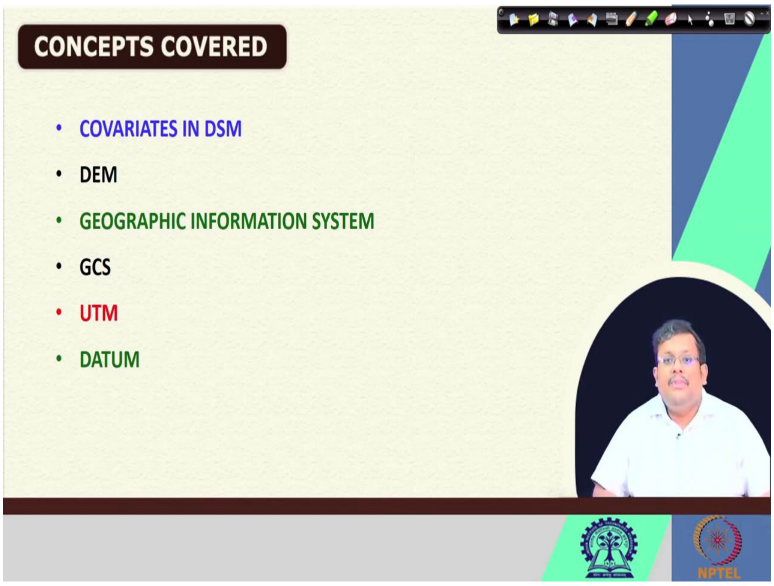
Machine Learning for Soil and Crop Management
Professor Somsubhra Chakraborty
Agricultural and Food Engineering Department
Indian Institute of Technology Kharagpur
Lecture 47
Digital Soil Mapping – General Overview (Contd.)

Welcome friends to this second lecture of week 10 lecture number 47. And in this week we are talking about digital soil mapping overview. And in this first lecture of this week, we have already discussed the basic overview of digital soil mapping, what is digital soil mapping, why it is different than non-traditional soil mapping, what is the motivation of digital soil mapping what are the uses of digital soil mapping, how these digital solving workflow operates.

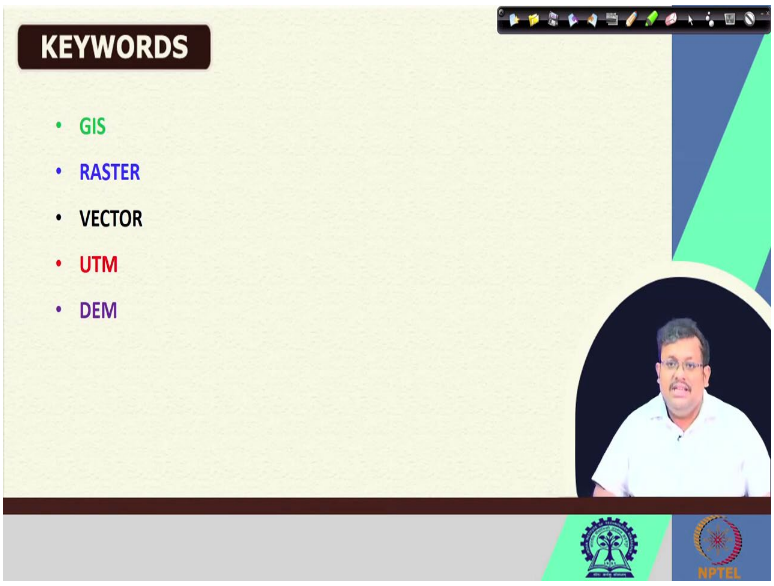
And then we have seen the Jenny's model of soil formation and SCORPAN plus e model given by McBratney et all in 2003. What are the differences, why we call it digital soil mapping and so on. So, in this week we will be will be continuing that and then we will be also discussing the geographic information system and why it is important in digital soil mapping we are going to also learn.

(Refer Slide Time: 1:17)



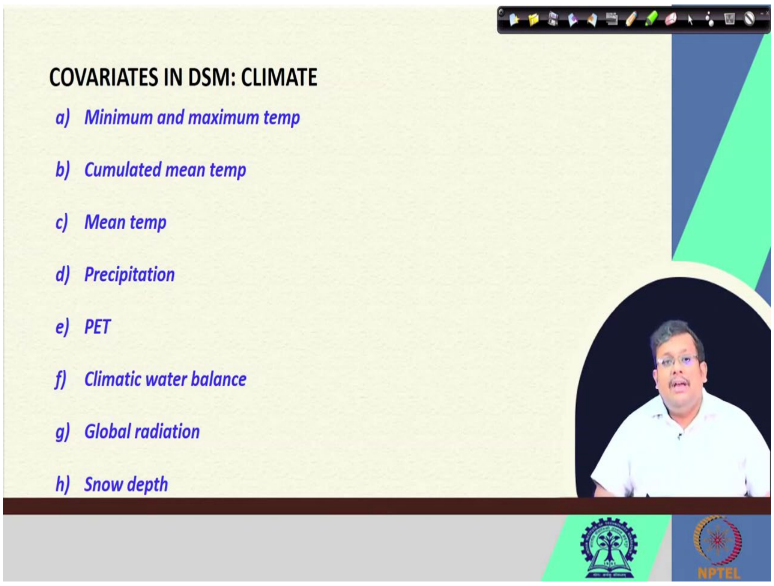
So, these are the concepts which we are going to discuss, we are going to discuss the covariates in digital soil mapping then digital elevation model then geographic information system then GCS or geographic coordinate system then UTM or Universal Transverse Mercator and then datum. So, all these concepts which are we are going to cover in this lecture.

(Refer Slide Time: 1:40)



These are some of the keywords which we are going to discuss like GIS raster vector UTM DEM.

