Forests and Their Management
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Module - 05
Forest Surveying
Lecture - 14
Photogrammetry

[FL] We move forward our discussion of the methods of forest surveying and today will have a look at the method of Photogrammetry.

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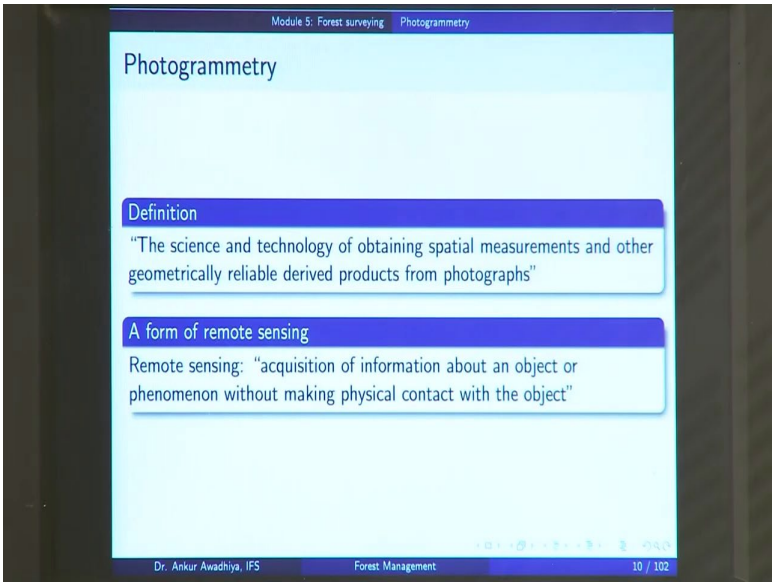

The photogrammetry is defined as, "the science and technology of obtaining special measurements and other geometrically reliable derived products from photographs." So, it is the science and technology of obtaining what? - spatial measurements that is measurements over the space, both in 2 dimensions and in 3 dimensions.

So, the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs. So, you take photographs and you measure them to get an idea of the spatial - the spatial locations or the spatial distribution of different objects on the photograph. It is a form of remote sensing or the acquisition of information about an object or phenomenon without making a physical contact with the object.

So, what we are saying here is that because you are using photographs, and in the case of a photograph you are not touching the object.

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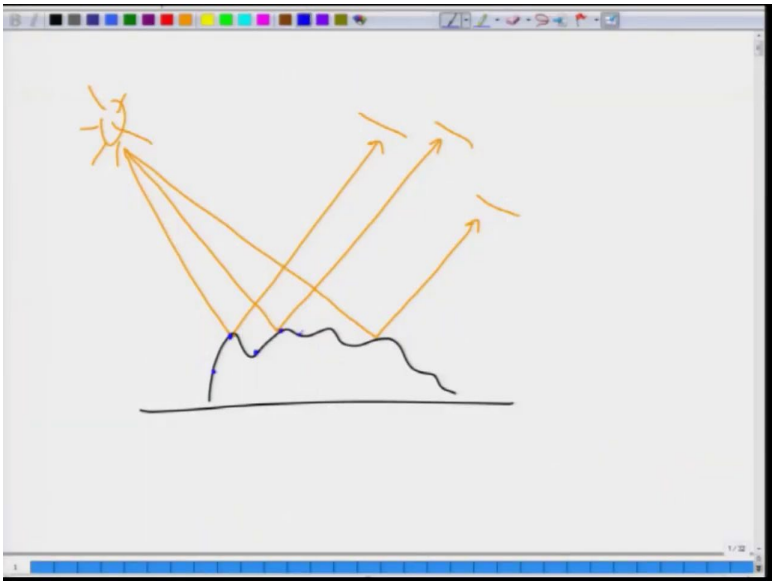

So, you have a situation in which you have certain objects here on the surface of the earth, and you are taking different photographs. So, let us see that here you have the sun. So, the sunlight is getting reflected from different objects, and you are taking different photographs. So, you take a photograph 1, 2, 3 and so on.

And, you are making use of all these photographs to figure out how these different points on these on the surface are located. So, you want to find out the x, y and z coordinates of each and every point that is there on the surface, and you are doing all of this without touching the surface, you are doing it from a distance.

So, it is a method that is using remote sensing or sensing from a distance; and, the aim is to find out the x, y, z coordinates of different points. Or, in other words we can say that spatial arrangement and the spatial distribution of different points on the surface.

