Soil Science and Technology
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Lecture – 51
GIS and GPS

Welcome friends to this week 11 of you know week 11 lectures of Soil Science and Technology. And that you know the highlight of this week lectures will be some advanced technologies, which we generally used nowadays for different soil applications. And we will be talking about GIS and then GPS or in other words they are Geographic Information System or Global Positioning System.

And then in the forthcoming in the coming lectures we will be talking about, geo statistics which is a specialized branch of statistics. And then we will be talking about some advance sensors like diffuse reflectance spectroscopy as well as portable X-ray fluorescence sensors.

So, in this first lecture of week 11, we will be talking about two important terms these are GIS and GPS. And nowadays, there has been extensive use of these technologies for different soil applications, be it you know efficient management of soil resources or precision agriculture and we will be talking in details about these terms. And then we will be talking about their you know, their principles and different backgrounds.

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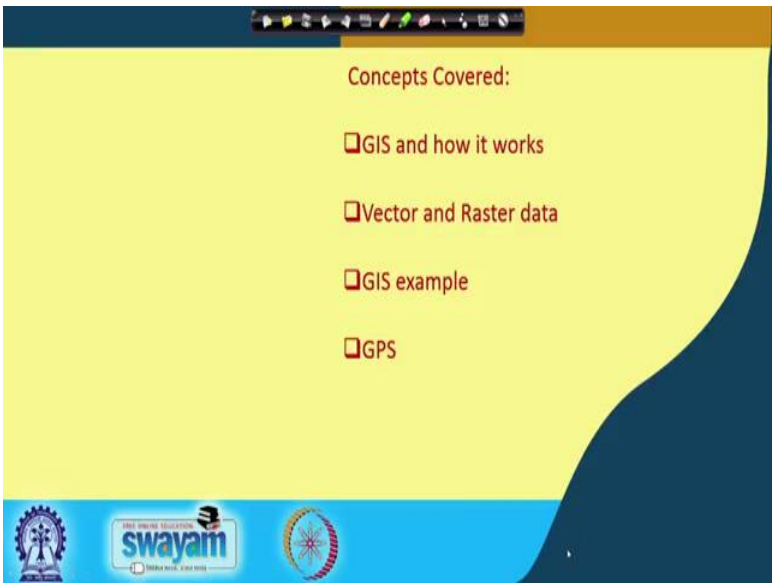

So, let us start today's lecture so GIS and GPS. So, the in this lecture we will be for we will be covering this following concepts slight; why it is GIS and how it works, and then what is vector data and raster data, and then I will give you some examples of GIS, and then we will be talking about GPS and how it works.

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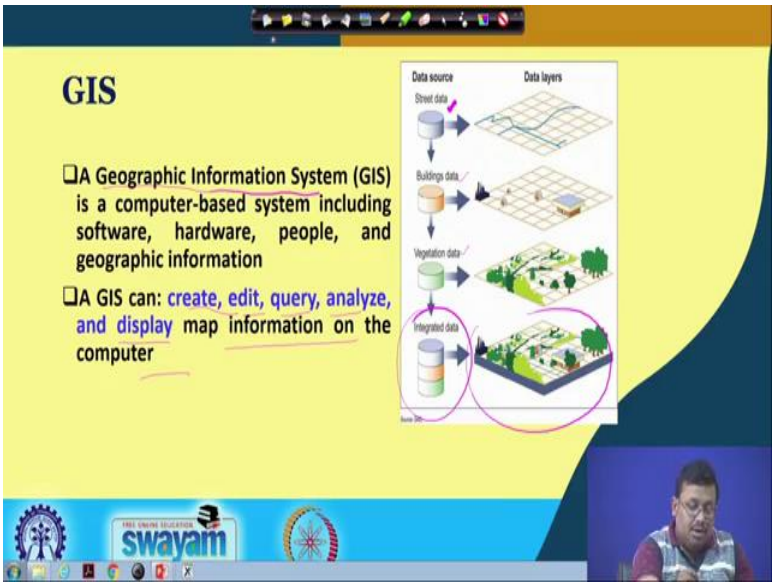

So, let us starts with the GIS. The GIS is a short form of Geographic Information System. So, this geographic information system or GIS is basically a computer base system including software, then hardware, then people and geographic information. Obviously, it requires some software, specialized softwares and there are some specialized softwares like ArcGIS, then you know QGIS, SAGA GIS. So, there are couple of specialized GIS software which you know we people or in our scientist uses use these days extensively.

So, it is a combination of software and then hardware you required computer system to produce this maps, and then obviously you require some user as well as some geographic information which is stored in the database. So, obviously GIS what is the utility of GIS we can see, a GIS can create and then you know a GIS can create, then edit, then query, and analyze, and display map information on the computer.

So, as we can see here in this picture, GIS basically composed of different data layers and here you can see that there are three different data layers, which are stacked over each other. Obviously, the first layer is the street data followed by building data and

vegetation data and this street data is overlaid on some background and followed by building data and vegetation data.

So, you see that while we stack all these three layers together we are getting an integrated data and we are getting a real world representation, where we get both street data building and you know street building as well as vegetation.

So, basically DIS is a combination of different layers, which are stacked over each other and after stacking them each other we you know we generalize any you know we generalize any real world feature. Not only that at the same time we create, edit, query, and analyze from those real world features or real world map also; apart from that traditional mapping.

