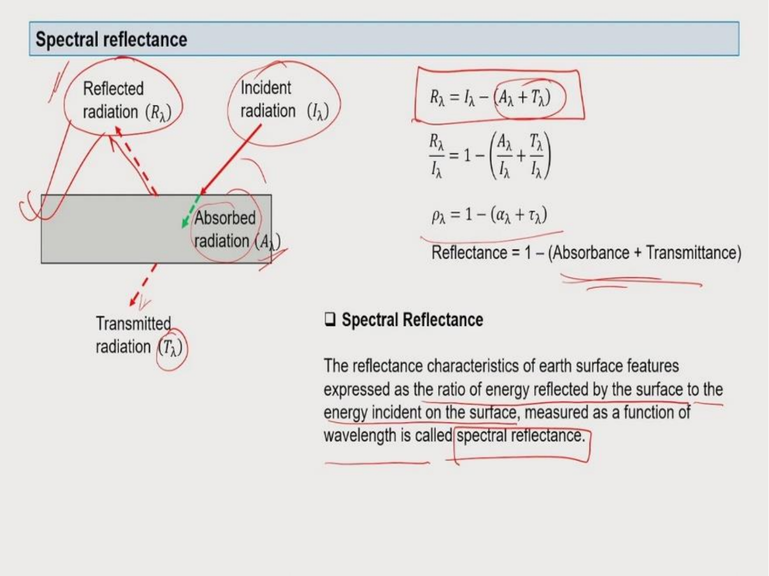
Natural Resources Management (NRM)
Professor Sudip Mitra, PhD
Centre for Disaster Management & Research (CDMR)
Head, School of Agro & Rural Technology (SART)
Discipline - Agriculture Engineering
Indian Institute of Technology, Guwahati, Assam, India
Week - 09
Lecture - 55
Remote Sensing and GIS Application in Agriculture and NRM: Part-01

(Refer Slide Time: 00:32)

So, in continuation with the Remote Sensing and GIS Application in Agriculture and NRM, we will today discuss about different curve of spectral reflectance.

(Refer Slide Time: 00:43)



Now, in previous lecture, we have discussed about different kind of spectral type, hyperspectral we have discussed. We discuss various other aspects, also those radiation, nature of radiation and how from different surfaces the radiation, electromagnetic radiation go back and get some sense by the different type of sensors. Today, we will focus on largely on the spectral reflectance and different type of curve that we actually get from this reflectance.

Now, if you look at that, we have incident radiation which is coming from the source which we call as I lambda. Some part of this incident radiation gets adsorbed on the surface or the object and that absorbed radiation we call as A lambda, but little bit of this incident radiation also get transmitted pass through this particular surface or object and that part we call as T lambda. But the most important aspect here is the reflected radiation that is R lambda that part of this incident radiation how it gets reflected and these parts actually gets sense by video sensor sitting up there in the satellite.

Now, how do you actually calculate all these A lambda, T lambda, I lambda? This is the way, we get

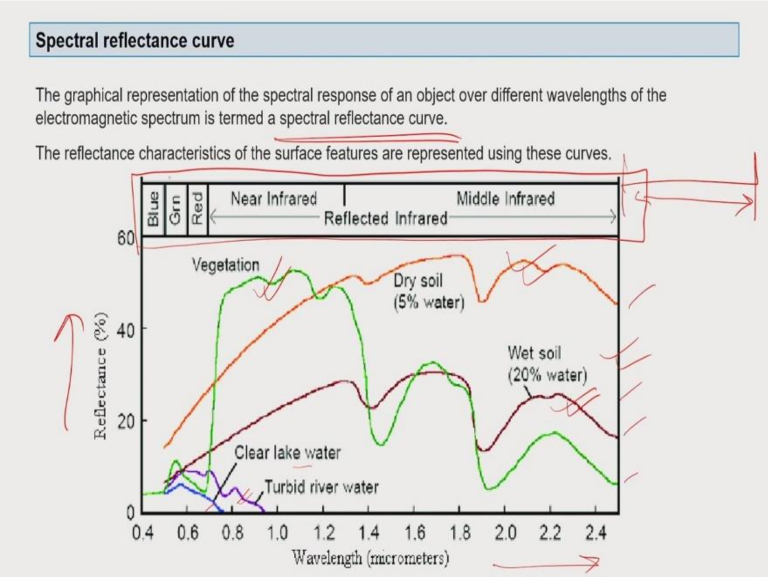
R lambda which is I lambda minus A lambda plus T lambda