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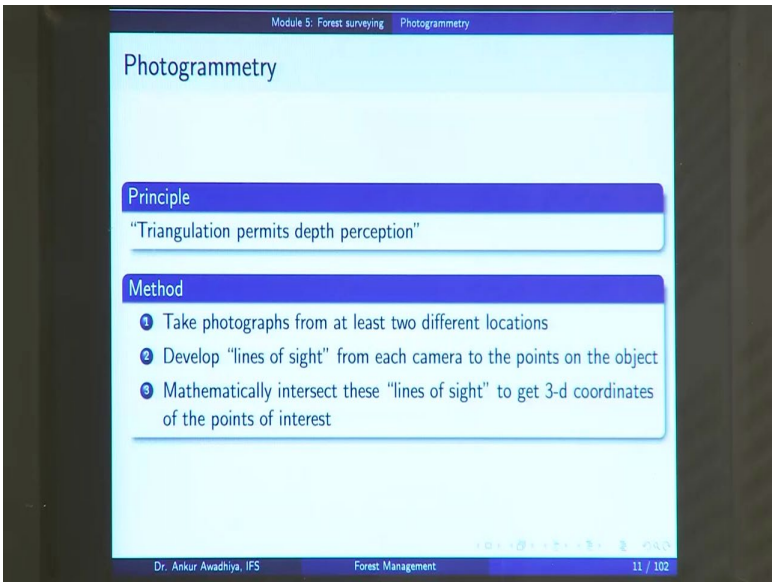

The principle that it uses is triangulation. So, in the process of triangulation you are able to perceive depth. Now, what is that mean? So, for instance, you are looking at one object and you are looking at it from two different points.

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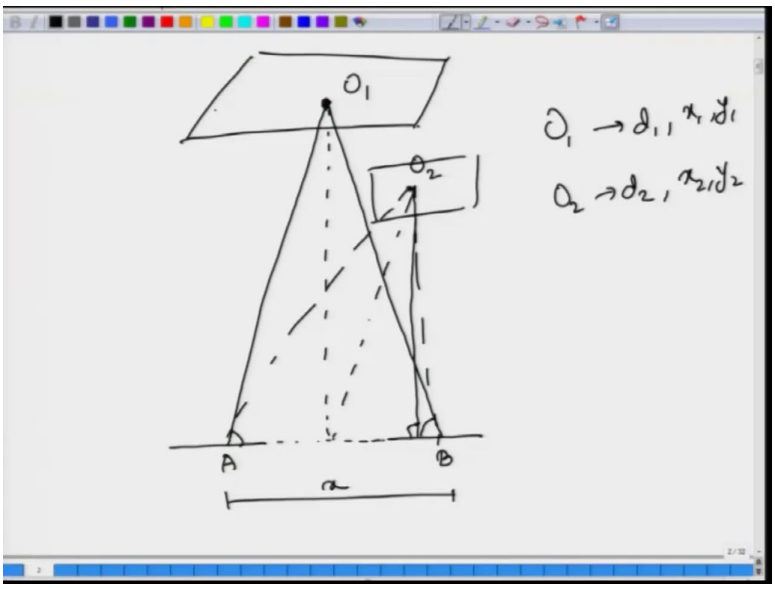

So, you are looking at this object. So, you are taking one photograph or let us make it in a plain surface. So, you are having one photograph and getting another photograph. Now, by making use of these two photographs, if you know the angle that is being subtended by this object; let us call it O at points A and B.

And if you know this distance x between A and B, then you can find out the location of O, and in this case, you get the depth of this object or the distance of this object from the AB plane. So, this is the method of triangulation. And in the case of photogrammetry what we are doing is that we take multiple photographs and we process that those photographs, in such a way that we are making use of the principles of triangulation to figure out the depth or the distance of different objects from these from the surface of these photographs.

So, if we do that, we will get that say point O1. So, point O1 is located at a distance of d1, and you are also getting the x1 and y1 that is the coordinates of this point on this surface.

Let us say that you have an object O2 here which is lying on this surface and you are getting the distance. So, you are getting that this is at a distance of d2, or if you want to have a perpendicular distance it is at a distance of d2 and it has the x and y coordinates is as x2 and y2. So, if you have these information for different points on the surface, you will be able to measure the surface; you will be able to get a 3 dimensional view of that surface.

Now, how does this method of photogrammetry work? You take photographs from at least two different locations and develop lines of sight from each camera to the points on the object. And then, you mathematically intersect these lines of sight to get 3D coordinates of the points of interest. So, this is what we just discussed, you are using different photographs, and these photographs need to be taken from at least two different locations. And, once you have those you develop lines of sight from each camera to the points on the object and you figure out what is the distance of those points from the camera, by mathematically intersecting the lines of sight to get 3D coordinates of the point of interest.

