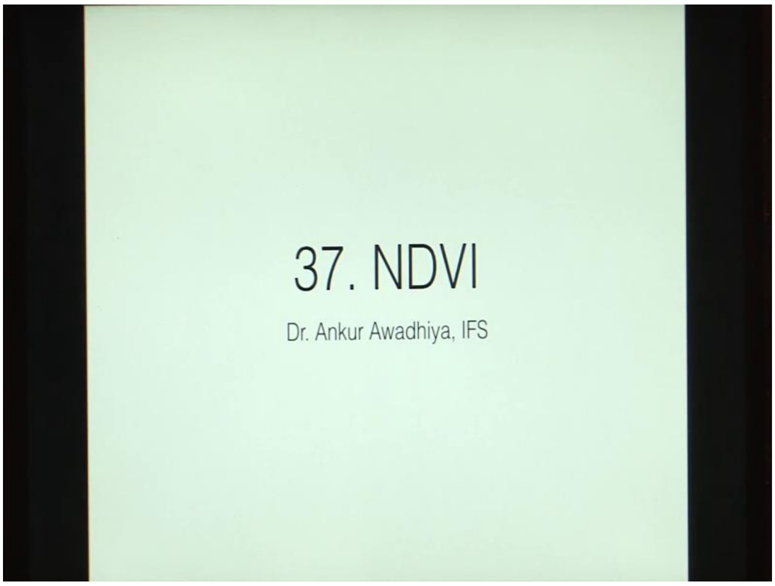
Forest Biometry

Prof. Mainak Das
Dr. Ankur Awadhiya
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture - 37
Normalized Difference Vegetation Index (NDVI)

[FL]. In today's session we will have a look at NDVI which stands for normalized difference vegetation index.

(Refer Slide Time: 00:19)

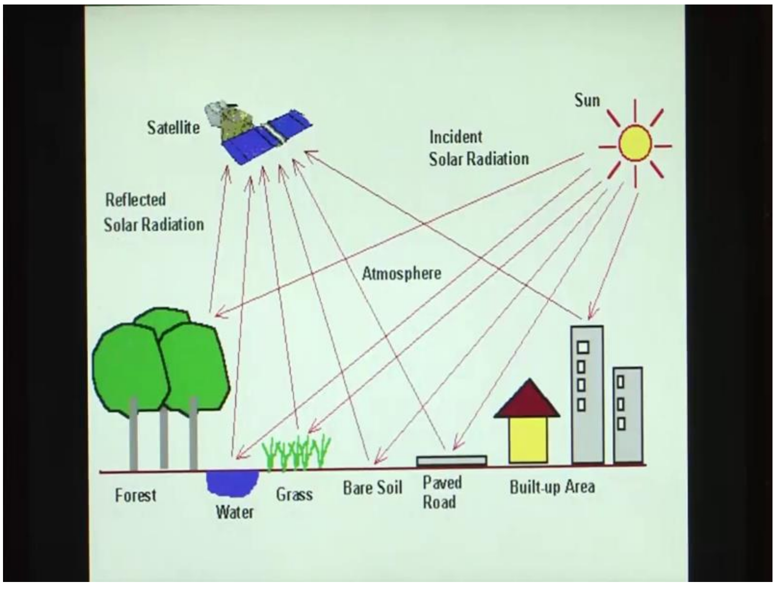


So, as we can see in this slide.

(Refer Slide Time: 00:24)

Leaves are green in color, now this is because they absorb red and blue ends of the visible spectrum and reflect the middle green portion. So, can we use these spectral qualities, to remotely discern information about our forests? So, this is an application of photogrammetry, in which we are trying to use these difference spectral qualities to discern information about our forests.

(Refer Slide Time: 00:52)

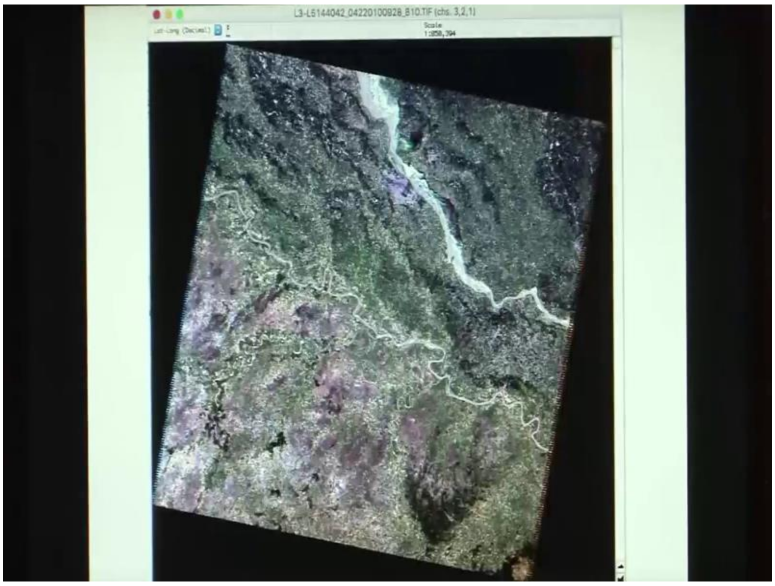


So, how does it this work? We are trying to use data as received by satellites to get an idea of our forests.

