, or may be topology, or maybe if we are looking for ground water exploration, then we have to go for subsurface.

So, we will come back if at this level the answers are not coming, you go back to the real word, collect few more data layers, and then develop the scenario again, and then we are able to supply the data to the decision makers, or the scenarios to the decision maker. If GIS expert himself can be also decision maker, that it does not mean that the GIS expert cannot be decision maker, but in many times there are people those who do not know how to handle GIS, they do not know the concepts of GIS, but these are the people who keep raising questions, about can we do this thing, can it be done through the GIS and so on so forth. So, therefore, this is a two directional thing both directions it work. So, if we simplified version of the real world, and the process is which are involved here. GIS is a integration machine, as indicated earlier. So, you are having data, coming from variety of sources that data you organize in spatial domain and so on and so forth.
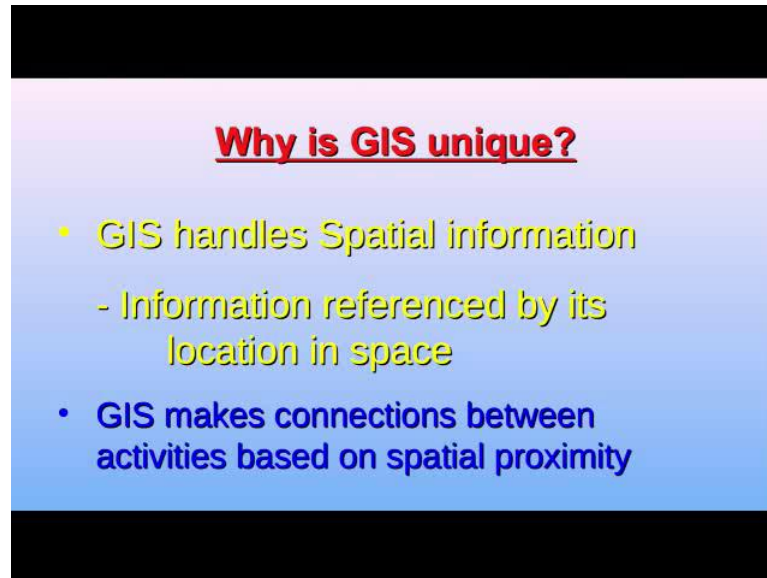
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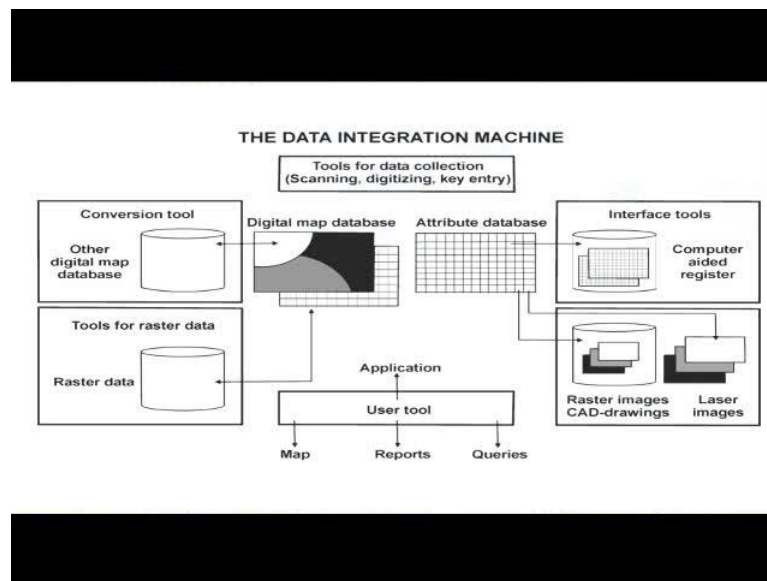
And finally, you start creating applications, output in may be form of maps, may be in form of reports, or may be some queries, ad hoc questions you raise to there is a system, you raise a question s that I want to like in Google map, you indicate to Google map, this is my origin, this my destination. And then you also indicate my mode of travel. So, if you are travelling by road, it might provide different scenarios, and therefore, the queries as per the user defined specification. So, user as defined, has already defined destination,

origin, and with the mode of transferred, and then as per the your query, your answers are coming, through map as well as a report saying that, this is the distance, this much time it would take, likewise.

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So, I am coming to the end of this particular small lecture is, that GIS handles spatial information. Information referenced by it is location in a space, that too in geographic coordinates system. GIS makes connections between activities based on spatial proximity, spatial word is very important, and this is spelling is correct this is not a special, but a spatial.

And the GIS who can use GIS, in government industry academics, even private people can use GIS, and what basically now the questions or which areas where GIS can be used, like in transportation system. I have given example of navigation in hydrology, ground water hydrology, in geology, in demographics, crime, and health. In demography like sensors department of government of India has is started using extensively the GIS.

Similarly, railway, Indian railways have started using GIS extensively. So, not only the government department, private departments are also using, even the police, in some in big cities police have also started using GIS, and in private you know many taxi operators which are having hundreds of taxies in their feet, they too are using not only the mobile technology, but GIS technology in integration. So, the operator all that taxi feeds exactly knows where it is a taxi line idea. And once that is taxi located a customer calls, the location of that customer is also plotted on the map, and if the taxi whichever is nearer to that customer, immediately get a message and that reaches to the customers, that is the advantage of having information in geographic coordinate system, and this is what the GIS basically provides.
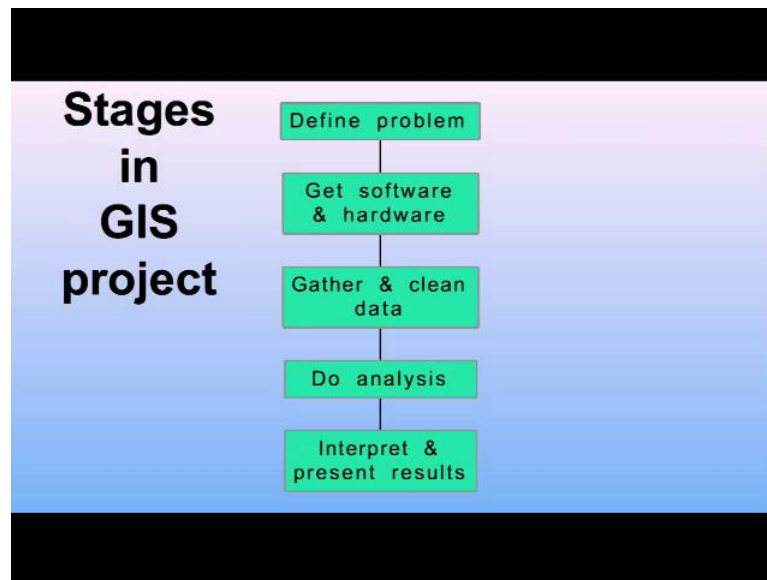
There are different stages in GIS project in very brief. One has to first define the problem the project then get software, and appropriate software and hardware. There are hundreds of GIS software's, starting from free public domain freely downloadable to commercial software. Very expensive software's also there, but very powerful, then gathers and clean data. The data has to be very reliable very clean, then only good decisions can be made, and perform the analysis, analysis is the key part of GIS including your modeling, if it is required. And then finally, interpret and present the results in form of map, tables, reports etcetera, and this brings to the end of this an introductory lecture on introduction to GIS.

In next lecture we will be seeing different components of GIS in detail.

Thank you.