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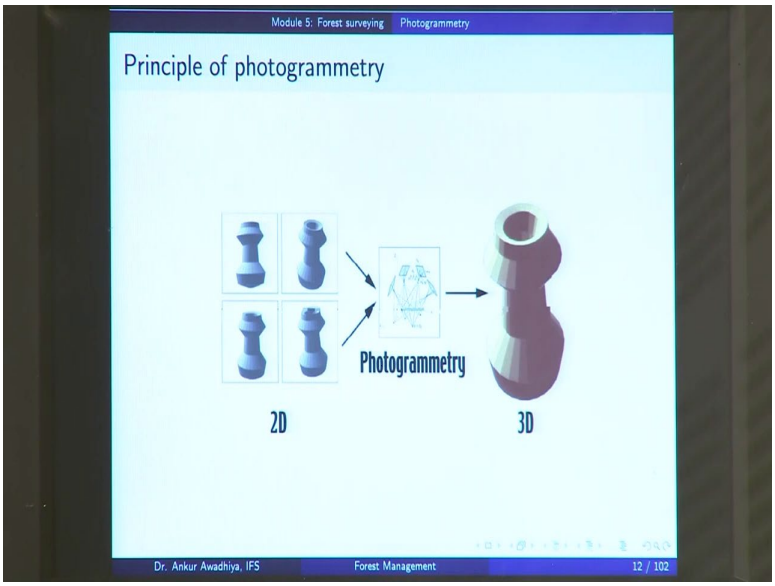

So, what we are saying here is that suppose you have this object, and you are taking photographs from different locations. Now, once you have these photographs these photographs are 2-dimensional representations of this object, but then you develop these photographs, you process them mathematically, and do the technique of photogrammetry. So, that you get a 3-dimensional representation of this object.

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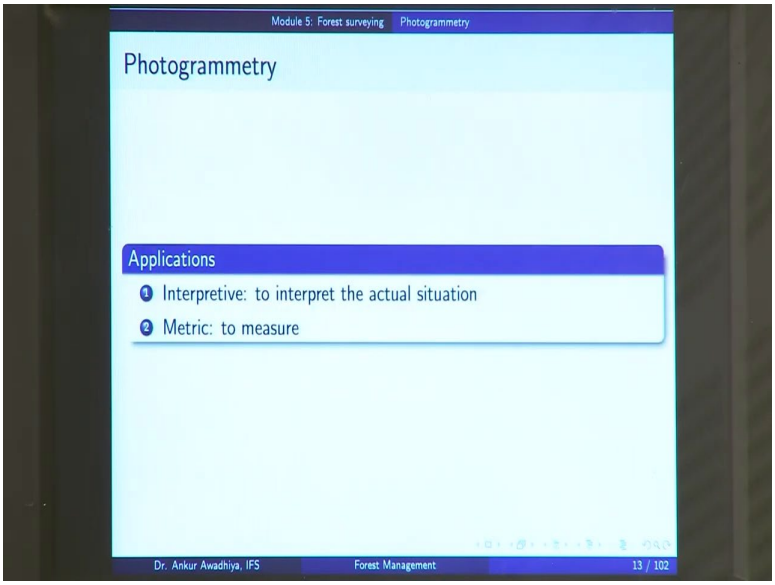

And, there are two applications of photogrammetry. You can use it for interpretation of the surface. So, you can, for instance, if you are doing photogrammetry of a forest area,

so, you can do an interpretation and you want to figure out what how many trees are there per unit hectare of the land. So, that can be done or you can do it to take measurements that is what is the what is the distance between two trees.

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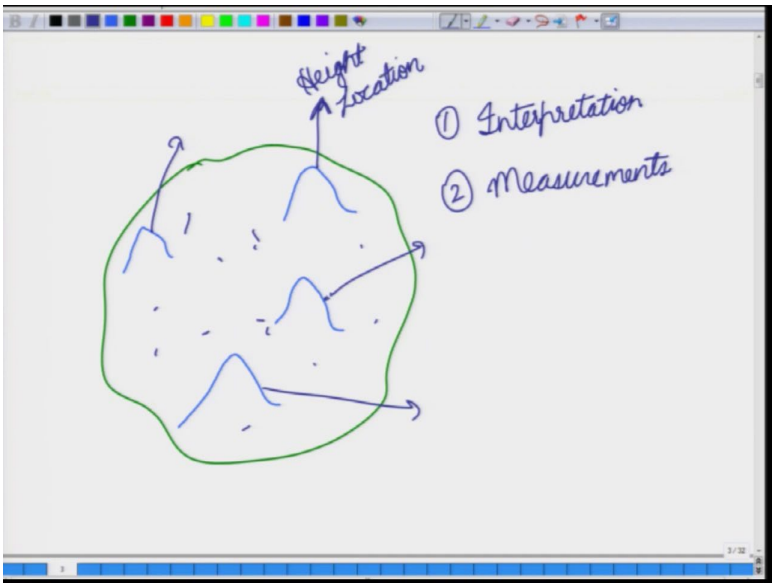

So, what we are saying here is that, if you have this forest and you are doing photogrammetry, so, you will probably be getting a different heights of different points. So, you are getting a 3-dimensional surface, and in that case, you are trying to use this method to gain two insights. One is interpretive or interpretation of this surface; so, in this case, you will say that this is a hill; this is a hill; this is a hill; this is a hill, but this is the plain area. So, this is an interpretation that you are doing.

The second thing is that you can do measurements.