So, in this image you can see that we have the sun that is giving out incident solar radiation towards the earth, which goes through the atmosphere and then it interacts with various surfaces. So, it is interacting with the built up area, it is interacting with roads with soil with grass water forests and so, on. After the interaction all these different surfaces are reflecting this radiation. So, this reflected solar radiation then goes back to the satellites. The sensors used in the satellites can be active sensors using energy or passive sensors utilizing sunlight as reflected from various surfaces. So, in this image what we are seeing is a passive sensor.

So, this passive sensor is utilizing the energy of sun, to get information about these various surfaces. On the other hand we could also be having active sensors into in the case of active sensors they might be giving out some radiation, say microwave radiation or say radio waves or some other things. So, that radiation goes to your object it interacts with the surface and the radiation that comes back from the object is then again measured. So, considering the passive sensors because they are mostly used, how does the earth look from up above there.

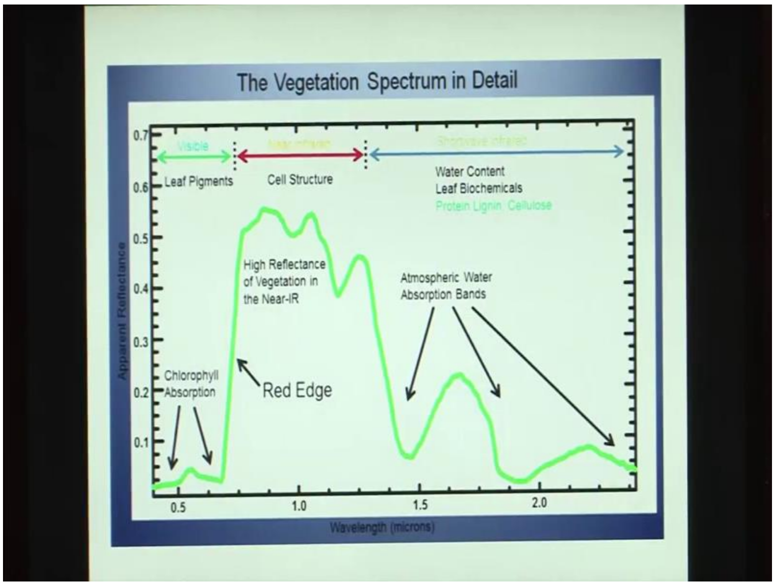
(Refer Slide Time: 02:16)



So, this is a true color composite of what you will see from a great height. So, this depicts the how the earth surface would appear to the human eye.

So, we are seeing various colors in this image. So, the blue color in this image is showing us the river Ganga, the green colors are showing us different kinds of vegetation and so on.

(Refer Slide Time: 02:44)

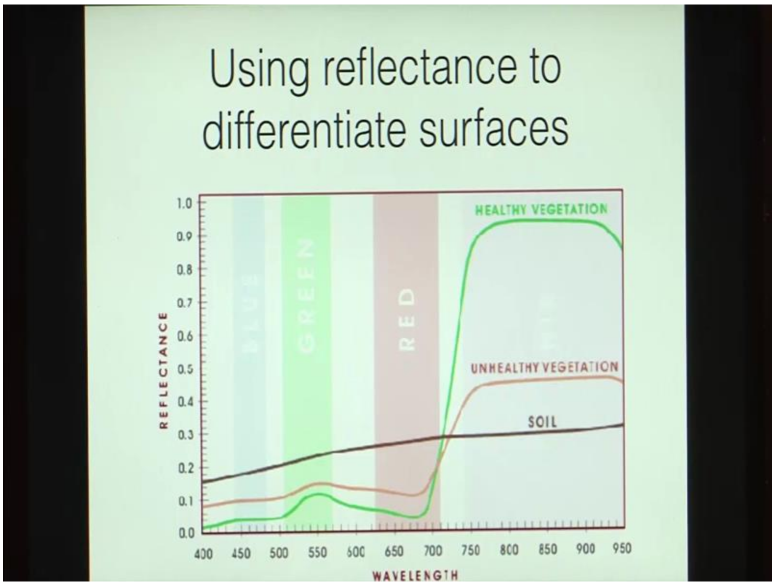


So, now if we try to look at the vegetation spectrum in greater detail, what do we see this image is showing you different radiations as or different wavelengths as are reflected from vegetation. So, as we can see if we move from left to right, we can see that we have chlorophyll absorption followed by an edge towards this near infrared portion. So, in the visible spectrum the leaf pigments dominate. So, that is why we are seeing the green colors. In the near infrared portion the cell structure dominates.