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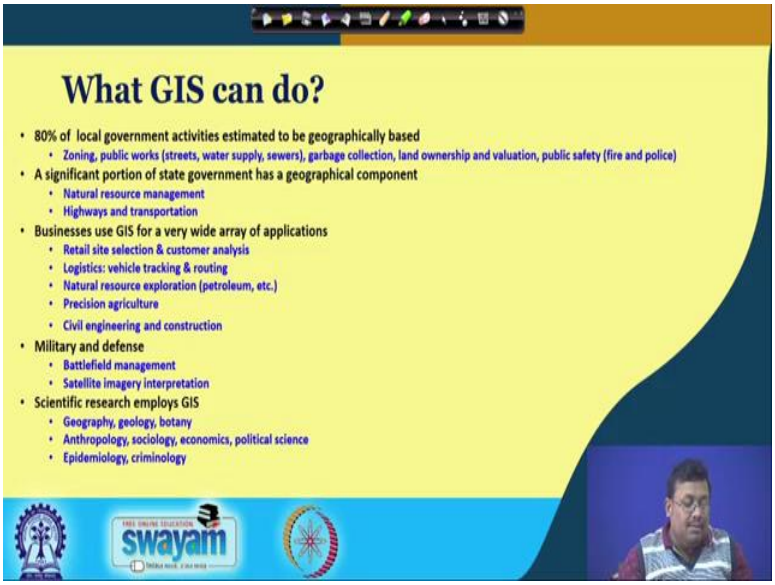

So, let us go ahead and see what GIS can do? Now, 80 percent of the local government activities estimated to be geographically based. For example, you know they do different types of zoning, then you know public work you know public works like streets, you know water supplies, sewers, planning and all these things, then garbage collections, then land ownership and variation, and you know public safety, fire and police. So, all these thing can be managed you know all these things are basically geography based. And you know GIS is very very helpful for properly managing these things, which have some geographical connotation.

Secondly, a significant portion of state government has a geographic component. For example, you know natural resource management or highways or transportation you can use GIS. Then third one is the business and you know business use of GIS for every wide arrays application; you can see you know different types of retail size selection, and then customer analysis, then logistic you know logistics like vehicle tracking and routing.

And then natural resources you know explorations for petroleum, etcetera. Then precision agriculture, precision agriculture is highly related to the; you know to the GIS and its applications and then civil engineering and construction. So, all these are related to different GIS applications.

Then obviously, for military applications also you indicate GIS; specifically battlefield management as well as satellite imagery representation. So, all these are managed through GIS applications.

And obviously, some scientific research you know also employees GIS; starting from geography, geology, botany, then anthropology, sociology, economics, political science, epidemiology, criminology and all these thing.

So, you can see GIS is a wide you know GIS can be used in wide range of domains and it is nowadays becoming a important tool in the hand of you know agricultural as well as national policy makers. So, let us see what are the other important thing in GIS?

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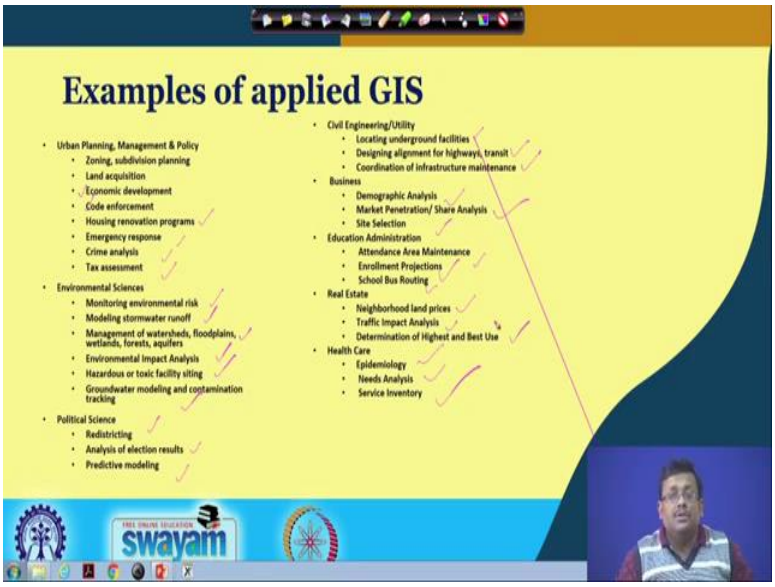

So, let us see some examples of applied GIS you can see. In this slide, I have listed a couple of them obviously, this list is not exhaustive list. So, you can see here for urban planning management and policy making you can do zoning, subdivision, planning, then land acquisition, then you know economic development, then code enforcement, and then housing renovation programs and emergency response, crime analysis, tax assessments.

For environmental science, you can use monitoring environmental risk, then modeling storm water runoff, then management of watershed, floodplains, wetland, forest, aquifers, then environmental impact analysis, hazardous or toxic. Toxicity analysis and you know toxic facility siting, then groundwater modeling and contamination tracking. And you know political science like you know, redistricting and then analyzing of election results then predictive modeling. So, these are some examples of you know of GIS.

Apart from that in civil engineering, you can use locating underground facilities, and then designing you know alignment for highway transit and then coordination of infrastructural maintenance. In case of business, you can do some demographic analysis, market penetration, share analysis, site selection you can do.

The educational administration you can do, attending you know attendance area maintenance and then enrollment projections and some time in you know in advance areas you can use GIS for school bus routing also.

For real estate, obviously neighborhood land prices then traffic impact analysis and then determination of highest and best use all these can be done through GIS. In case of health care you can do epidemiological study and then needs analysis and service inventory. So, you can see a lot of thing you can do using GIS. So, now you know about the application of GIS let us move ahead and see you know how GIS works.