So, in the case of say, this hill what is the height of the hill, what is the location of this hill? So, if you measure these, then we say that we are doing we are using photogrammetry for a metric cause. So, there are two applications. One is interpretive; to interpret the actual situation, and two is metric that is to measure different things.

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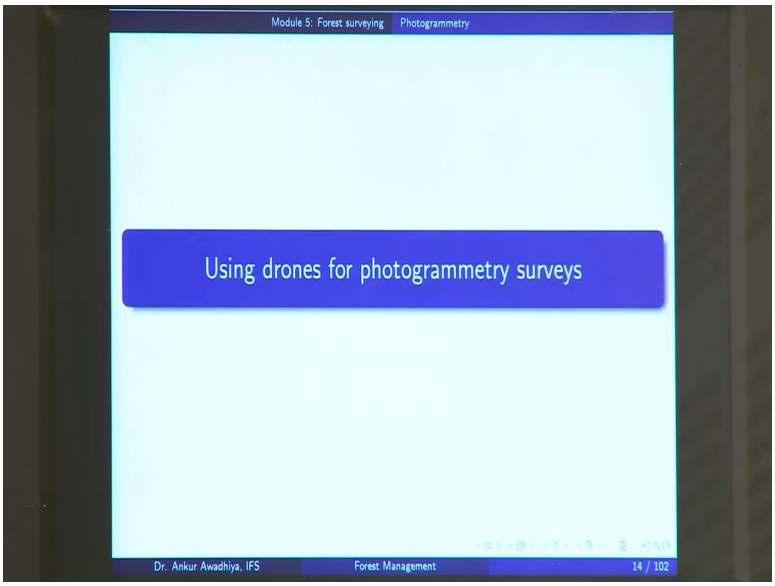

So, let us have a look at the one application of photogrammetry that in which case we were using rules for photogrammetric service.

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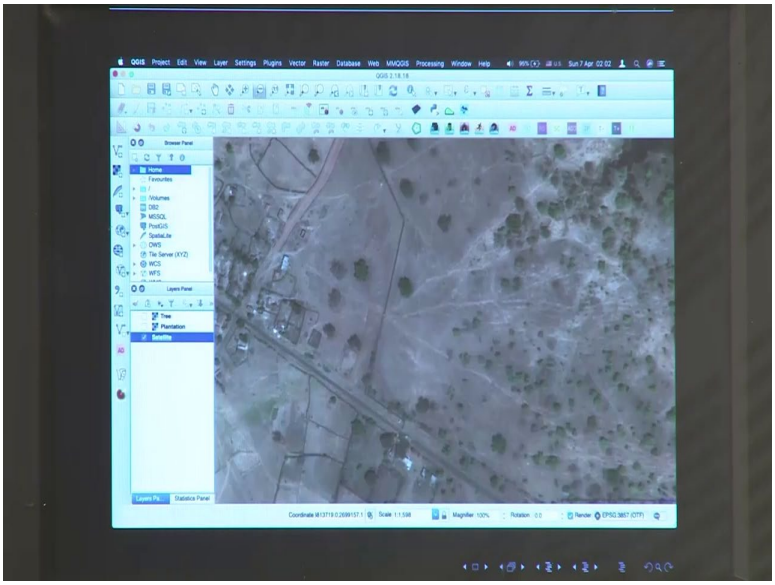

So, this survey was done in Nauradehi Wildlife Sanctuary, and in this picture, we are seeing a satellite image of the area that we were trying to perform photogrammetry on. So, this is the satellite image.

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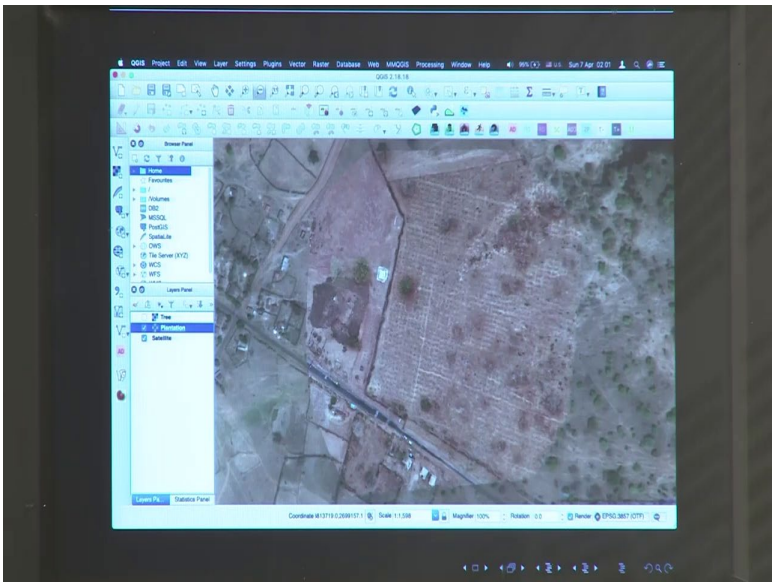

And next, you have the image from a drone. So, in this case, what we did was we took several individual photographs. So, the drone flew over the whole area, and at every point or at certain distances, it was taking the pictures. Now, all of these pictures were then processed so that they become a single image, and this image was also geo-referenced. So, in this case what we are saying is that, if you look at the previous image and if you look at the location of this road, and now if you have a look at the drone image, you will see that the road is falling on the same point.