So, our trees give out lots of radiation reflected in the form of near infrared wavelengths, then as we move towards the right we have the shortwave infrared that is more affected by the water content, the leaf bio chemicals, the proteins lignin, and cellulose as are found in the tree cells. So, can we use these? So, what we see in this image is called the vegetation spectrum. So, this is a spectral signature of one particular surface that is the leaf surface.

So, every object has a different spectral signature. So, can we use these spectral signatures to differentiate various objects? So, this is what we see in the next slide.

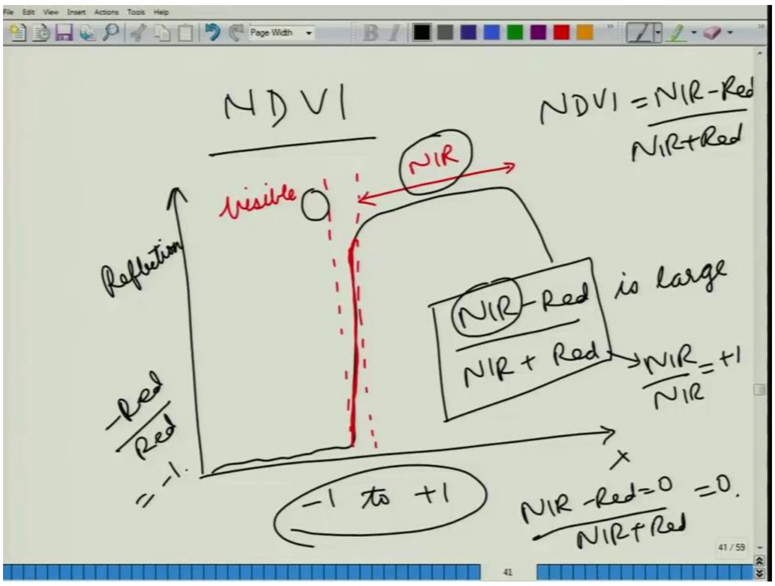
(Refer Slide Time: 04:11)



So here we are saying the spectral signatures of healthy vegetation unhealthy vegetation and soil. So, all these three have very different spectral signatures.

So, if I gave you the spectral signature of soil, you will be able to say that this is not leaf. So, we can use spectral signatures to differentiate between various of surfaces, but can we have a single index to analyze vegetation that we are interested in. So, that index is called the NDVI.

(Refer Slide Time: 04:43)

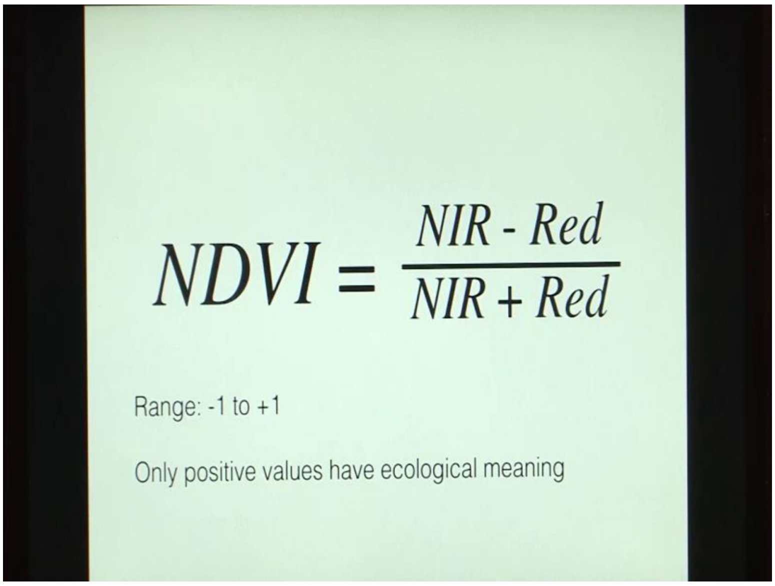


What do we do in the case of NDVI? So, if we plotted the spectral signature it would go something like this then it should have a very high peak and then it would go down. So, this portion is the near infrared and here we are having the visible spectrum. So, we are interested in using this edge to discern vegetation.