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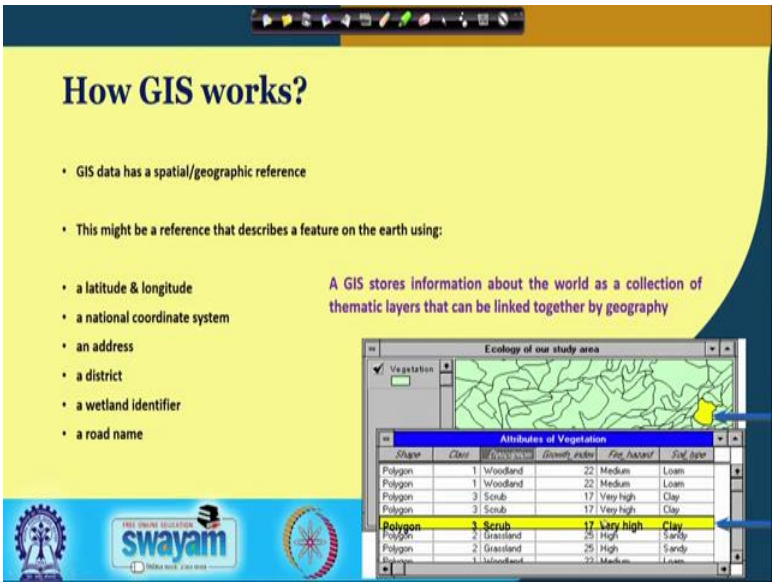

Now, this slide basically shows GIS data has a spatial or geographical references. So, this might be a reference that describe the feature on earth using some a latitude and longitude, and national coordinate system, an address, a district, a wetland identifier, a road name. So, basically they a sense is a GIS store, a GIS stores information about the world is a collection of thematic layers that can be linked together by geography.

So, you can see here in this we call it attribute table. So, in this attribute table, it is basically linked with the actual map which is shown above this attribute table. Now, this map or the study area is the map of the study area is divided into some numeric you know into some you know, large number of polygons is we can see, this one polygon, this one polygon. So, this polygon basically represents some you know mapping unit or homogenized area based on certain characteristics.

Not only we can map it, but also in the attribute table we can you know, we can tag this individual polygons with some specific features and we can actually you know populate or actually input their respective properties in the attribute table. Just like here you can see, the polygon of class 3 basically you know represents as scrub with growth index of 17 and fire hazard a very high and soil type of clay.

So, obviously this polygon which has been identified some with some identifier can be grouped into can be characterized by this particular properties. So, if you want to know what is the particular property of that polygon if we make a query, it will automatically

extract this information from the attribute table and make the further analysis or give us the output.

So, this is how these information in the attribute table is geographically related or tagged with any location, so that is why not only we can see and analyze and query from map, but also we can extract whatever information we can you know whatever information we required by you know analyzing this database. So, you now you probably have an idea about how this GIS thing works.

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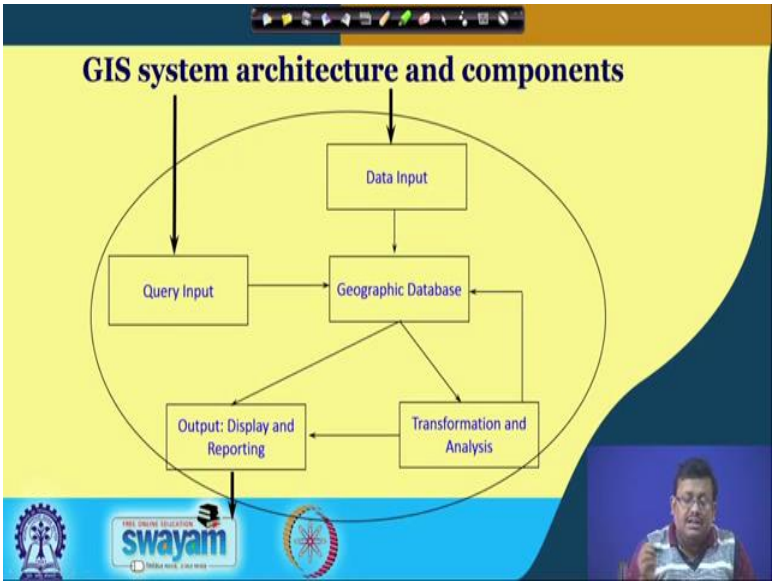

So, in the GIS system architecture and components you can see, basically it starts with data input so we basically input the data, which creates a geographic database. Once we create the geographic database, the next step is to input some query for example, you want to answer certain questions and I will show you one practical example later one. So, if we input our query obviously, it will be directed to the geographic database. And this geographic database will automatically do some transformation analysis and based on this transformation analysis, it will give us the output display and reporting.

So, we can get directly report from the geography database or this geographic database can produce some transform, you know geography database some came under grow some transformation and show us some analysis and do some analysis and then further it produces the output. So, ultimately the output we are getting in terms of maps as well as in terms of some quantitative measured or different or specific queries.