(Refer Slide Time: 1:49)

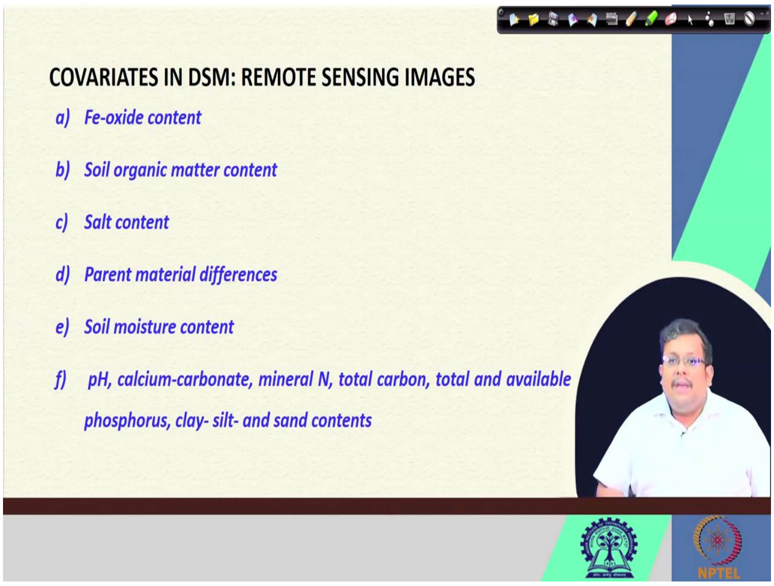


So, let us start with the covariates in DSM. Now, guys we have seen according to both the Jenny's model as well as the SCORPAN plays plus e model the soil formation depends on apart from soil properties, it depends on different types of other auxiliary soil properties, auxiliary properties like climate organism parent material relief.

So, why the why are they important because it has been found that soil formation sometimes depends on these factors and there is a direct correlation between these factors and the soil properties. So, that is why by incorporating these auxiliary variables in the soil inference model of DSM it is possible to produce higher resolution soil maps.

So, that is why these properties have been included in the digital soil mapping concept. Now, what are the most common soil climate variables which we generally incorporate in the DSM you can see here minimum and maximum temperature cumulated mean temperature mean temperature precipitation potential evapotranspiration, climatic water balance global radiation snow depth all these are incorporated in the as covariates in the digital soil mapping.

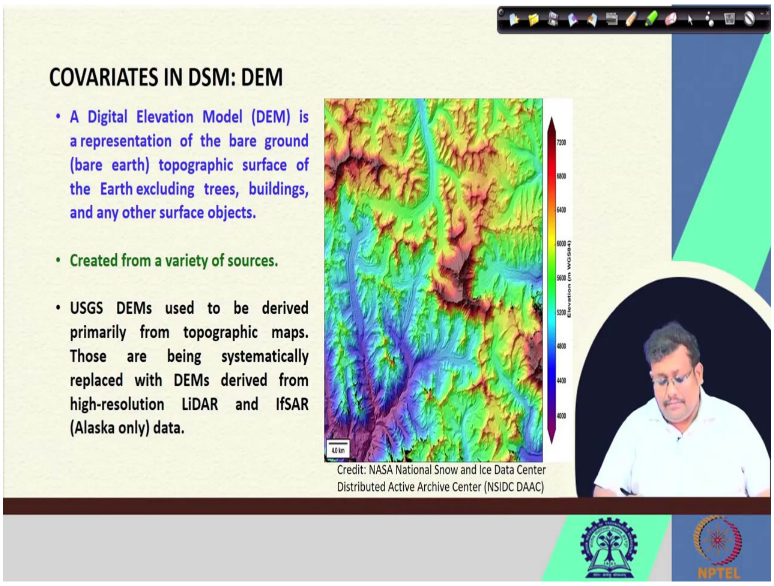
(Refer Slide Time: 3:13)



And if we talk about the remote sensing remote sensing has got an immense importance in digital soil mapping. Here we have seen that remote sensing images have highly correlated with the iron oxide content of the soil, then soil organic matter content salt content, parent material differences soil moisture content, then pH calcium carbonate mineral nitrogen, total carbon total and available phosphorus clay, silt and sand contents all these can be inferred from the remote sensing images.

So, remote sensing images have utilized or imagined indices image derived indices have been well utilized in different DSM application as auxiliary variables.

(Refer Slide Time: 4:10)



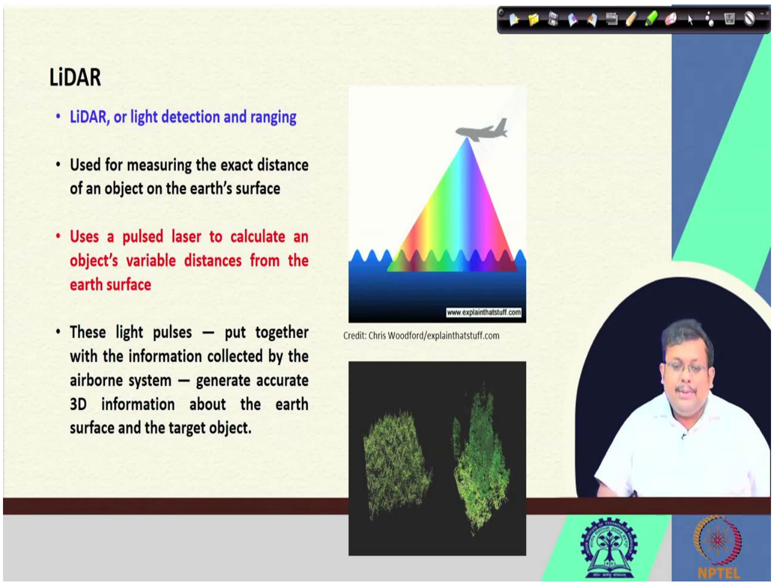
So, let us talk about DEM which is another important covariant. So, DEM stands for the full name is digital elevation model, it is basically a 3d representation of the bare earth or bare ground topographic surface of the Earth excluding the trees, buildings and any other surface objects.