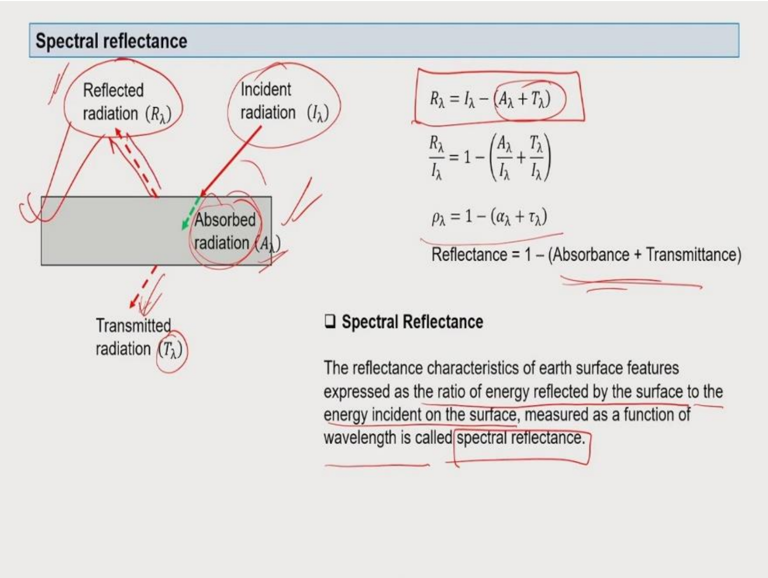
R lambda is equals to I lambda minus A lambda plus T lambda

and then we get finally, Rho lambda. Rho lambda is basically the reflectance which is 1 minus (absorbance plus transmittance), this is what actually here we are talking about the, spectral reflectance is actually very important part of the remote sensing aspect.

The reflectance characteristics of earth’s surface features it could be vegetation, could be land, water bodies generally expressed as the ratio of energy reflected by that particular surface to the energy incident on the surface is this figure that we have just now discussed. It is measured as a function of wavelength and is called as spectral reflectance. So, spectral reflectance is the key aspect of remote sensing technology.

(Refer Slide Time: 03:23)





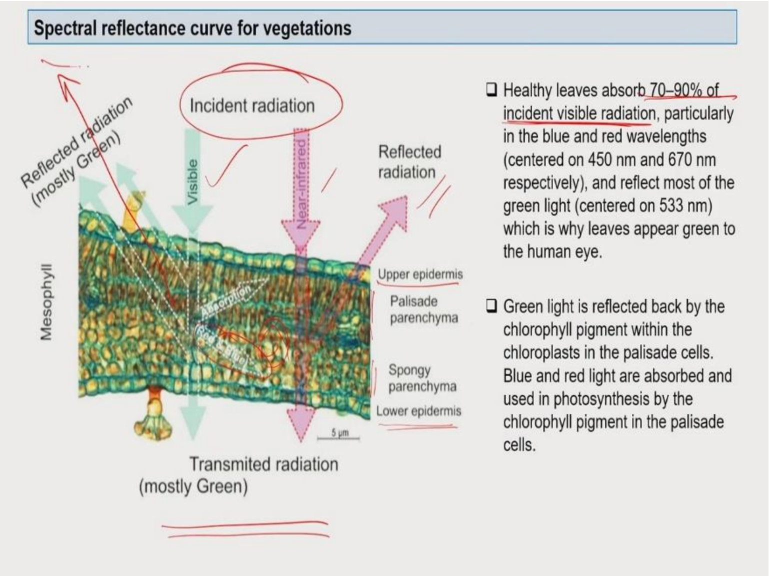
Now, let us see that how different types of reflectance curves actually we get from spectral reflectance. This particular figure or graph representation, it shows the spectral response of an object over different wavelengths of the electromagnetic spectrum and that is known as spectral reflectance curve. I repeat once again, the graphical representation as you see here of the spectral response of an object; suppose a plant and from satellite you are getting the signal from the plant surface.

So, the spectral response of an object over the different wavelengths of the electromagnetic spectrum, you remember, we discussed about the entire spectrum of electromagnetic wave and then that wavelengths of electromagnetic spectrum when actually as a response of it object, say plant or land or water body in different wavelengths, different type of electromagnetic spectrum will come and that is termed as spectral reflectance curve.