Now, you can make use of this information for certain interpretations. So, for instance, if you look at this point in the drone image, you are saying that there is some construction this white spot that is come up was not there in the satellite image. So, probably there was this construction that was done after the satellite image was taken, but before we did this drone survey. The other thing is that you can see that here you have some sort of excavation that is happened.

So, we are using photogrammetry to do an interpretation of this area. We can also see that in the previous image these sections look plain, whereas in this image this section is looking dotted, because there was a plantation that was done in this region. So, we are using the technique of photogrammetry to interpret the whole situation. We can see where we had a construction? we can see where we had a plantation? we are seeing where there was in an excavation? we can even see what was the difference in the road!

So, in this case, in the previous image this you have a plain road, and now in this image you can see that here the road is has thickened and here it is a single lane road. So, probably this road was expanded after the satellite image was taken. So, now, you are using photogrammetry to interpret different locations to get an idea of your area. So, it becomes very important from a management point view.

Because, if you say have a in illicit construction that is going on or say in illicit deforestation that is happening in your forest, you cannot reach every place at all the times, but you can make use of photographic information to get an idea of whether your trees are getting cut, or whether there is an encroachment that is happening in some area, or whether people have started to cultivate crops in your area and so on. So, this is an interpretive use of photogrammetry.

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Now, we can also make use of photogrammetry, to say to make metric computations. So, for instance, in the case of this plantation, we can find out whether these I mean what is the distance between these different pits. Now, if you have an idea of the distance between different pits, you will have an idea of the density of the plantation, and you will also have an idea of whether there will be in overcrowding in this plantation or not.

So, you can make use of these photographs. So, when you have this photographs, you can directly take a scale, measure these distances, and then scale it them up by using a standard distance. So, for instance, here you are seeing this road and you are having this

zebra crossing. And, in this case, you can measure this distance on the ground; measure this distance on the photograph, and so, you get a scale factor that in the case of your photograph 1 centimetre, on the photograph is say equal to 8 meters on the ground.

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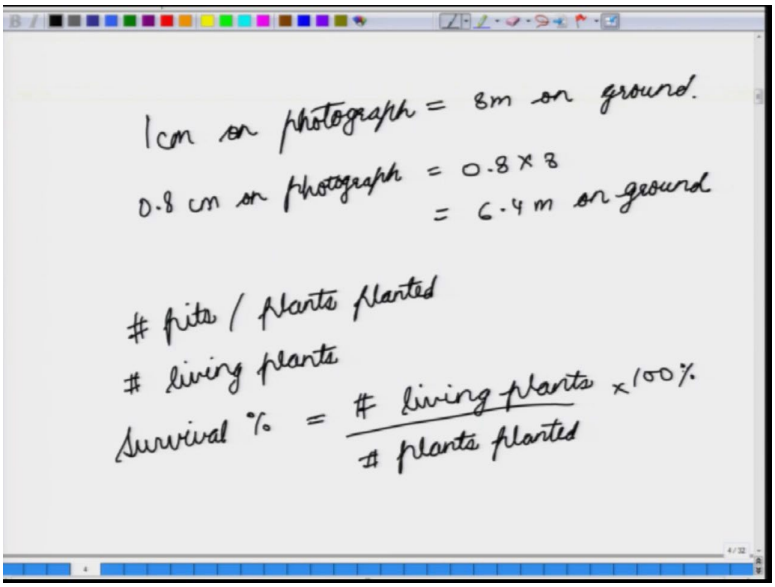

And once, you have that scale that 1 centimetre on photograph is equal to say 8 meters on ground. Now, you can make use of this information, and suppose the pits are at a distance of say 0.8 centimetre. So, 0.8 centimetre on photograph in that case will be equal to 0.8 into 8 is 6.4 meters on ground. So, what we are using photogrammetry in this sense is to is to use it for a metric computation.

So, you are trying to measure different points on the ground without going to that location, just by making use of the photographs.

Now, another use is that, if you look at this image; if you say flew the drone at a lower height, so, you are getting now much more amount of information.