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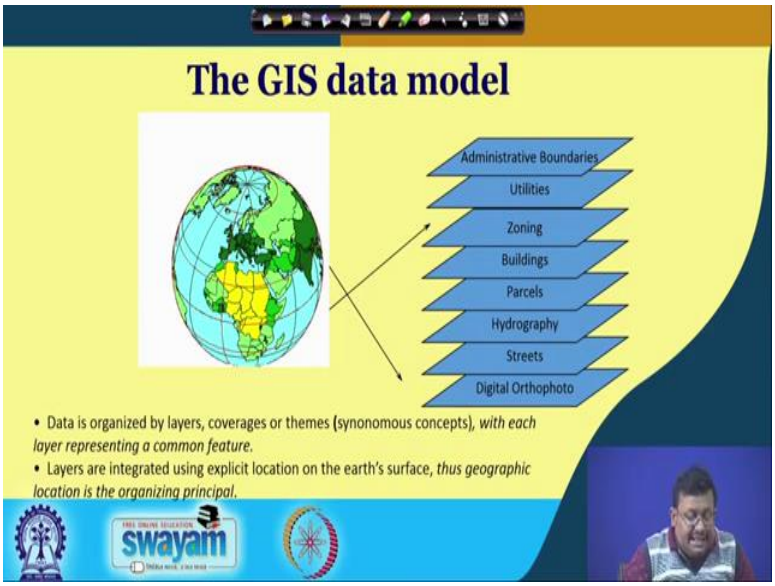

So, the GIS data model is basically can be shown as I have told you, it can be shown as a you know is as a stacked feature as a stacking of individual data layer. So, you can see these GIS data models can be produced as a stacking of you know as a you know, this GIS model can we can be can be produced as a result of stacking of this individual layers.

Starting from digital ortho-photo, we will be talking about digital ortho-photo later, and then you can see about the streets, then you know hydrography, then parcel of lands, then buildings, then zoning, then utilities as well as administrative boundaries. So, all these layers are you know stacked over each other or laid over each other to produce this ultimate representation of earth features.

So, data basically is organized by layers and coverage's or themes these are basically synonymous concept this layers coverage's or themes with each layer representing some common feature. For example, in the buildings obviously, this layer will be shown only the building, we will show only the buildings which is present at that particular place

And layers are integrated using explicit location on the earth surface thus it geographic location is the organized principal. So, these layer are basically will be stacked together based on some geography connotation, so that is why this geographic location is the organizing principle in case of GIS data model. So, let us see some example.

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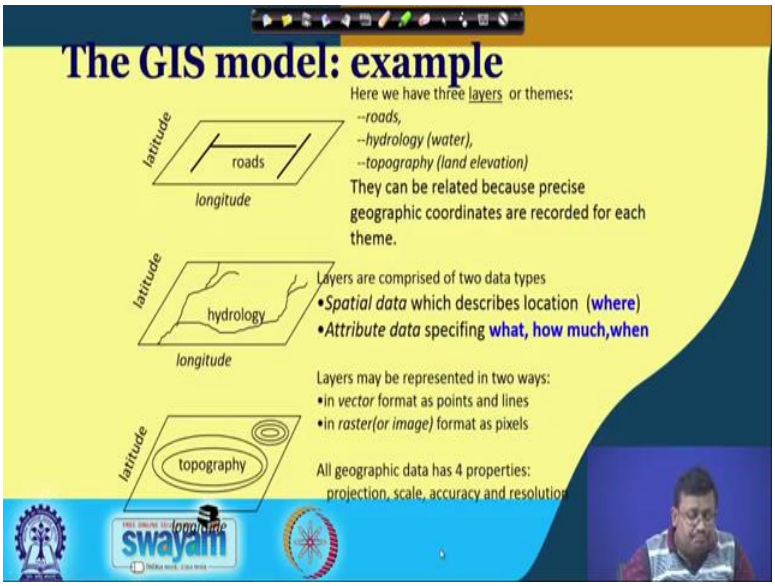

So, you can see here we have three layers or three themes, these are roads and then hydrology or water and then topography or land elevation. So, you can see here all of them are represented in terms of longitude and latitude, these are the road, this is the hydrology and this is the topographical features that means, the surface and awareness or you know or land elevation basically. So, they can be related, because the precise geographic coordinates are recorded for each of the theme.

So, you can for each of these layers or you know or theme basically we have got the precise, you know geographic location or geographic coordinates or latitude longitude. So, basically we can be integrate these layers together and layers of comprised of two types of data, you can see here, one is called spatial data which describes the location.

So, basically you see GIS is basically geographic information system. So, the first objective of GIS to give a some spatial inference that means, we want to see what is the spatial variability or in other words you want to see where the data exist or where a particular feature exist. So these spatial data can helps us to describe the location or where in terms of some geographic location.

Secondly attribute data, which is present in the attribute table can specify what, how much and when. So, these all queries can be answered by using proper GIS analysis. So, you can see here roads are been tagged with a longitude and latitude, then hydrology can be tagged longitude and latitude, then topography is again will tagged with longitude and

latitude. And layers may be represented in two ways, first of all in vector format as points and lines and secondly in raster format or image format as pixel.

So, there are two types of features you will in case of GIS will be talking about this later on, one is call the vector format which is basically represented by line, points and polygons whereas, another feature of GIS is basically in the raster format and these raster is basically represented by grid of cells and we will be talking about that in a few minutes. So, all geographic data has four properties for example, projection, scale, accuracy and resolution; we will be talking about those terms later on.