So, if we remove all the surface objects and will take the picture of the bare ground and the differences at the surface, then it will be a 3d representation and that is called Digital Elevation Model. Now, there are different types of digital elevation model from a variety of sources variety of resolution. More high resolution means higher large is the file size.

So, depending on your computer resources you can select what resolution DS DEM you are going to use. So, DEM is a very important auxiliary variable or covariate in the DSM domain. Now, for example these USGS United State geological service, DEMs used to be derived primarily from topographic maps.

And those are being systematically replaced with DEMs derived from high resolution, LiDAR and IFSAR data. Now, this is an example of this DEM map produced by NASA.

(Refer Slide Time: 5:33)

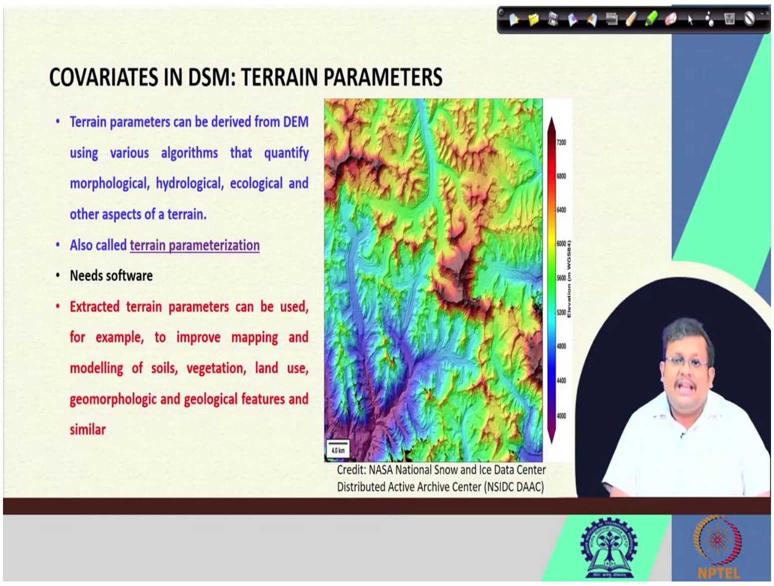


And as I have told you that these DEMs are basically generated by LiDAR. Now the question comes what is a LiDAR? So, LiDAR is a short form of light detection and ranging. So, it is basically used to measure the exact distance of an object on the Earth's surface. So, it basically uses a pulse laser to calculate an object variable distance from the Earth's surface as you can see, in this picture, it can be either airborne or it can be fixed in some moving vehicle or tripod.

So, using these they basically use a pulsed laser to measure the unevenness or the distance objects variable distance from the Earth's surface. So, using these LiDAR data, it is now possible to develop the DMR digital elevation model. So, these light pulses put together with the information collected by the airborne system generates is accurate 3d information about the earth surface and the target object as you can see, these a DEM of the forest.

So, using this type of LiDAR based technologies nowadays, the traditional topographic map base DEMs are replaced. So, these are more accurate.

(Refer Slide Time: 7:01)

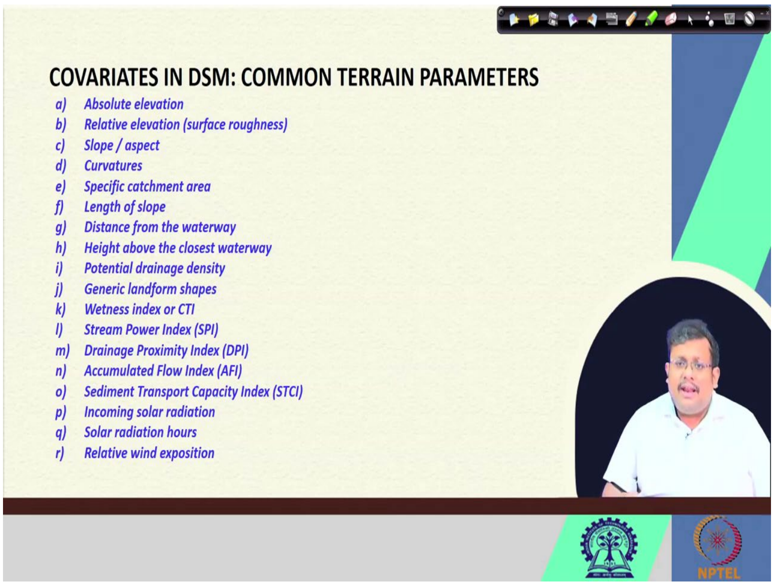


Now, why DEM is very much important. Now, we have seen that there are multiple terrain parameters and this terrain parameters we can extract from DEM using different types of software and these extraction is known as terrain parameterization. And using these terrain parameterization and via dedicated software, these extracted terrains are highly correlated with the soil properties.

For example, a depth of for example, altitude channel, altitude of channel which is an important terrain parameter extracted from DEM. So, this scan helps you to understand the movement of water, when there is rainfall and how these water will drain and where these water and from this movement of water you can gather information about the formed soil.

So, these extracted terrains parameters can be used to improve the mapping and modeling of the soil, vegetation land use and geomorphic and geological features and similar. So, when we combine these terrains parameters in a digital soil infer spatial inference model that helps us to get better accuracy of the predicted maps.