So, basically it is a response after the incident electromagnetic wave comes in, strike the object and then you see this is the figure. So, some parts will be absorbed. Some will target retransmitted but some will get reflected. So, these reflectance characteristics of the surface features are represented using different kind of curves. So, this is the full range of electromagnetic wave. So, near infrared to middle infrared and blue, green and red you are getting. So, here, this is reflectance percentage and this is your wavelength in micrometers.

So, as you see that clear lake water will give this kind of blue line, turbid river water, purple line. Then you have vegetation green, dry soil reddish type, wet soil brownish type. So, different type of surface characteristics is giving different type of curve and these we call as spectral reflection curve.

(Refer Slide Time: 05:54)

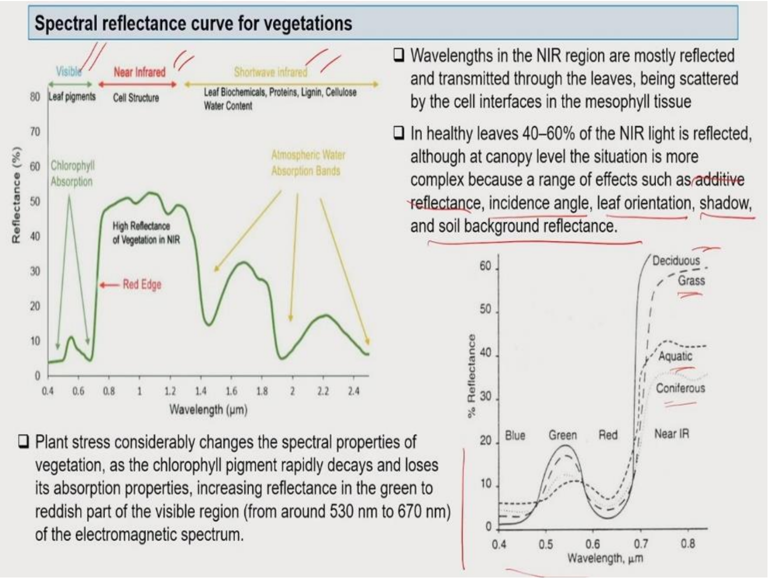


Now, spectral inflation curve for vegetation, how it actually can look like. So, in case of relatively healthy vegetation or plant they would absorb almost 70 to 90 percent of the incident visible radiation. Particularly in the blue and red wavelengths, they will absorb and reflect most of the green light and that is why the plant leaf appear green to human eye. So, that means leaving all the colors which are getting absorbed, the green colors is actually getting reflected most and that is why we are actually our sensor which is eye we are able to absorb the green and that is why we see that plant leaves are green.

Now green light is reflected back by the chlorophyll pigment within the chloroplast. So, blue and red light are absorbed and blue and red light is absorbed inside the plant for photosynthesis by again the chlorophyll pigment which is there in the palisade cells. Now look at this figure on the left hand side. This is a plant leaf internal structure. So, when the incident radiation means sunlight visible or infrared near infrared get inside the plant leaf, some part will get reflected back, some will transmit through but a major part 70 to 90 percent will get absorbed.

So, you see that if a leaf you see inside the leaf you can see a structure of leaf it has upper epidermis layer, then has palisade parenchyma, then we have spongy parenchyma and then lower epidermis. So, within, when the incident radiation get inside through the upper epidermis layer, then the red and blue part inside the cell actually used for photosynthesis. The green part which is of no use here inside, so, most of that green light gets reflected back and that is why when we look at a plant, we see green leaf. So, this is called spectral reflectance curve for vegetation.

(Refer Slide Time: 08:22)



Now, this graph will also show that how your different wavelengths will on when falls on plant leaf how it actually give you different kind of reflectance? So, in case of plant what happened that wavelengths within the NIR region near infrared region mostly get reflected or transmitted through leaves or some part gets scattered by the cell interfaces within the mesophyll tissue.

Now, as I said that the healthy leaves 40 to 60 percent of the NIR light is reflected at the canopy level. But if you look at the canopy level, the situation is more complex because range of effects such as additive reflectance, incidence angle, leaf orientation, shadow, soil background reflectance. Imagine a plant in front of you. So, it has branches, it has leaves, it gives also shadow. So, when the light falls on the top of a plant, so different kind of things happens.