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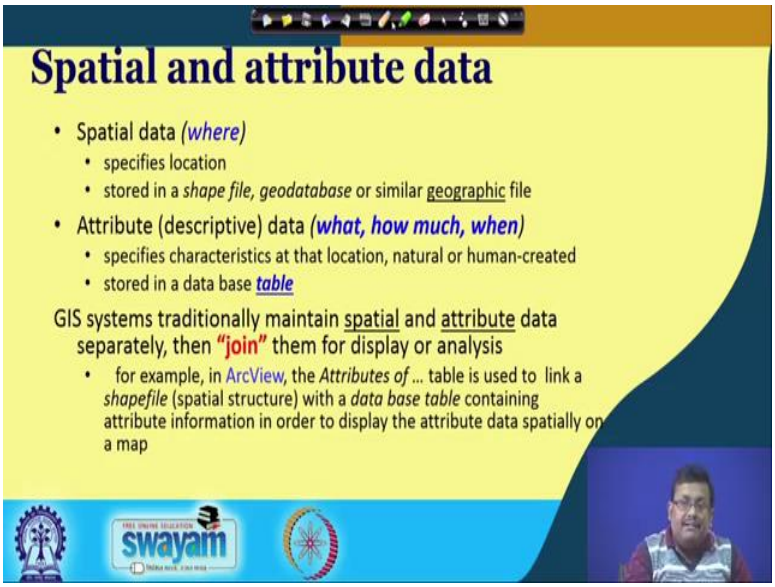

So, let us go ahead and see what is the you know of what are the other features? For example, here you can see spatial data basically shows your spatial data gives you the information of where, a particular you know a particular feature is located or in other words this gives us the spatial a specific location or the you know remember that these spatial data is basically located or stored in terms of a specific file feature file type we call it shape file.

And the shape file or geo database or similar geographic file. We will be seeing the shape file in a you know shortly I will show you, some shape file and remember that another type of data as we have talked about is attribute and descriptive data, which basically gives you the information about what, how much and when. And these specifics these specifies characteristics at that location natural or human created and

stored in a database table, just like in you know and this database table is called the attribute table.

So, this descriptive data is basically stored in attribute table and we have to input this data basically from different sources. And these attribute data in the attribute table basically helps us to answer this question what, how much and when. So, GIS system traditionally maintain spatial and attribute data separately. So, in a GIS software it can be maintained separately both in a spatial file or shape file, another in a attribute data and the GIS software has the capability to join them for display or analysis. So, this is the beauty of GIS software.

It is not the simple mapping, it is not that simple database management, it is a combination of both of them to create an interactive solution for each and every problem, which is related to geography. So, for example in ArcView, which is a software the attributes of table you know, attributes of a specific thing in a table is used to link a shape file that is a spatial structure with a database table containing attribute information or in order to display the attribute data spatially on a map.

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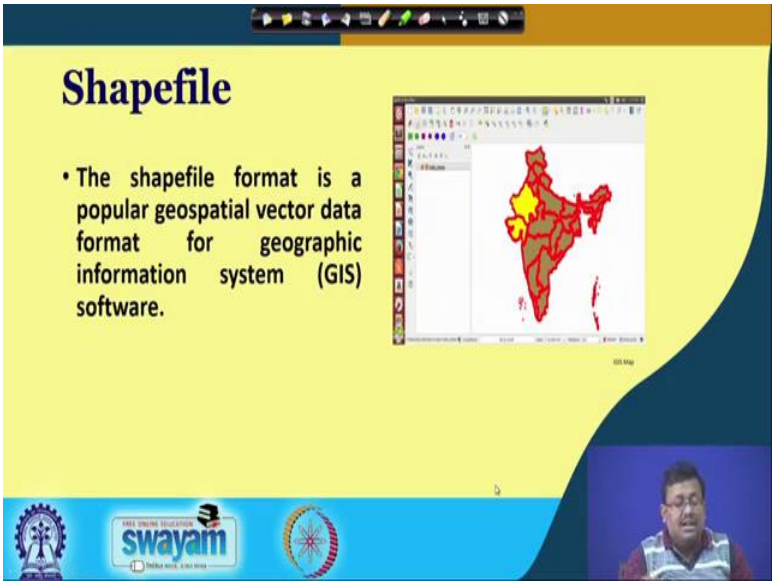

So, you can see this is a shape file. And the shape file format is a popular geo spatial vector data format for geographic information system software. And the type of you know these the you know you can see these are the political boundaries of India and this

can be called this can be considered as a shape file. Remember that the shape file can be represented by either points polygons and you know or lines, we will see that later on.

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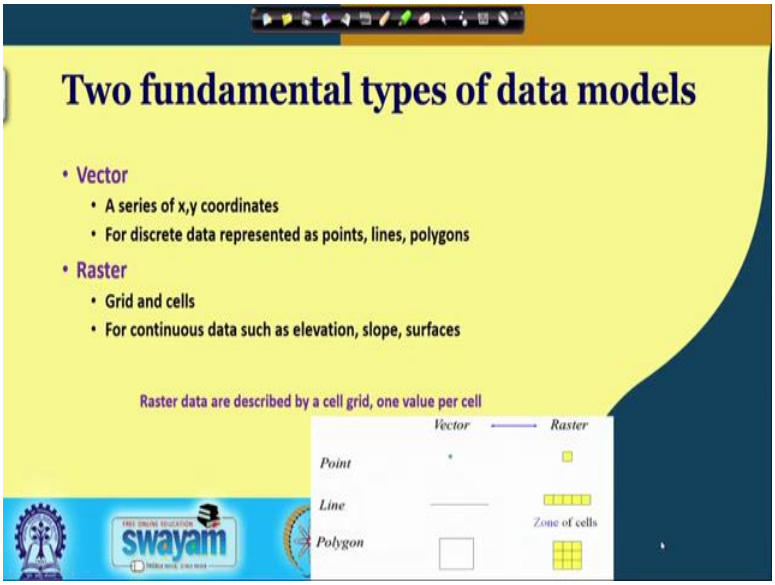

So, the two fundamental feature of data models we will see there are two types, one is called vector data another is raster data. So, in vector is basically a series of x and y coordinates and we basically you know, used for representing discrete data like you know for you know for discrete data representing as points lines and polygons. And as I have told you, the raster is basically represented by grids and cells and it basically shows the continuous data such as elevation slope and surface.