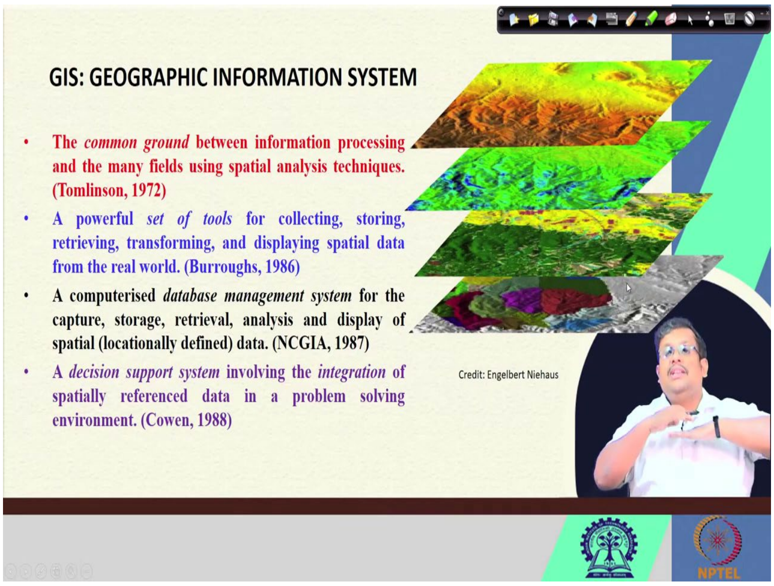
(Refer Slide Time: 8:30)



So, these are some of the covariance terrain parameters which are gathered from DEM file using software like absolute evaluation rating elevation slope aspect curvature, specific catchment area length of the slope, distance from the waterways, height above the closest waterway, potential drainage density, genetic land form shapes, wetness index, or CTI, then stream power index, then drainage proximity index, accumulated flow index, sediment transport capacity index, incoming solar radiation, solar radiation hours, relative wind exposition.

So, all these different terrain parameters are important for predicting the soil properties along with other parameters. And basically incorporating these parameter extracted terrain parameters in any spatial inference model can improve the spatial prediction of soil properties. So, this is how these common terrain parameters are extracted and used in in digital soil mapping.

(Refer Slide Time: 9:40)

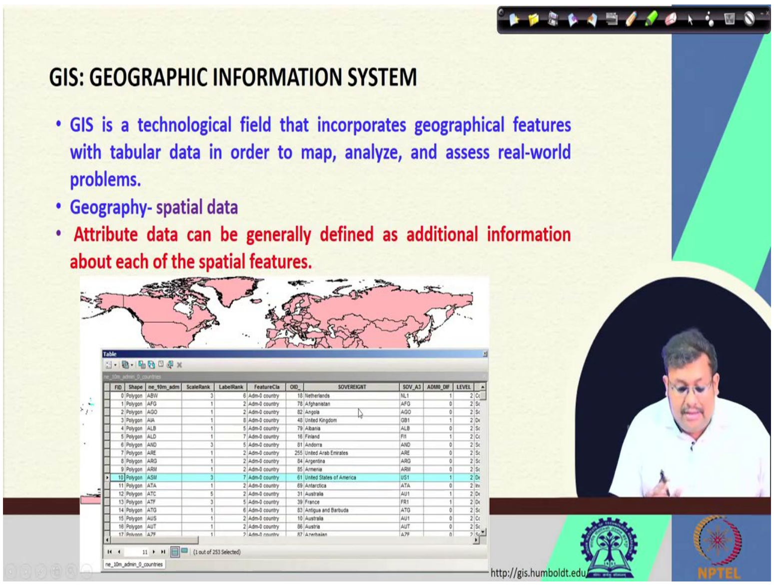


Now, we have discussed about the digital soil mapping. Let us discuss a very important concept that is called geographic information system. Now for creating the map in digital soil mapping it is required extensive use of geographic information system as the name suggests, this is a basically requires the geographic application and since we are dealing with the locational data in case of digital soil mapping of course, that will have these geographic information system has a tremendous impact on this product production of the maps.

So, different scientists have defined these digital these GIS in different ways. These are some of the these are some of the definition of GIS. But to in a short form it is basically a technology where we can utilize AI software to make some query from a map and of course, we can relate both the locational context as well as the attribute in terms of a digitized map.

So, this is called geographic information system, geographic information system can be can be visualized as a super imposition of multiple layers. So, each of these layer may indicate any important features and then when they superimposed over each other, they will produce the real world situation.

(Refer Slide Time: 11:21)

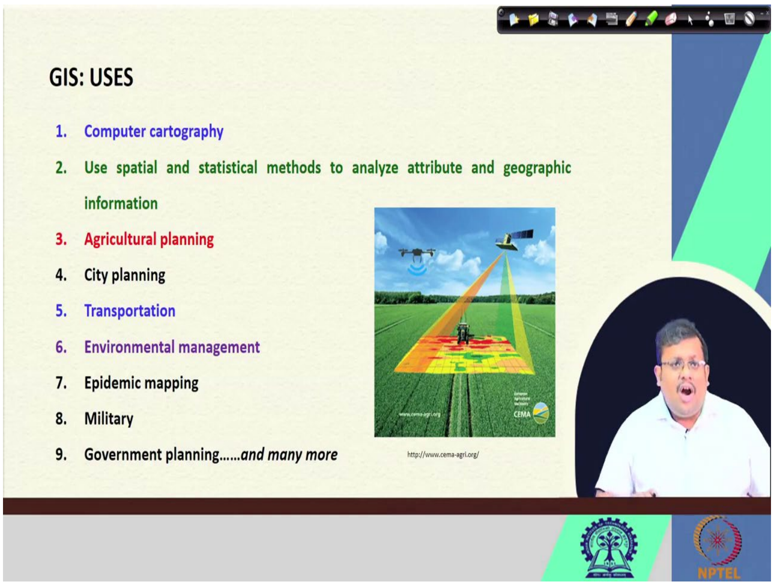


So, GIS Of course, in a short form is a technological field that incorporate the geographical features with tabular data in order to map analyze assess real world problems. So, as the name suggests these geography is deals with the spatial data and it attributes data can be generally defined as additional information about each of these spatial features. For example, if you want to develop the political map of the world, you are getting these each of this country can be described by a polygon.