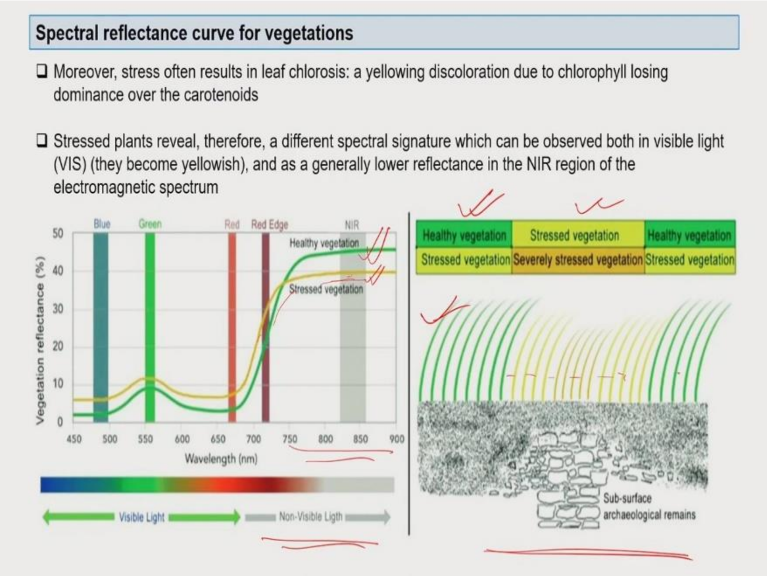
So, when you actually consider a relatively big mature tree with a lot of canopy things become a little bit complicated as far as spectral reflectance is concerned. So, plant stress also considerably changes the spectral properties of vegetation. Suppose the plant is running out of water is suppose you have not irrigated there is no rainfall. Then plant will give a different kind of reflectance because the chlorophyll pigment it rapidly decays and loses his absorption properties. If there is not appropriate moisture in the plant system, it will affect also the chlorophyll pigment and the internal structure of the leaf as well as the plant.

So, that actually what happened that it chlorophyll pigment because of certain stress may lose the absorption properties and if absorption property gets reduced, so, reflectance will increase. So, the reflectance in the green to reddish part of the visible region of the electromagnetic spectrum will get enhanced in case of stress condition.

So, you see that here also one graph it shows that blue, green, red wavelength and how different wavelength how actually reflectance takes place. So, near infrared, see coniferous trees, aquatic plants, grass and deciduous. So, different plant has different type of reflectance curve nature.

So, accordingly when we actually sends it to say satellite, so, then your sensed information or data will be different on the basis of these different properties of the plant and the plant properties also changes depending upon the condition in the soil. Because if soil does not have water plant will lose water and then entire internal structure and dynamics of the plant will change. So, accordingly the leaf structure inside leaf as I just now said that it will also change. So, the absorption and reflection, transmission properties of the plant can suddenly change because of these kind of various stress and so, your observation will be also changing.

(Refer Slide Time: 11:50)

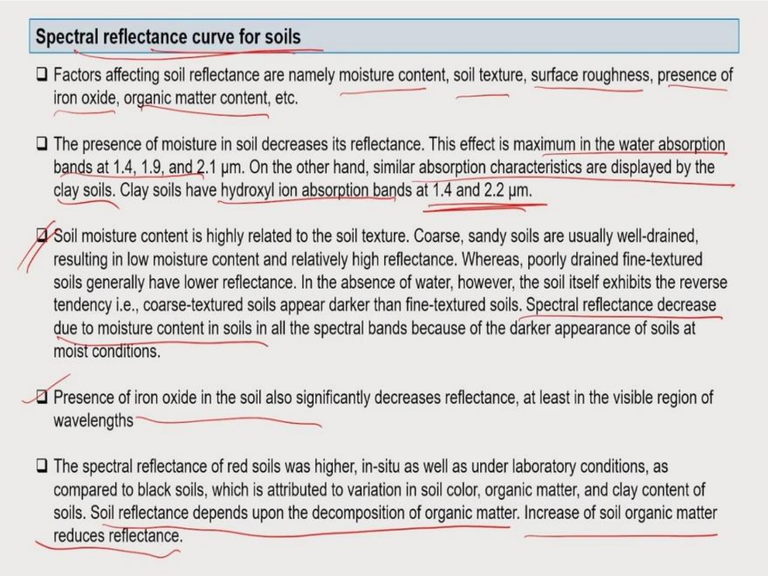


And that is what actually help us through remote sensing to estimate the condition in the field, you understand? So, that actually sometimes helps you to understand, this is the this is dry season or there is some problem with water in the field. Spectral reflectance of vegetation, when stress what happened is that often say water stress or even stress from some chemical toxicity or any other way, reason that largely leaf chlorosis or yellowing or discoloration of leaf takes place and that will certainly will get reflected also in this sensor database.