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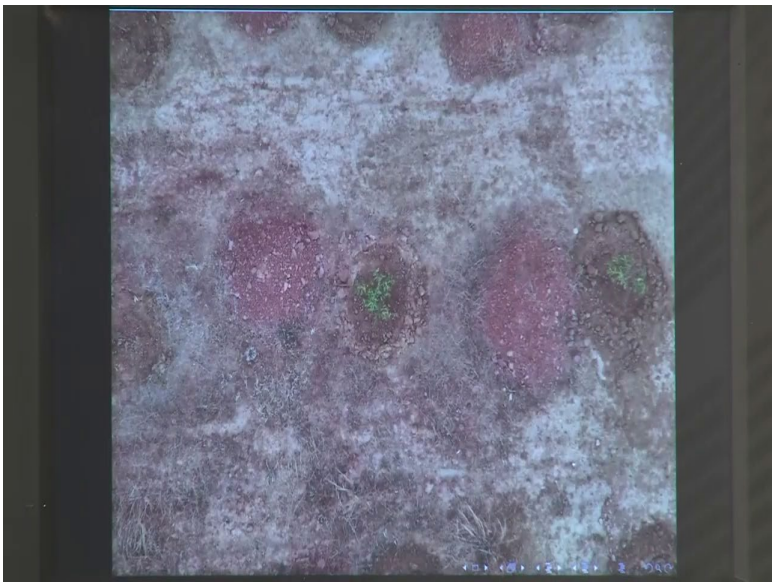

So, for instance, here you can see that you have a plant you can even see the leaves of this plant and you can make use of this information to get for instance the survival percentage in your plantation.

So, in that case, what you will do is - you will find the number of pits or the number of plant or the number of plants planted, and the second thing will be the number of living plants, and your survival percentage is given by number of living plants divided by number of plants planted in to 100 percent. So, in this case again, we are using the technique of photogrammetry to measure something.

So, we are trying to measure the survival of the plants that were planted in that particular plantation. Now, another good thing about photogrammetry is that you can alter these images. You can process these images for other applications.

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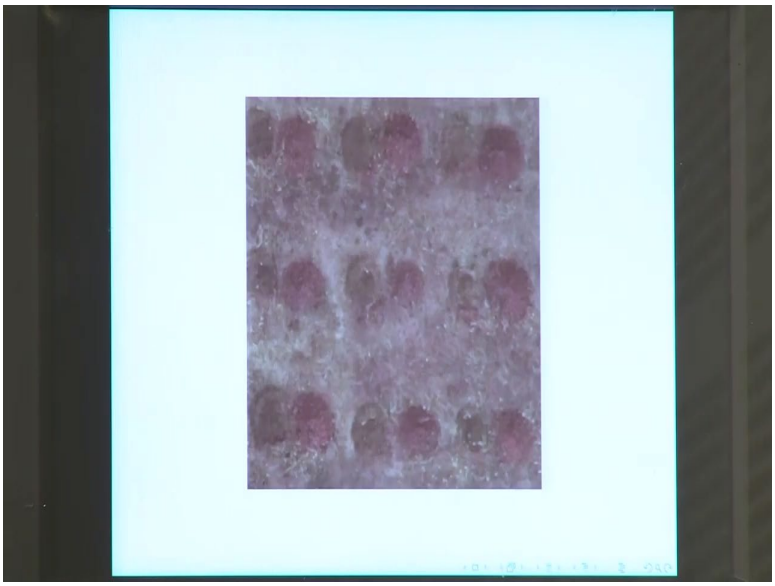

So, for instance, this is a section of the plantation that we processed.

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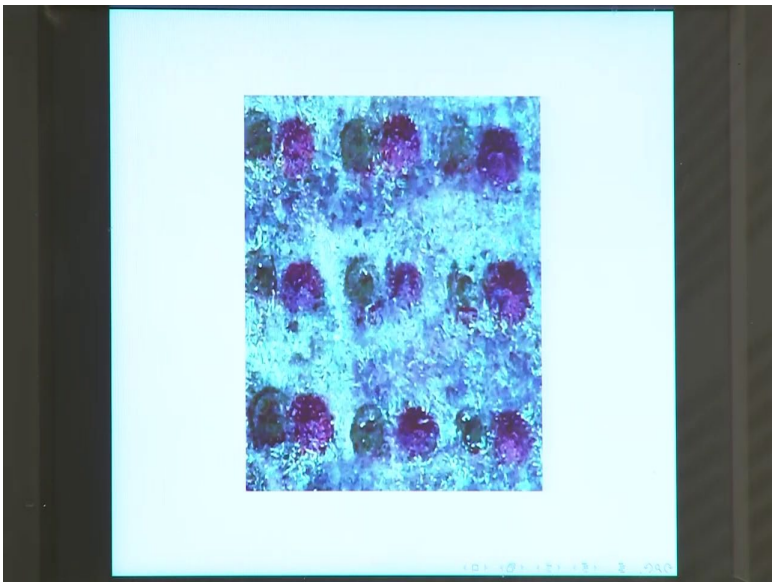