So, this NDVI is defined as NDVI is equal to NIR minus red upon NIR plus red. So, what do we get here? So, in the case of leaves we have a very high spectral signature in NIR, and a very low spectral signature in the case of red. So, NIR minus red is large now we divided by NIR plus red. So, this whole thing NIR minus red upon NIR plus red it would be a large value. Now what can be the theoretical range of this value what can be the theoretical range of NDVI. So, this NDVI can go from minus 1 to plus 1. So, for instance suppose our red value was 0. So, in that case it would become NIR upon NIR is equal to plus 1, suppose our NIR red was 0.

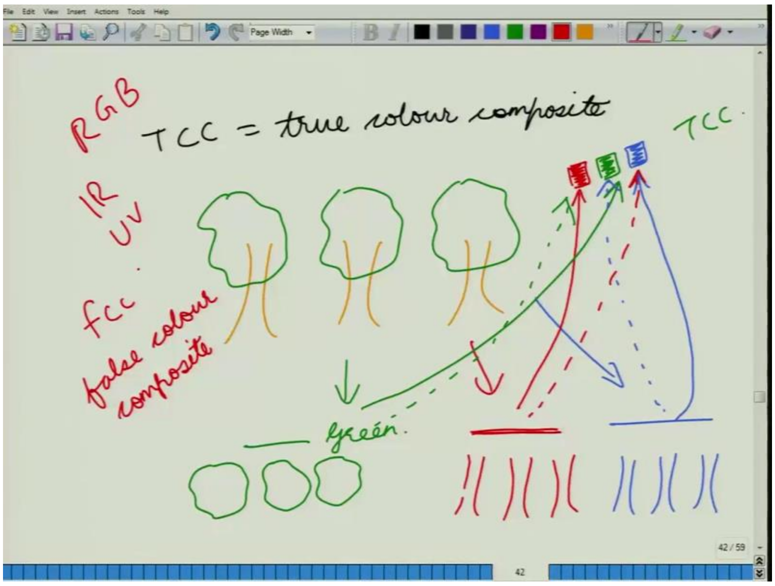
So, in that case we would have NIR minus red which is equal to 0 divided by NIR plus red. So, this whole value will become 0. On the other hand suppose we have our NIR value itself was 0 and red was having some positive value. So, in that case we would have the value as equal to minus red upon red, which will be equal to minus 1. So, the range of the values of NDVI goes from minus 1 to plus 1. Now only positive values have ecological meanings.

(Refer Slide Time: 07:13)



So, now coming back to how the earth looks from up over there, this is a true color composite. So, in the case of a true color composite what we do is that any radiation that we measure in the green channel is shown in the green channel any radiation that we measure in the blue channel is shown in the blue channel any radiation that we measure in the red channel is shown in the red channel, which gives us ATCC which is a true color composite.

(Refer Slide Time: 07:42)



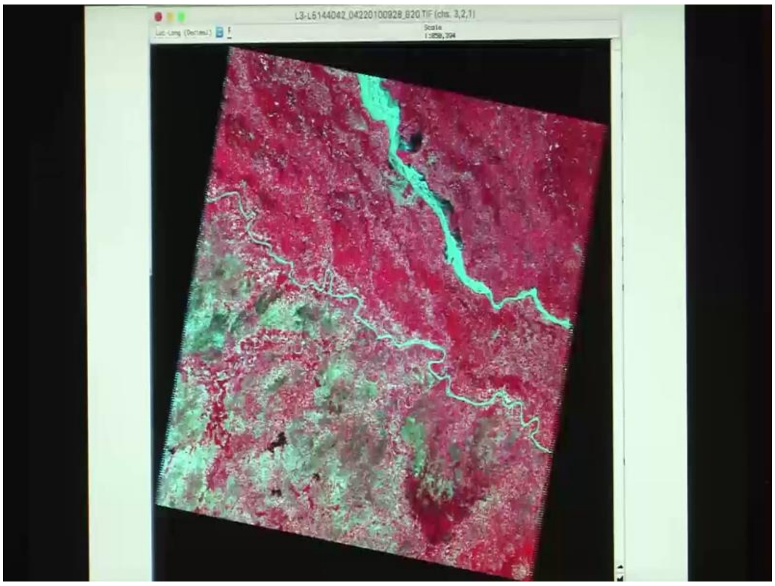
Now to understand what this TCC means let us do an experiment. So, suppose you had trees; now suppose you set your camera such that it only measures the green signal. So, let us set our camera to measure green what would it figure out? It will not be able to see the stems it will only be giving us the green portions now suppose you state your camera to look at red.

So, in the case of red you will be seeing some portion of the stems, similarly if you set it to look at blue it might also be showing you some portions of the stem. Now when you project this image on say your computer screen and suppose in the case of your computer screen you have pixels that can show red green and blue. Now if you fade this blue channel information to the blue pixels the red channel information to the red pixels and the green channel information to the green pixels then it would give you a TCC. On the other hand suppose you mixed up these channels. So, what you do in this case is that you take the green channel.