So, raster data described by cell grid one value per cells. We can see its shows, the clear differences between these two data type, this is the vector data, which is shown by points and this is by line and then polygon. And you can basically describe any vector data by using three different features. And raster data is basically denoted by either this cells or zone of cells or you know this grids of cells.

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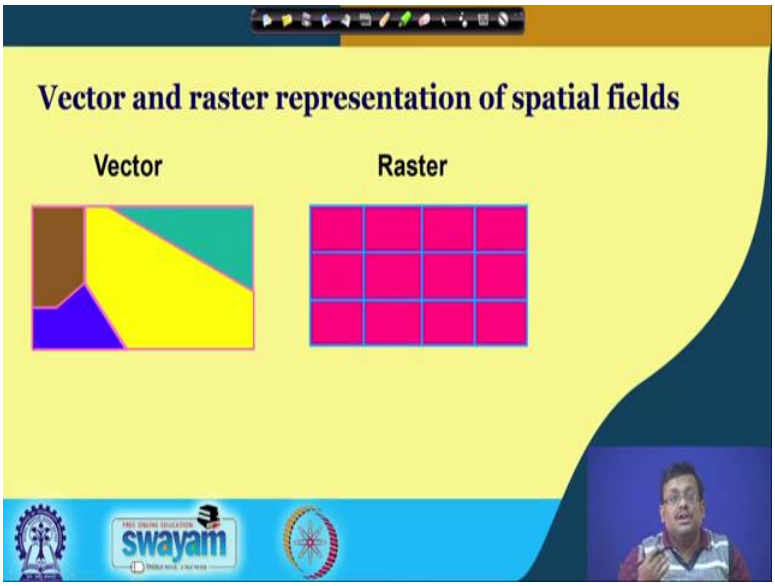

So, this slide shows vector and raster representation of the spatial fields as you know see here. Vector data is again can be represented in terms of some polygons whereas, raster data can be represented in terms of some you know some gridded cells. Remember that the raster data is you know raster data basically represents some continuous data fields, like elevation.

For example, the image is basically a rasterize format. Any image is basically can be converted in you know is basically a raster data format, where each individual pixel represent a grid or you know a grid in that raster data.

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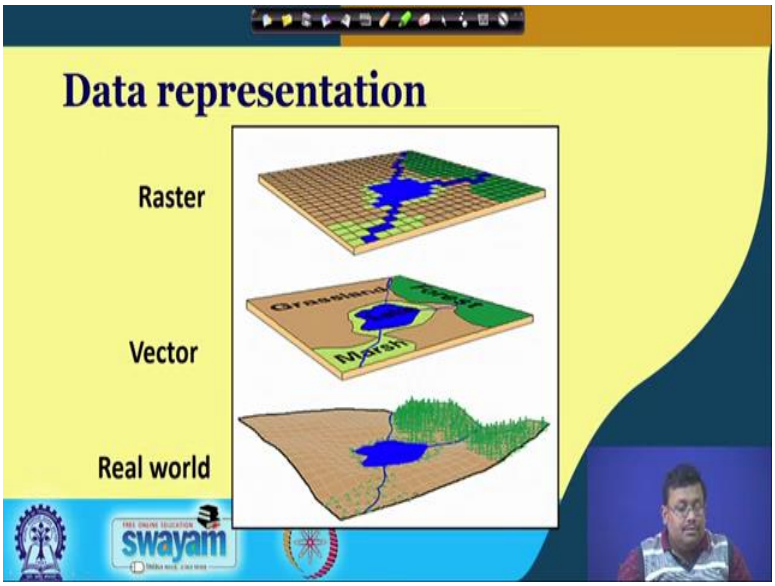

So, let us see the data representation in a GIS obviously, remember that in the real world anything or any feature can be represented by a combination of a raster and vector data.

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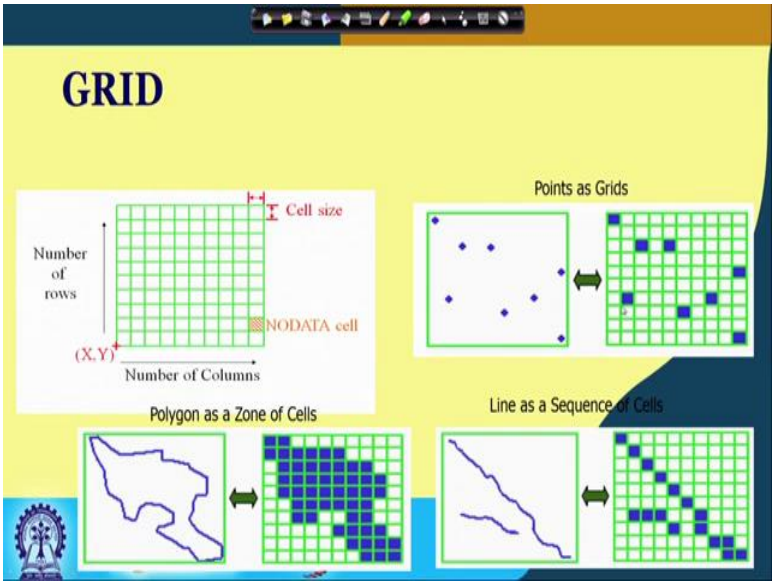

And so let us see how it go, you know how it happens. So, you see it is a gridded cell basically you know these are you know number of rows is we can see and also the number of columns and these are basically contains some cell, where there is no data and cell size are almost similar. So, we can see points data which is a kind of vector feature,

you can assign this points as grids just like this. And also polygons has a zone of cells just like this and also line is a sequence of cells like this or sequence of grids like this.