So, stressed plant reveals therefore a different type of spectral signature and that can be observed both in the visible light and as a general lower reflectance in the NIR region of the electromagnetic spectrum is observed. So, what happened is that in case of this is the green color in this picture is the reflectance curve for healthy vegetation. And this light yellow is one is for stress vegetation. So, you see that the vegetation, reflectance percentage is pretty less here in case of stress a vegetation especially in this NIR wavelength.

So, in case of visible light wavelength as you see that the reflectance percentage will be higher in case of stressed vegetation and in case of non visible wavelength or length they are the healthy vegetation is giving higher reflection percentage. So, this also is another picture which shows that in case of healthy and stressed vegetation, how actually things changes. So, these are green color is healthy vegetations and then you see the stress vegetations and again the healthy vegetation.

(Refer Slide Time: 13:50)



So, depending upon the chlorophyll nature, which is highly dictated or regulated by the stress conditions that the plant may face.

Now, let us look at the specter reflectance curve for soils. Now various factors affecting soil reflectance are moisture content, soil texture, surface roughness, presence of iron oxide, organic matter contents, etcetera. Now, the presence of moisture in soil decreases its reflectance, if soil is dry reflectance will be less.

Now, this effect is maximum in the water absorption bands that is 1.4, 1.9 and 2.1 micrometer. On the other hand, similar kind of absorption characteristics are displayed by clay soil because clay soils have hydroxyl ion absorption bands at same 1.4 and 2.2 micrometer. So, what happens that within that kind of absorption band, you get that clay soil also give similar kind of adsorption characteristics.

Now, soil moisture content is highly related to the soil texture, because we have three different type of soil texture, texture classes a course, then we have fine soil and then we have medium soil, which is largely clay, sand and silt divided into three faction. So, clay is the fine soil, sand is the coarse soil and silt is in between these two.

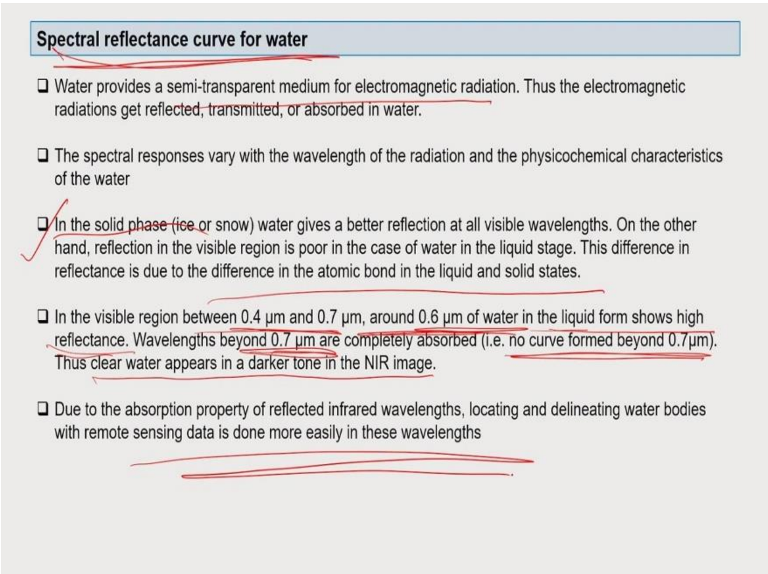
So, coarse or sandy soil are usually well drained. You put water, very quickly water will drain out. So, that means, in sandy soil moisture content of the soil will be less because you water and it goes down. So, if moisture content is raised then it will have high reflectance whereas, poorly drained fine textures heavy clay soil will general have lower reflectance and in the absence of water that means, if moisture is not there in the soil, that higher reflectance will that means, allow you to understand the soil is dry there that means water is not proper amount present in the soil.