And you depict it on to red then you take the blue channel you depict it on the green, and then you take the red channel and you depict it on the blue. So, this would give you an image that is not something that you are very naturalized to seeing. So, it would give you something that is again a picture, but it is a very unnatural sort of a picture. So, that would be called an FCC or a false color composite. Now in the case of our human eyes we can see only those radiations that come under the visible spectrum, but in the case of cameras you can even have sensors that can look into the ultraviolet range or say the infrared range.

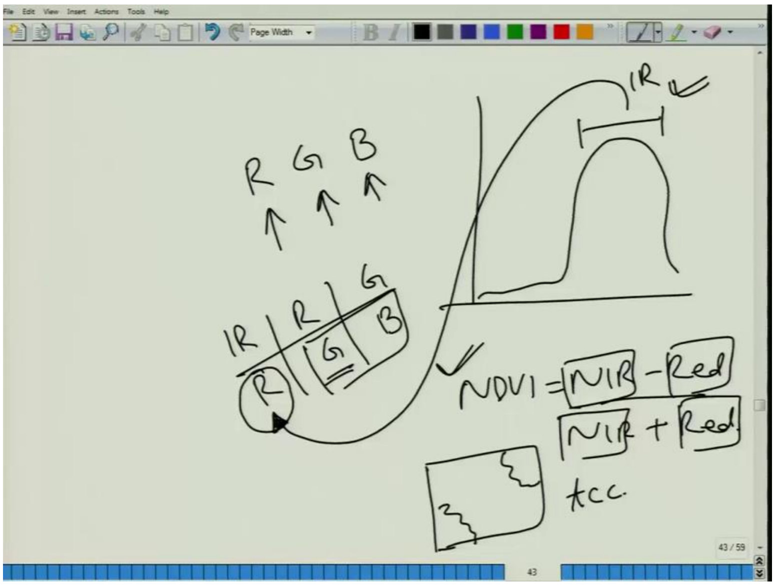
So, in the case of cameras these channels are not just RG and B, but it can also be infrared it can also be UV or it can be anything else. So, let us now have a look at our NFCC.

(Refer Slide Time: 10:46)



So, this picture in on your side this shows you in FCC. So, this is a standard FCC. So, in the case of a standard FCC what we do is this.

(Refer Slide Time: 10:59)



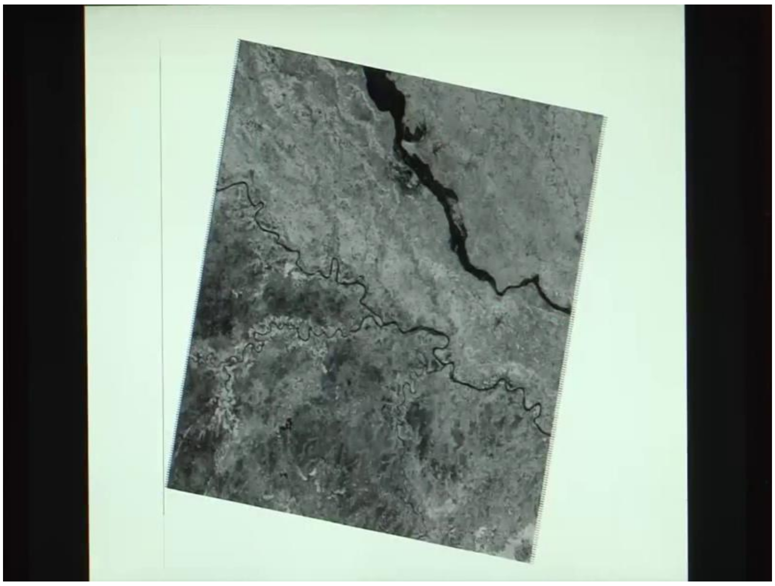
So, normally we have RG and B and we are showing red here green here and blue here. In the case of standard FCC we show infrared red and green as red green and blue. So, what does that mean? Now coming back to our curve of the visible spectrum the near infrared portion is very large, in the case of the reflected curve. So, this portion would be shown as red in your image anything that was red would be shown in the green channel and anything that was infrared in green.

So, anything that is infrared is shown in the red channel, anything that is red is shown in the green channel and anything that is green is shown in the blue channel. So, what would this do? Because your plants are giving out lot of reflection in the infrared range, anywhere where you have plants would be shown in red color, and other surfaces would be shown in green and blue colors.

So, now, coming back to the slide, here we can see that right next to the river. So, here we are seeing the river as a very bright blue in color and right next to it we can see lots of red patches. Now these red patches are trees. So, in a standard FCC we can say that wherever we are seeing red color that is the trees, now how would this image look if we just depicted the NDVI values.