So, each of these polygon will not only have these their identifier but also we can incorporate we can include some other values also like the population, the number of cities and all these important information we can tag these polygons with in this table. So, you can see this is called the attribute table.

So, not only we are seeing the map the digitized map. These maps are also having some attributes. So, using some software we can extract these information and interpret based on our requirement. So, this is called the geographic information system.

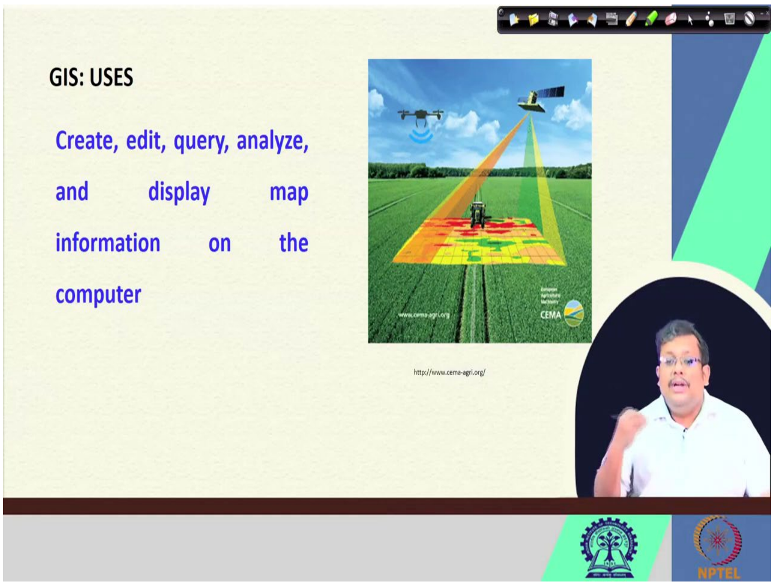
(Refer Slide Time: 12:49)



Now, what are the uses of geographic information system, GIS can be used for computer cartography, it can be can use spatial and statistical methods to analyze the attribute and geographic information, agricultural planning suppose you want to develop a soil web spatial variability map of soil properties using remote sensing data you require GIS.

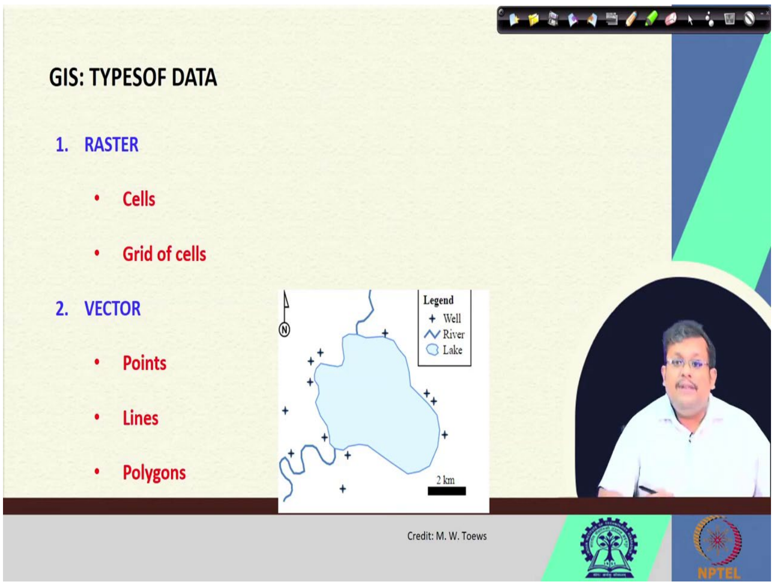
Because without GIS you cannot map and interpolate and also the agricultural planning. So, city planning if you required GIS transportation map, you required GIS, then environmental management, endemic epidemic mapping, then military use, and then government planning and many more. So, there are endless application of GIS.

(Refer Slide Time: 13:36)



And then so basically, if we summarize, we can see that GIS helps in creating editing and making queries and analyzing and displaying map information on the computer. So, that is why GIS is nowadays has become an integral part of our society and in every discipline, we use the GIS to interpret the data and give them some locational context.

(Refer Slide Time: 14:07)



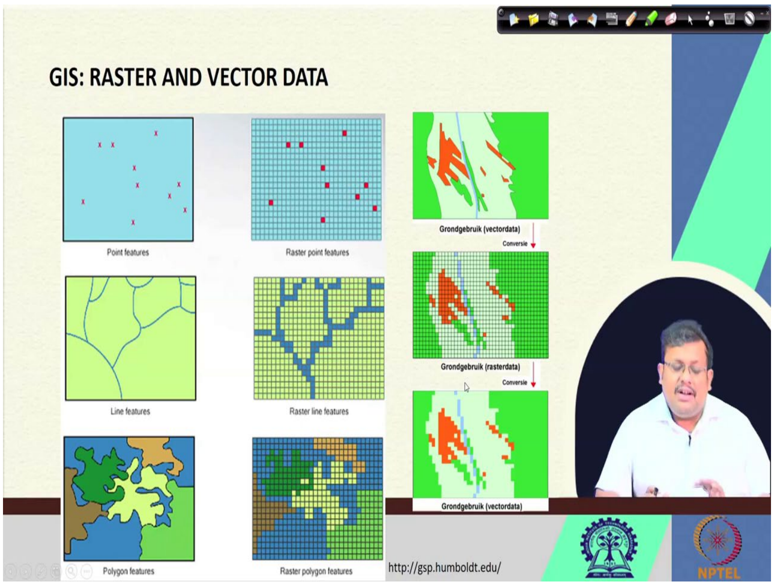
So, what are the two different types of data GIS have two different types of data one is called raster data and other is called vector data. Raster data basically cells or grid of cells I will show you and vector data are of three types one is point lines and polygons. Now, any feature on the earth surface can be described in terms of points polygons and lines.