So, that would give you a signal that probably irrigation is needed. So, coarse textured soils appear darker then fine texture soil in the remote sensing picture. Spectral reflectance it decreases due to moisture content in soil, remember that. Spectral reflectance decreases due to moisture content in the soil in all the spectrum band because of what because of the darker appearance of soil at moist condition. If water is there, it looks dark. So, the reflectance is less.

So, less reflectance when you are getting on the soil, that means your water is having lot of water, moisture in the soil. So, presence of iron oxide in the soil is also significantly decreases the reflectance at least in the visible region of the wavelengths. And also the spectral reflectance of red soil, we have red soil many parts of our country. So, the spectral reflectance of red soil generally higher as compared to the black soil. And this happens due to the variation in soil color, organic matter content, clay content.

So, soil reflectance that means depends upon decomposition of organic matter quite significantly. Increase of soil organic matter will reduce your reflectance. So, see, if reflectance is less then there are a few condition that can happen. One is moisture could be in high amount, organic matter could be there or it could be clay soil. So, these kind of situations could appear and of course, it should be followed up backed up by your ground truthing.

(Refer Slide Time: 18:17)

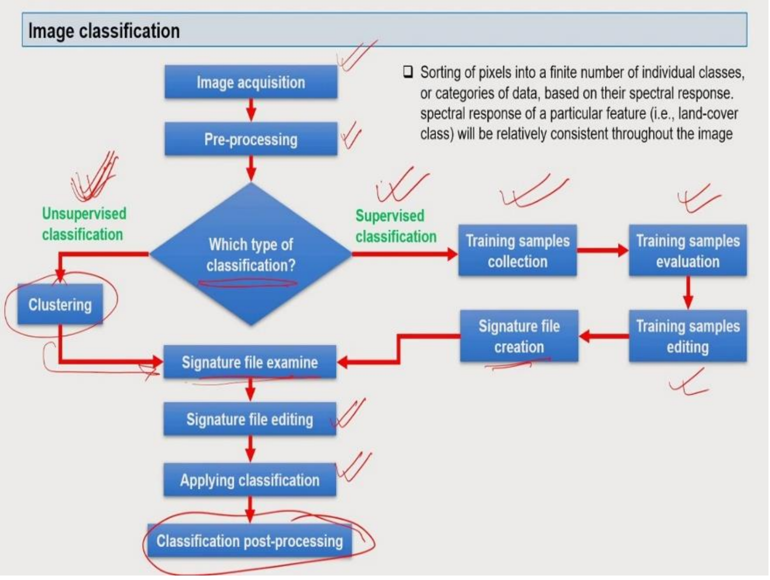


Now, let us see how spectral reflectance curve of water. Now water provides semi transparent medium for electromagnetic radiation. So, electromagnetic radiation when it falls on water get reflected, transmitted or absorbed in water. Now, the spectral responses from the water body for various wavelength of the radiation will have different type of reflectance. Also, the physico-chemical characteristics of the water itself also will decide how much actually spectral responses or reflectance will take place. Water when it presents in suppose solid phase like ice or snow this gives a better reflection so reflectance at all visible wavelengths.

On the other hand reflection in the visible region is poor in the case of water in the liquid stage just now we discuss, it will be like giving dark impression. So, these difference in reflectance is due to the difference in the atomic bond in the liquid and solid states. If you see that in the visible region, between 0.4 micrometer to 0.7 micrometer and especially around 0.6 micrometer, the water in the liquid from shows very high reflectance and wavelengths beyond 0.7 micrometer are completely absorbed.

So, that means no reflectance curves will be formed beyond wavelength of 0.7 micrometer and that is the reason clear water appears in a darker tone in near infrared image. So, due to this absorption property of reflected infrared wavelengths, locating and delineating water bodies with remote sensing data is done more easily in these wavelengths. So, infrared, near infrared wavelengths, help us locating delineating water bodies, remote sensing data and we can do it much more easily.