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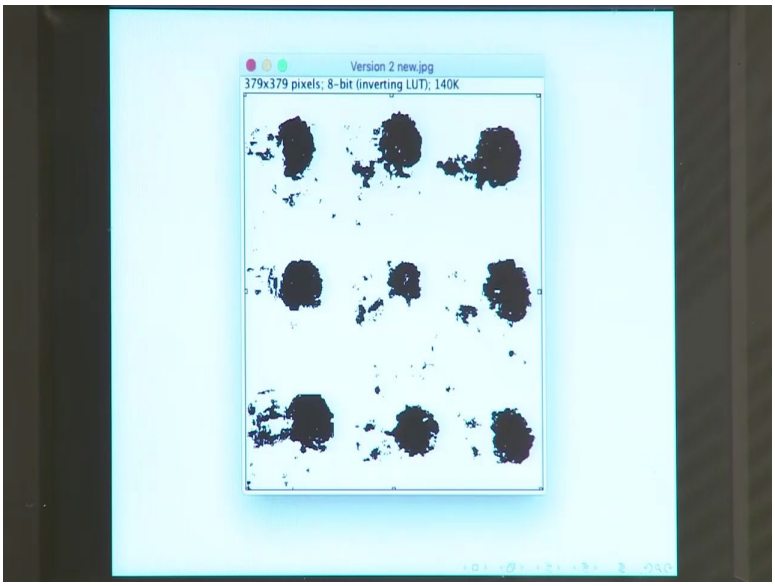

So, in the case of this processing, we increase the contrast of these points, then we converted them into a binary image. Now a binary image is either 0 or 1, and in this case, the dark spots are 0 the bright spots are 1. So, we have converted your image into a binary image.

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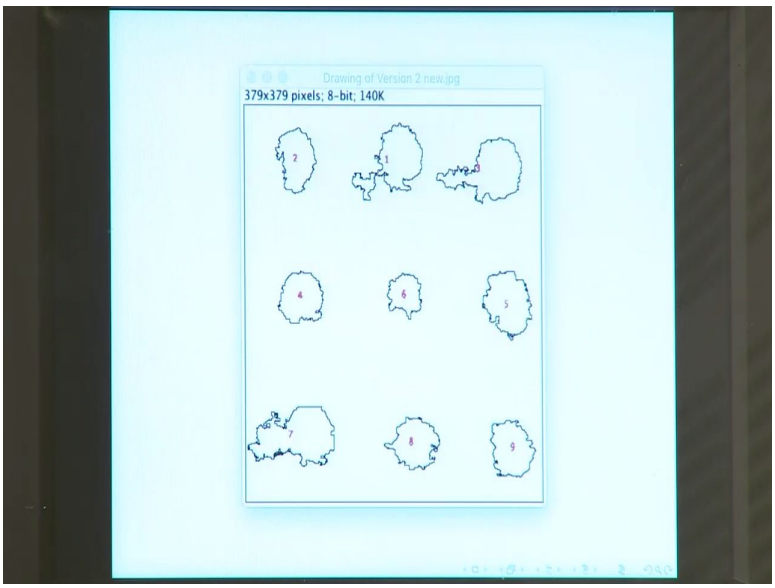

And now, this binary image can be processed in a computer to give you an idea of the number of pits that were dug, and also the area of each and every pit. So, in this case, these numbers were given by the computer. And here, we can see that this is pit number

1, 2, 3, 4, 5, 6, 7, 8, 9. So, the computer is very accurately able to identify that there are these 9 pits. Now, in this case, you have pits and you also have the earths that was dug from this pit, it is kept right next to it.

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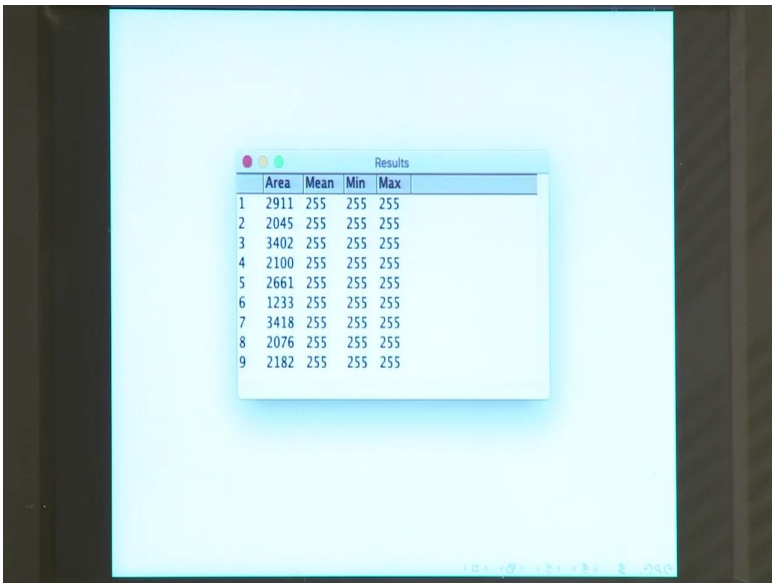

So, in this case the computer was able to tell you that there are 9 pits. At the same time, it is also giving you, what is the area of each pit. Now, it is giving it in terms of pixels, but we can always make use of a scale and get the actual area.