So, for example, here in this map you can see these are suppose these are some of the wells and these lines so these points are indicating the well. So, these lines are indicating the river and these polygon is indicating the lake. So, these vector data can be used to define these type of features in the map, whereas raster data is more or less continuous using cells or grid of cells.

For example, an image can be also considered as a is a collection of pixels we know that. So, this is a raster file which is continuous and each of these pixel remember this is grid shaped or square shaped. So, this is an example of raster. So, any continuous feature of the art surface can be represented in a raster file for example, digital elevation model which we have already discussed can it is it is a raster file which has locational context in terms of latitude longitude and also they have the elevation.

So, using these continuous elevation data you can produce the raster of digital elevation model. So, this is the two types of data we generally use in case of GIS.

(Refer Slide Time: 15:53)

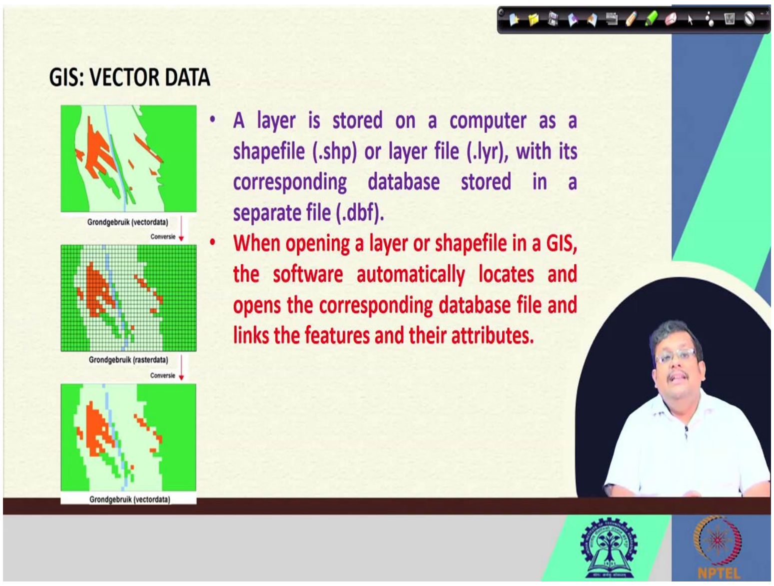


Now, you can see some a pictorial description of these raster and vector data, you can see some point features and same point features you can represent in terms of raster data. So, raster data you see, they are divided into grids, equally sized cells. So, you can produce you can you can identify these grids.

You can identify these point features in the grids in these features line features can be used by the raster line features and then polygon features can be used by the raster polygon features or zones of these cells. So, using these you can you can see that all the properties all the features can be described in terms of both vectors and raster.

For example, here it shows the vector to raster and raster to vector conversion you can see this is the vector data, we can convert it to the raster data and then again we can convert it to the vector data. So, this is how the one data type can be converted into other data type and then we can re convert it back.

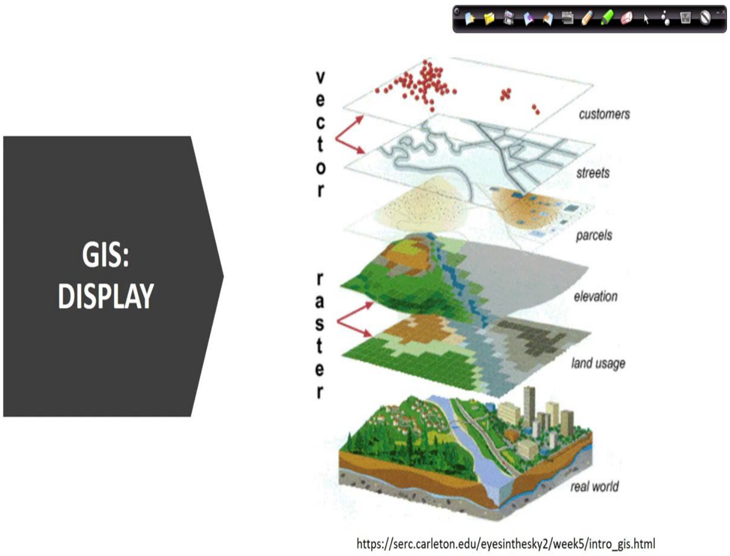
(Refer Slide Time: 16:59)



So, vector data a vector data remember a vector data generally stored on a computer as a shapefile the extension is dot shp or a layer file that is dot lyr with its corresponding data to the database stored in a separate file that is dbf file. So, dbf file is known as is the short form of database file.

So, not only the geographical features are stored, but also their attributes from the attribute table are also stored in the dbf file. So, when opening a layer of shapefile in GIS software that automatically locates and opens the corresponding database file and links the feature and their attributes.