So, now remember the position of the river, river here is in blue color and the trees are there in red color.

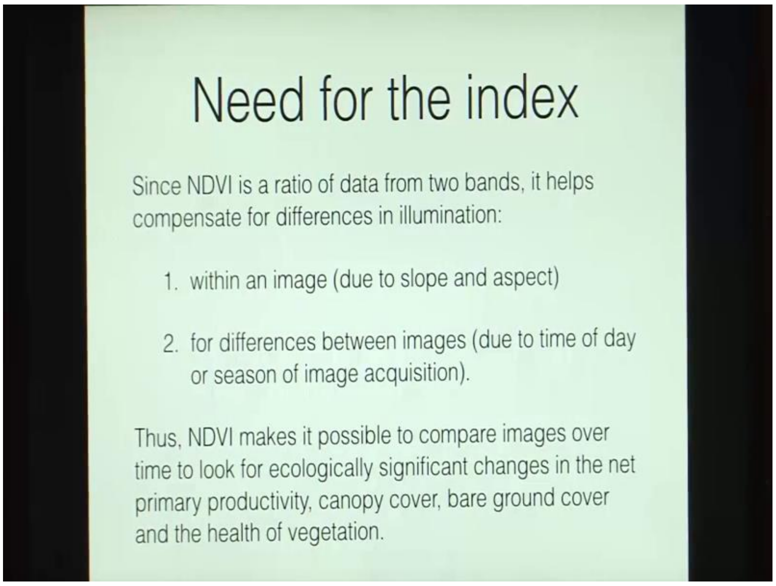
(Refer Slide Time: 12:42)



So, let us now look at an NDVI image. So, in this NDVI image the river is looking black in color which means its NDVI value is 0 whereas, the trees are now showing some NDVI value. So, this image is a grayscale image which goes from 0 to 1. So, anything that is 1 would be shown in white, anything that is 0 will be shown in black and anything that lies in between will be showing a grey color.

So, here we can see that anything that is not vegetation would be looking blackish in color, anything that is vegetation would be looking in a greyish or whitish color, and anything in between would be showing some different hue. So, this is an NDVI indexed image. So, why do we need this?

(Refer Slide Time: 13:33)

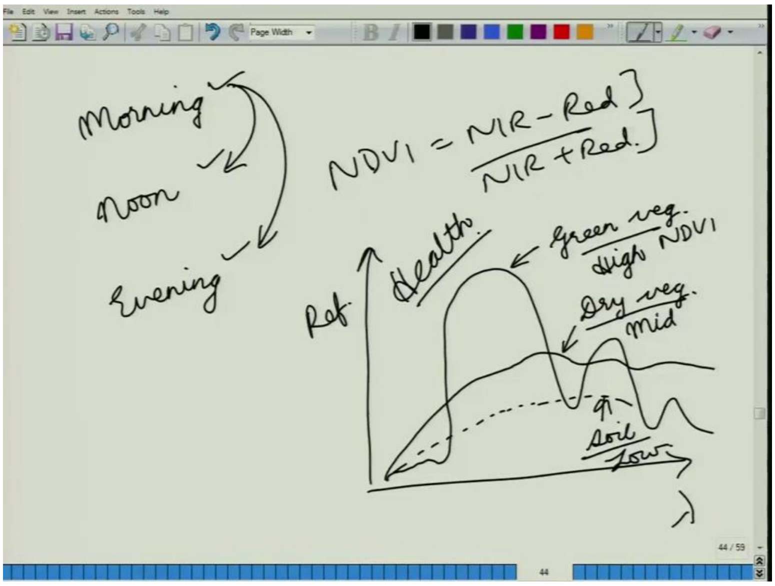


Index since NDVI is the ratio of data from two bands; it helps to compensate for differences in illumination. So, basically we have NDVI is equal to NIR minus red divided by NIR plus red. Now because this is a ratio it helps to compensate for differences in illumination. So, for instance if you had one image and this portion was more brightly lit as compared to this portion.

So, if you had just the image in the case of a TCC, it would be difficult to know whether these dark areas were because of darkness or because of a different material, but here because we are using a ratio. So, it helps compensate for both of these, anything that was dark would be having lesser NIR values and lesser red values. So, the whole because we are dividing it by NIR plus red, it will not matter whether it was brightly illuminated or slightly lesser illuminated. So, it can help compensate for differences in illumination within an image now this difference in illumination could be because of slope or because of aspect as well.

However, it is also important because it helps to compensate for differences in illumination, because of differences between images due to time of day or season of image acquisition. So, for instance you took one image that was taken in morning and another that was taken in noon and say another that was taken in evening.