(Refer Slide Time: 20:38)

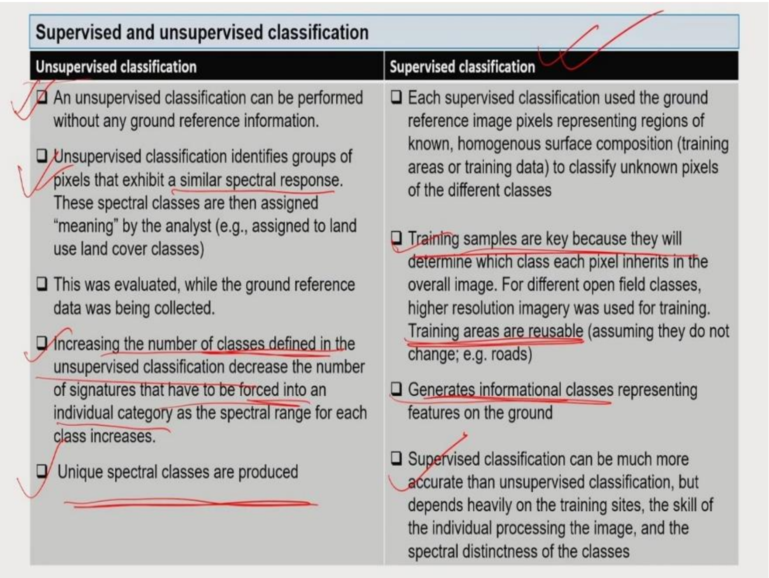


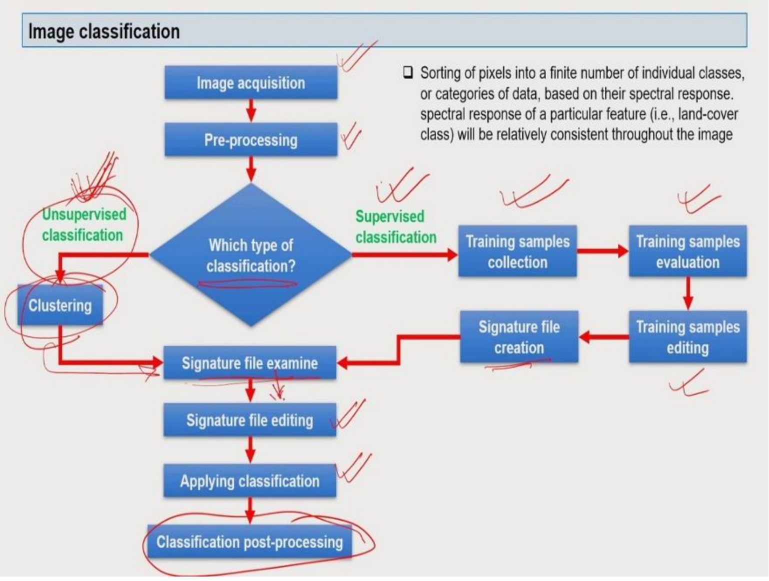
Next section is image classification, this is again very important, part of remote sensing for especially, when you go to study natural resources. So, we need to know a various important steps of image classification, we will not go into the detail, because this is not the scope of this course. In within NRM course, the GIS remote sensing I have kept just to introduce you as a tool for natural resource management. So, while doing so, little bit of inside aspects I am sharing with you. But the detail aspect of remote sensing will you need to go through remote sensing course separately.

Now, what we actually do in image classification that first image acquisition. You get the image, then you go for pre-processing, then you go which type of classification that we require supervised classification, unsupervised classification or supervised classification, you have to decide that. Suppose you go for supervised classification, you follow this route, you go for then training sample collections, training sample evaluation. Samples editing means the pictures that you have got from the remote sensors, then signature file creations. And then you send it to the signature file examination stage.

Similar way if you go for unsupervised classification, then you go for clustering process and from here you go to again this type signature file examination process, after this you go for file editing, signature file editing, then you apply classification. And then finally, you go for classification, post processing, and your image classification processes done. But these sounds very easy, but it is really a time consuming process. If you become an expert of remote sensing these days, various tools are available and that makes your task much easier.

(Refer Slide Time: 22:48)





Now, let us see the characteristics of supervised versus unsupervised classification of images. Now, if you look at the supervised classification, what it says is a classification, unsupervised classification can be performed without any ground reference information means you do not need the ground reality information to classify your image.

Unsupervised classification identifies groups of pixels that actually exhibit similar kind of spectral response. And these spectral classes are then assigned means meaning by the analysis for example, assigned to land use, land cover classes, the person. Suppose you are doing it you will assign to those pixels in the image so, that you will assign.