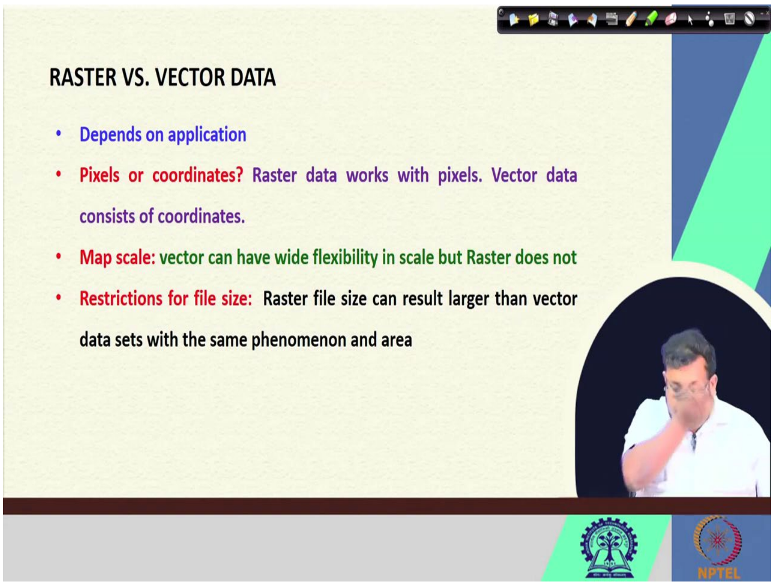
(Refer Slide Time: 17:42)



So, you can see this is how these GIS basically works in different layers. Suppose this is the first layer which shows the customers and this is the second layer which shows that street this is the third layer which shows the parcel in the fourth layer shows the elevation fifth layer shows the land use and when we superimpose all the so among these also these customers and then streets and parcels these are the vector data whereas these elevation land use these are raster layers.

So, when we superimpose all these together we will get these real world scenario that is the final output or display from a GIS platform. So, this is how GIS basically works, we can peel out all these layers one by one from these GIS and we can make some query to get the important information interpretation from this type of representation.

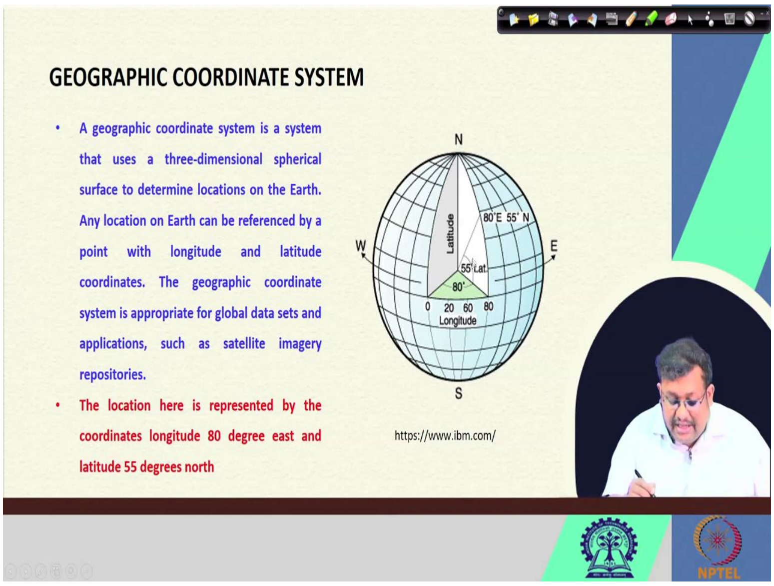
(Refer Slide Time: 18:39)



So, what we should use a raster data vector data of course it uses it depends on a specific application. First you ask the question whether you are interested in pixel based or coordinates based representation. Now, raster data works better with pixel whereas vector data consists of coordinates.

The second important consideration is mapping scale vector data can have wide very flexibility in scale, but raster data does not have wide flexibility and restriction for file size. So, raster file size can result in larger they are larger in size than vector data set with the same phenomenon and area. So, that is these are some of the consideration you should issue you should take into account for digital for using this raster data and vector data.

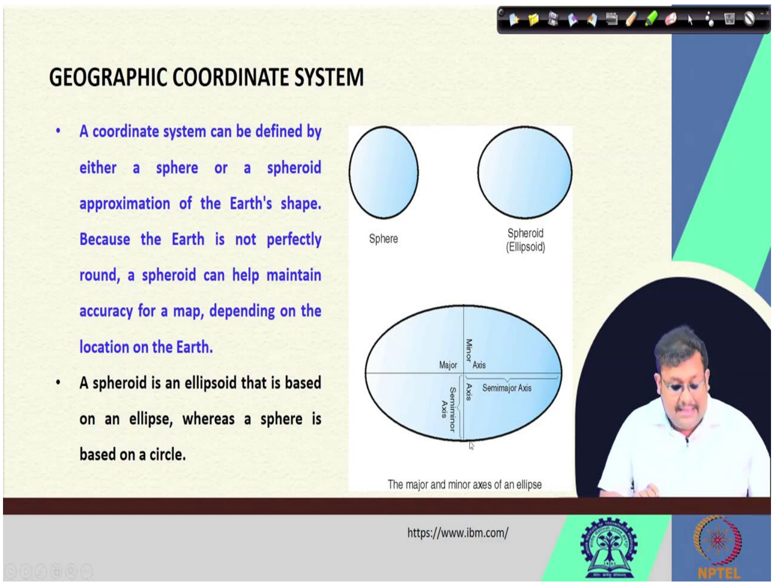
(Refer Slide Time: 19:34)



Now, another important concept is geographic coordinate system. Now you all know about the latitude and longitude why we require it. So, geographic coordinate system is a system that uses the three dimensional spherical surface to determine location on the earth. Any location on the earth can be referenced by points with latitude and longitude that geographic coordinate system is appropriate for all Global dataset and applications such as satellite imagery repositories.

For example, here in this location you can see these location is represented by coordinates, longitude of 80 degrees. So, this is the prime meridian so this is the longitude of 80 degree east and latitude 55 degree not. So, this is this information this location can be can be identified by giving this this particular latitude and longitude.