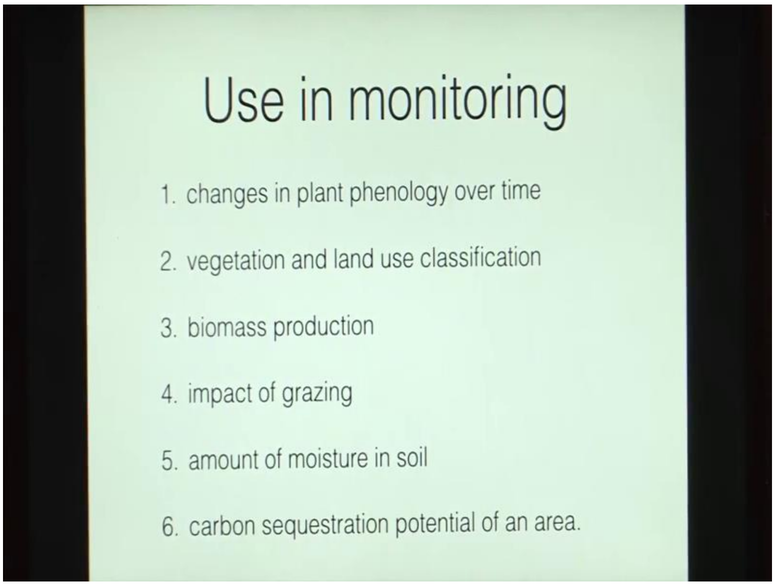
(Refer Slide Time: 15:11)



So, because we are using this ratio NDVI is equal to NIR minus red upon NIR plus red. So, it does not matter whether you are taking of the morning image or the noon image or the evening image because the differences in illumination between these images would be covered by this ratio.

So, you can compare the morning image with the noon image and with the evening image and so on. So, coming back to the slide, NDVI makes it possible to compare images over time. To look for ecologically significant changes in the net primary productivity; net primary productivity refers to how much of the sunlight is being converted by vegetation into biomass. So, that is the net primary productivity, it can tell us ecologically significant changes in canopy cover, bare ground cover and the health of the vegetation. So, where do we use NDVI?

(Refer Slide Time: 16:22)

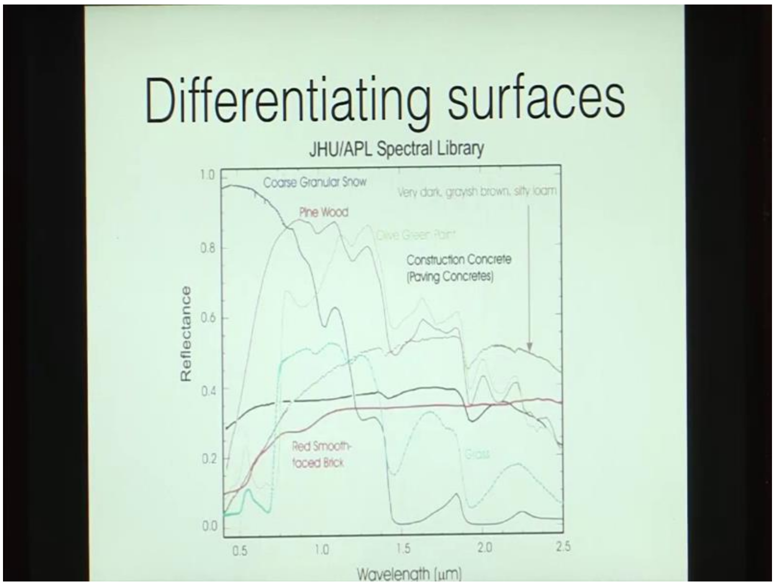


We use it in monitoring changes in plant phenology over time vegetation and land use classification, so for instance if your NDVI value changed from say 0 towards 1. So, it means that the amount of vegetation that is there on your chunk of land has increased. So, probably that land is now being used for cultivation or it has grown into forest. Now the good thing about NDVI is that suppose you saw the top of a building that was painted in green color.

So, in our true color composite we will not be able to differentiate whether that green color is because of green colored paint or because of vegetation, but your NDVI will be very easily able to discern whether that green color is because of vegetation or because of the paint.