So, you can see you can literally represents your vector data in terms of your you know raster data by using either specific grids or a zone of cells or line as a sequence of cells. So, this is how you can represent any feature of the earth surface, in terms of both you know vector data as well as raster data.

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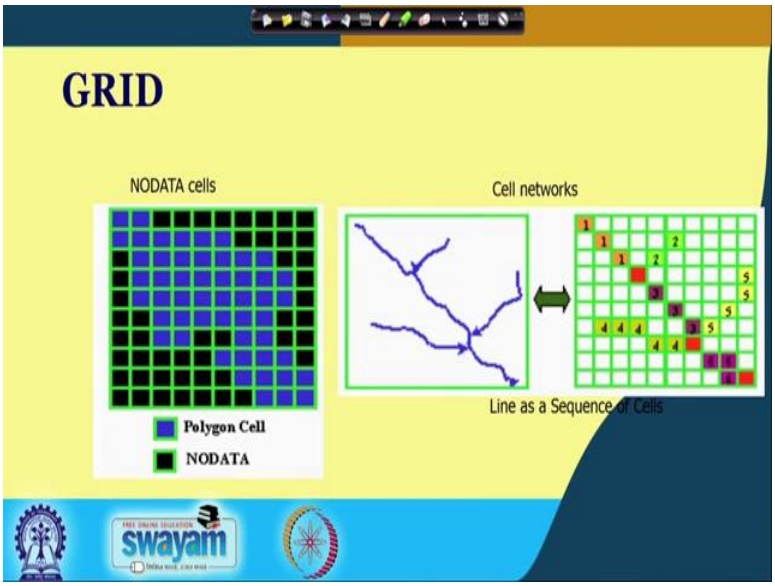

So, this is again note you can see it is the gridded cell. The polygon cells are represented by this green field you know grids whereas, this no data or the cells which does not contain any data is basically represented by this black cells. So, again this is a cell network which is basically line as a sequence, and as you can see you know these are some examples to show how these you know vector data and raster data can represent any feature over the earth surface.

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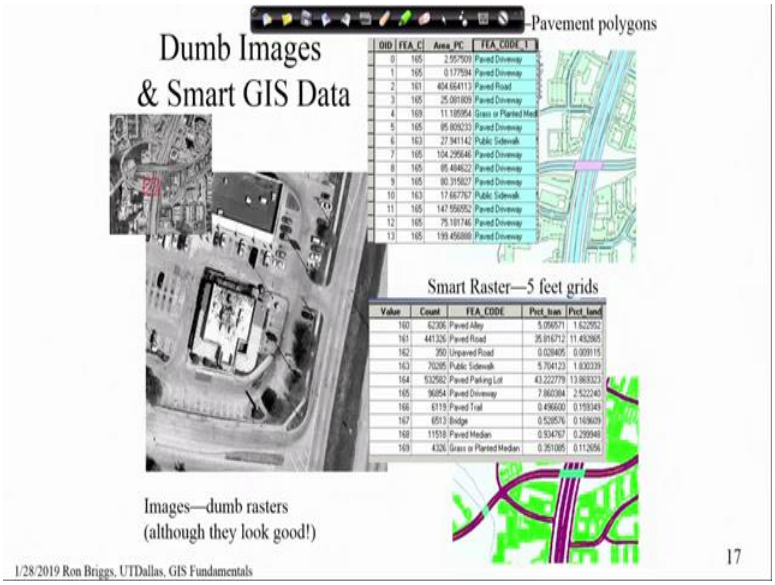

So, let us see some good examples you can see this you know this some images or we call it dumb rasters, why we call it dumb rasters? Although, they look very good, however, they does not produce any good quantitative or you know or any good information about you know about some specific features. If we ask the question, I like how way you know if we ask the question when, how and all this things, now all these cannot be answered by just interpreting this images; so this called dumb rasters.

And as you can these are the smart raster obviously, because all these are you know represented by some specific attributes. For example, it is a smart raster of 5 feet grid and you can see the values are given and counts are given and also some features are given for each of the cell. So, whenever any images is associated with a in attribute table, we call it as smart display of data.

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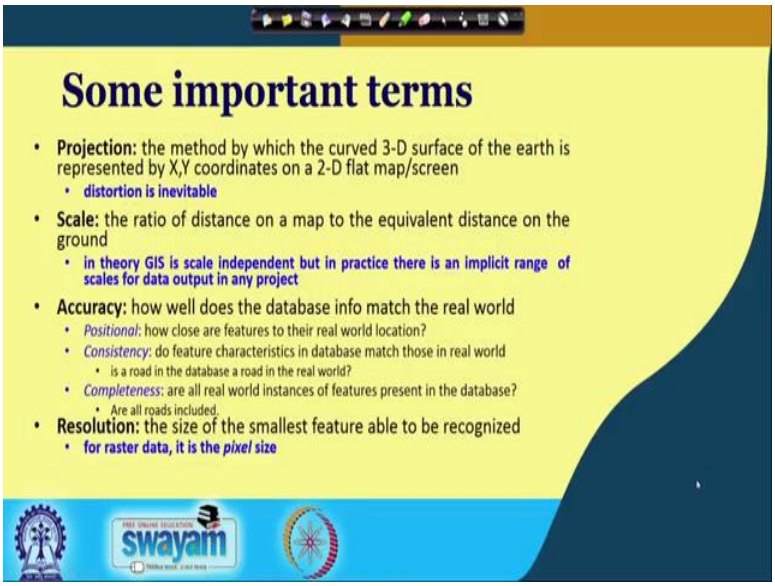