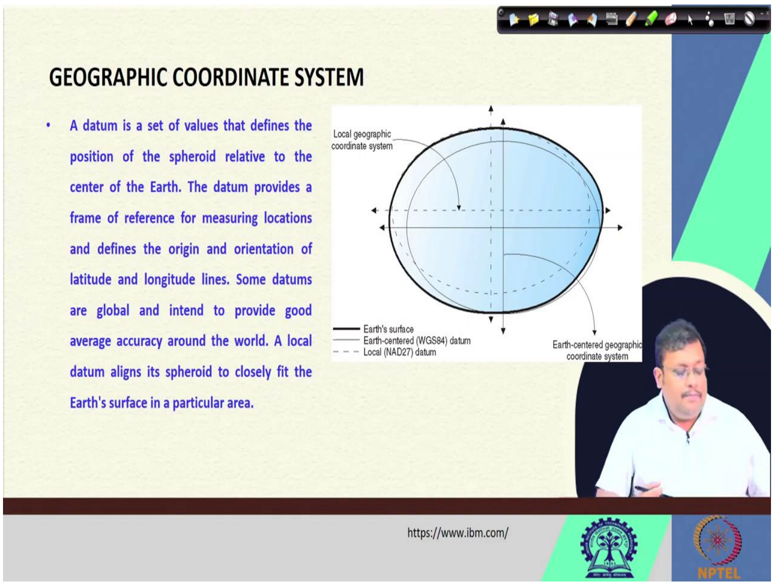
(Refer Slide Time: 20:34)



Now, the next question comes to our mind a coordinate system what is required. So, a coordinate system can be defined either as a sphere or a spheroid approximation of the earth shape. Now, because the earth is not perfectly round, it is spheroid in nature it is ellipsoid nature. So, it is ferrite can be held can help to maintain the accuracy for a map depending on the location on the earth. So, it is spheroid is an ellipsoid.

So, you can see this is spheroid which is basically an ellipsoid that is based on an ellipse and where is the sphere is based on a circle. So, in this speed in this spheroid you can see there is major axes and this is the minor axis. And this is known as the semi major axis this is known as the semi minor axis.

(Refer Slide Time: 21:24)



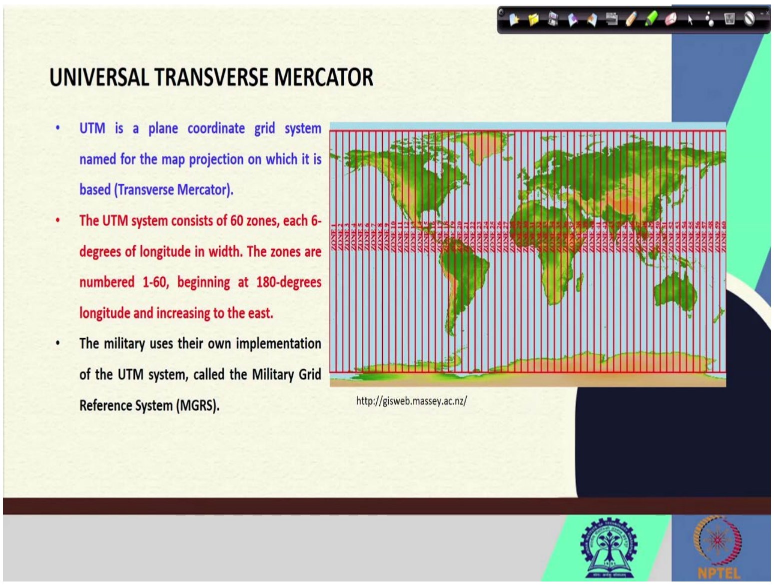
So, next important concept is datum. So, a datum is a set of values that defines the position of the spheroid relative to the center of the earth. So, basically it is basically it is a reference system for this these different types of coordinate reference system, we need a kind of reference. So, these data gives us the reference.

So, it is a set of values that defines the position of the spheroid relative to the center of earth. So, that data provides a frame of reference for measuring location and defines the origin and orientation of the latitude and longitude line, some datums are global and intended to provide good average accuracy around the world, a local datum aligns with the spheroid closely fit and the earth's surface particular area.

So, here you can see suppose, this is the earth's surface this broad this thick black line and here there are two datums one is the earth center datum, which is the continuous line, which is WGS 84 also known as world Geodetic Survey 1984. And this dotted line is another datum that is NAD 27 that is not the north American datum 27 so this is a local datum.

So, you can see that this in NAD 27 in this case approximately aligns better to these we know earth surface better than these of these WGS 84. But depending on the data sources depending on your application, these datums the use of datum get changed. So, datum is basically a reference system for your geographic coordinate system. So, which approximates the spheroidical nature of the earth.

(Refer Slide Time: 23:18)



Now, the next is Universal Transverse Mercator UTM. UTM is basically a plane coordinate grid system which named for the map projection on which it is based so transverse Mercator.

So, what happens in this UTM zone is the two dimensional representation, we divide the whole art surface into 60 zones, each zone is then the number them 1 to 60 zone 1 to zone 60 beginning at this 180 degree longest with an increasing to the east.

So, each zone is 6 around 6 degrees. So, these military uses their own implementation of the UTM system called the military grid reference system. So, these UTM is also extensively used in geographic in GIS and digital soil mapping.

(Refer Slide Time: 24:10)

So, guys, I hope that you have gathered some important insights from this lecture we have now understand we have now understand what is a DEM? How to extract, what are the important terrain parameters which you can extract and uses an auxiliary variables in the digital soil maps also we have seen what is GIS? What are the uses of GIS, what are the different types of data types in GIS.

And then how GIS can help in AI for the presentation of any geological features, making some queries and then also we have seen some geographic coordinate system datum and Universal Transverse Mercator. So, guys, I hope that you have gathered some good knowledge who Remember all these will be required for understanding the digital soil mapping concept or digital soil mapping applications.

So, in the next lecture we are going to discuss the geo statistics and then we are going to see some application focusing on agricultural soil and crop management. So, thank you let us meet in our next lecture.