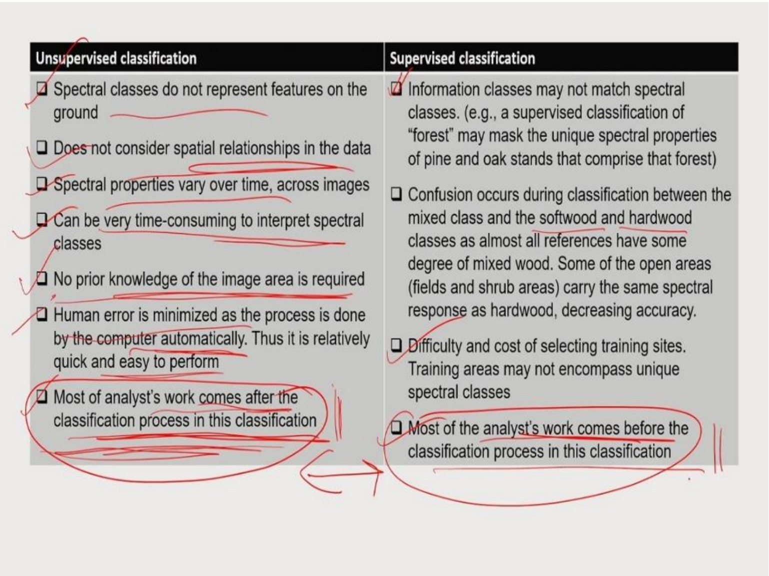
Now, once this was evaluated, while the ground reference data actually was being collected. Now, increasing the number of classes defined in the unsupervised classification decreases the number of signatures that have to be forced into an individual category as a spectral image for each of the class. I repeat again, increasing the number of classes defining the inside the unsupervised classification will decrease the number of signatures which have to be forced into an individual category as the spectral range for each class increases, see here.

So here unsupervised you go for clustering and then you go for signature, examination, editing. So, signatures step is important. Then unique spectral classes are produced in case of unsupervised. Now, let us see the supervised classification. Each supervised classification, used the ground reference image pixel representing the regions of our known or homogeneous surface composition. Means, we know that there are supposed thousands of mango trees are there. So, that image you are processing it.

So, in case of supervised classification, you will have a ground reference of each pixel. Then you training samples here are very important because those will determined which class of each pixel will actually inherit in overall image. So, the training samples will actually determine, which class each pixel will go. So, for different open field classes higher resolution imaginary are generally used for training purpose, and training areas are also reusable.

In case of supervised classification, it generates information classes representing the features of the ground. So, you can actually represent the ground features which are actually there in reality. Supervised classification can be much more accurate than unsupervised classification, but it depends heavily on the training sites unlike unsupervised classification. The skill of the individual who is processing the image are actually deciding factor. So, the person who is working with supervised classification has to be really sound in technique. So, good amount of training is required while going for supervised classification.

(Refer Slide Time: 26:49)



In unsupervised classification, spectral classes do not represent the features on the ground, ground information is also not that much necessary. It does not consider spatial relationships in within the data. That is an important point to remember. Spectral properties in case of unsupervised image, unsupervised classification, spectral properties vary over time across the images.

And unsupervised classification also can be very time-consuming to interpret the spectral classes. You have to do lots of processing, lot of analysis. No prior knowledge of the image area is required for unsupervised. I just mentioned, which is other way is your ground information.

Human error in case of unsupervised classification is minimized, as this process is done by the computer automatically. And that is why it is relatively quick and easy to perform. Most of the analyst work comes after the classification process happens in unsupervised classification, then actual work starts.

Whereas, supervised classification, the information classes may not match the spectral classes. Confusion may also occur during the classification between mix classes and the soft wood or hardwood classes, because almost all references have some degree of mix wood.

Some of the open areas you will carry the same spectral responses as suppose hardwood in the forest, suppose you are considering about a forest area. So, the softwood, hardwood classes almost all reference have same degree of mixed wood and that could be sometimes bit confusing to identify.

Now, difficulty and cost of selecting training sites is an issue in supervised classification. Training areas may not encompass the unique spectral classes and most of the analyst work comes before the classification process in supervised classification. So, this is one of the significant difference between unsupervised and supervised classification. In unsupervised classification, most of the analyst work comes after the classification process, in case of supervised before the classification process. So, this thing actually, we need to remember.