So, some important terms before we see some examples of GIS first of all is projection. Projection is the method by which the card 3-D surface of the earth is represented by X and Y coordinates on 2-D flat map or screen. And remember that although know we are trying to represent any 3-D surface in terms of 2-D flat map of screen, they are you know there has to be some distortion and so this distortion is inevitable.

Second is a scale. So, there is a ratio of distance on a map to the equivalent distance on the ground. And in theory GIS scale independent, but in practice there is an implicit range of scales for data output in any project. So, if you see any GIS map it always a will associate with some scale.

Thirdly, you know accuracy. How well does the database info matches with the real world. So, it can be measured into three you know aspects. First of all positional accuracy so that means, how to lose the features to their real world location. Secondly, is a consistency, so do feature characterization in database match those in the real world? So, the second consistency so the second is consistency base accuracy. So, is a road in the database, a road in the real world, so that type of validation can be done by consistency based accuracy measurement.

Thirdly is completeness, which is are all real world instances of feature present in the database. So, or in other words are all roads are included. So, these type of answers you can see while you are doing this you know accuracy analysis.

And also resolution; resolution basically shows, the size of the smallest feature which is able to be recognized. So, for raster data it is the pixel size obviously, as the size of the pixel goes down, the resolution is increases. Similarly, just like in case of in any photograph as the resolution increases, the size of the pixel size goes down or in other words as the size of the pixel size goes down, their smallest feature can be identified through these individual pixels. So, guys you know so I hope that you have gathered some knowledge about this important terms.

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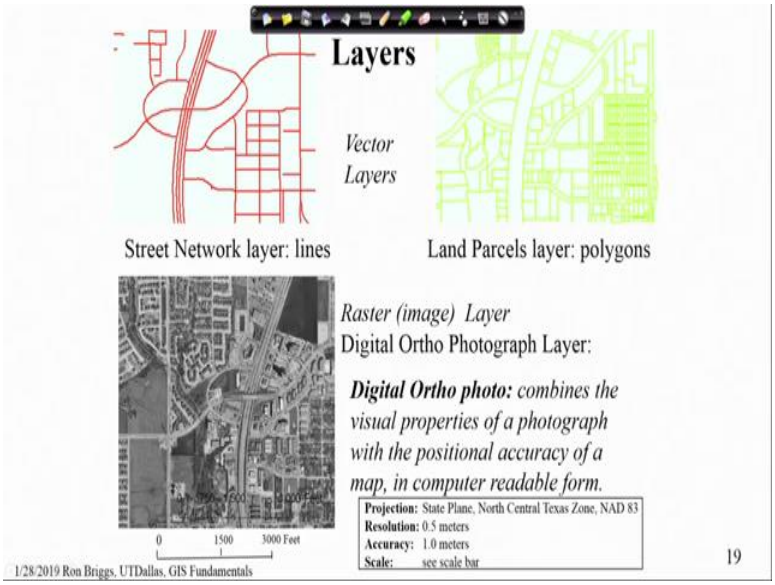

And you can see here, you know let us see some one example of GIS. Here you can see this is a; you know this is basically shows a raster image layer, which is the digital ortho-photo photograph layer. And digital ortho-photo is basically combines the visual properties of a photograph with the positional accuracy of feedback in computer readable format.

So, this is the our base map and then people have used the you know there are two types of vectors layer. This is the vector layer of street one street network, and this is another vector layer showing the land parcel layers. So, it is represented by lines however this land parcel vector layer is represented by polygons. So, let us see how these three can be integrated to produce you know to produce the answer of a specific query.

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So, in this picture you can see, these three layers basically two vector layers and one raster layer are overlaid based on the common geographic location. So, they have similar geographic location; so they are overlaid to each other.

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And ultimately you can see, after the we put some query. So, our query is to identify the parcel, which you we within a half mile buffer of the park and central. So, if it is the park and central and we are overlaying all these three layers to each other, we are stacking all these three layers to each other. Obviously, then you can identify the areas which are the

you know identify the areas which are containing the parcel, you know a half mile buffer of park and central.

So, you can see by using by this is the actual use of you know GIS and by using these GIS we can query in our case the query was to identify the specific locations, which are within half mile buffer park and central. And you can see by overlaying all these layers together we can identify those areas.

So, I hope guys now you are getting some ideas about this GIS and obviously they you know the you know a plenty of research is going on the GIS applications in soil science. Obviously, we can use the GIS for identification of aspect of you know different filed location not only that we can also do some geo statistical mapping using GIS software's we will see that later on.

And so all these better resource management to identify you know to identify the earth surface features are in efficiently managed by this geographic information systems. So, guys let us stop here and in the next lecture we will be starting from GPS. And then we will see that how this GPS is helping us for identification or you know for positional identification and how we are using this GPS nowadays and so on and so forth. So, guys thank you let us meet in the next lecture of week 11.

Thank you.