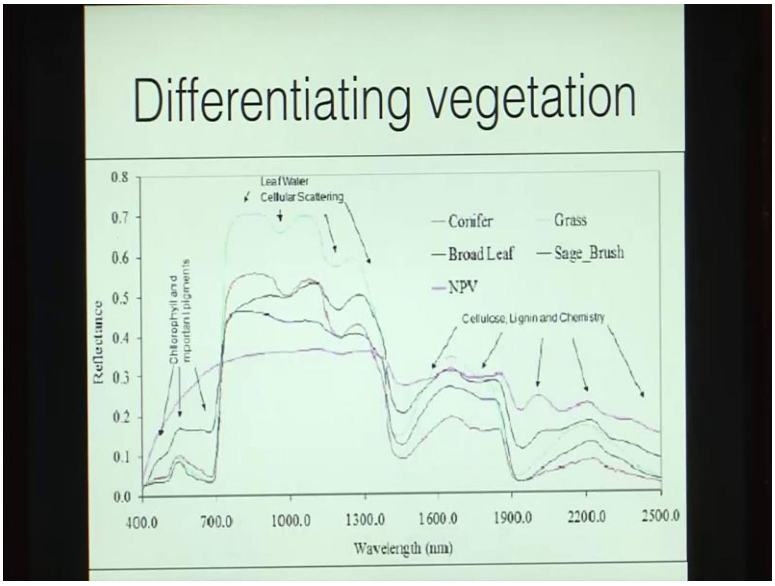
Because in the case of vegetation, it will be towards positive one value in the case of paint it will be nearly 0 values. Now coming back, back to the slide NDVI is also used in monitoring biomass production, which you can get from the amount of bio by the amount of vegetation that is there, it can tell you the impacts of grazing, it can also tell you about the amount of moisture in soil because if there is more moisture in the soil it will result in more vegetation doing, it can also tell you the carbon sequestration potential of an area. So, these are all the derived products that we can get from NDVI it also helps us in differentiating surfaces.

(Refer Slide Time: 17:53)



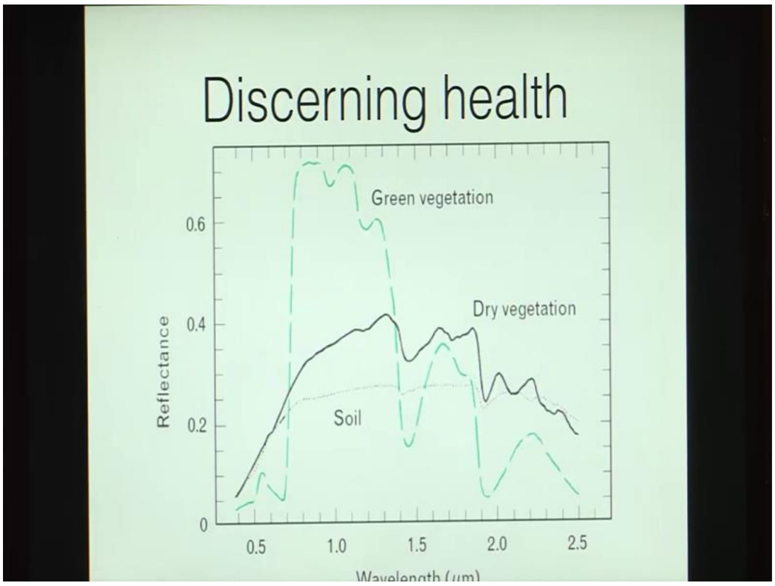
So, for instance this image tells you the spectral signatures of pine wood then it also shows you olive green colored paint, construction concrete grass and so on. So, as you can see the reflectance values for all of these are different, and so the NDVI values of all of these will also be different.

(Refer Slide Time: 18:23)



Now NDVI can also be used in differentiating vegetation and the health of plants, because if you look at different vegetations like conifers, broad leaves and grass sagebrush and so on. So, all these vegetations are having different spectral signatures would which would result in different NDVI values of all of these. So, just by looking at NDVI values we would be very close to differentiating these vegetations.

(Refer Slide Time: 18:53)



It also helps you to understand the health of the trees. So, for instance the green vegetation dry vegetation and soil are shown in this chart. So, green vegetation shows us the generalized reflectance curve, reflectance versus wavelength. So, in the case of a green vegetation it will grow like this. So, this would be for a green vegetation. In the case of a dry vegetation it goes like this whereas, in the case of soil it goes like this. Now if we calculated the NDVI values green vegetation will give us high NDVI values, dry vegetation will give us middle NDVI values whereas, soil will give us low NDVI values.

So, just by looking at the same spot over different points of time, and by using this NDVI values which helps us to counter any differences in illumination over these time periods, we would be able to compare these spots at different time points. So, that would tell us how the health of the vegetation is changing with time, is it becoming more healthy with time in which case it the NDVI values will go on increasing or do we see some sort of stress in which case the NDVI values will go down for the same spot.

Now remember that in the case of a TCC or in FCC, it would be very difficult to compare between the same spot at two different time points, because any difference could be because of differences in illumination.

But because we are using NDVI which is cancelling out these differences of illumination, we would be very easily able to compare the same spot in different time points. So, it also helps us in discerning the health of the plants.

Thank you for your attention. [FL].