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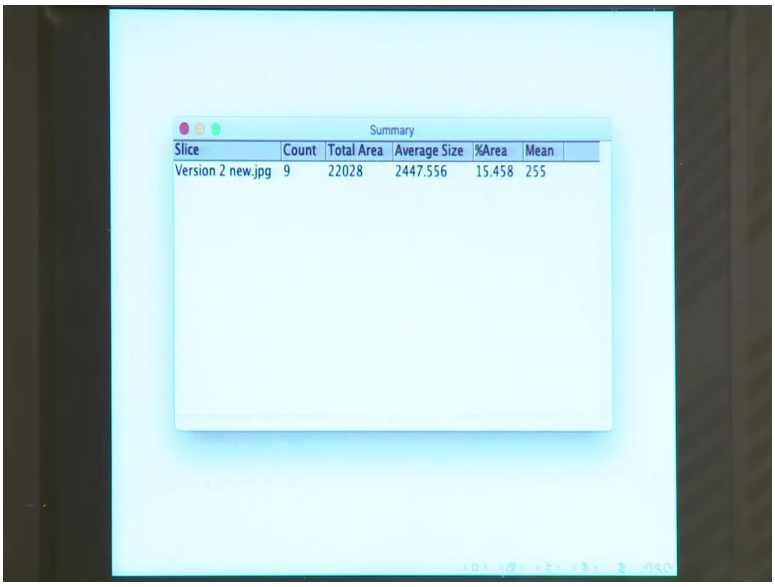

So, we can make use of such information to get say, the count of the number of pits; the average size of each pit.

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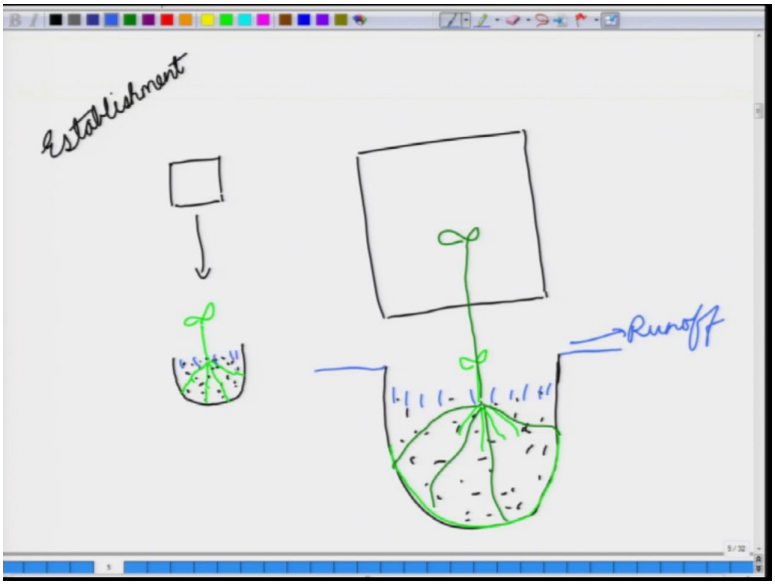

Now, that is important because, for instance, if you make a small pit versus a large size pit, then there will be differences in the establishment of your seedlings. Why? Because, in the case of this smaller size pit, there is a smaller area on the earth that has been made into a pulverized soil, and so, when you are having your seedlings. So, now, they are able to so, their roots are able to enter into the soil in a in an easier fashion, but then once your roots have reached to the size of the pit, now they are encountering hard earth.

Whereas, in the case of this pit, so, you have a larger sized pit there is a larger volume of soil that has been pulverized and made more porous. And so, now, if you have your seedling here, it is able to or its roots are able to reach till the boundary of this pit in a very large time. So, when your plant will say be this big, then you will be having the roots that have reached to the boundary of the pit.

So, you are giving your plants more time; in a more amenable situation to establish themselves. Now, this pit digging is also very important, because as we have seen in the lecture on soils; the soils are comprised of not only the middle portion, but also the organic matter - water as well as air. Now, when you are making your soil more porous, so, air can reach can enter into the soil much more easily and water can also enter into the soil much more easily.

So, in this case whereas, in the surrounding areas the water will just move away as a runoff, but in the case of this pit, more and more amount of water will be able to percolate inside. In the case of a smaller size pit, less amount of water is able to percolate inside. So, essentially water which is a nutrient for the plants is able to percolate inside a larger pit in a larger quantity, and inside a smaller pit in a smaller quantity. So, more the amount of nutrients the plants are getting more the amount of water that it is getting the faster will its growth be.

So, typically we want to go for a larger size pit, and whether or not the staff has made those larger size pits is something that you can make you can discern from the photogrammetric data.

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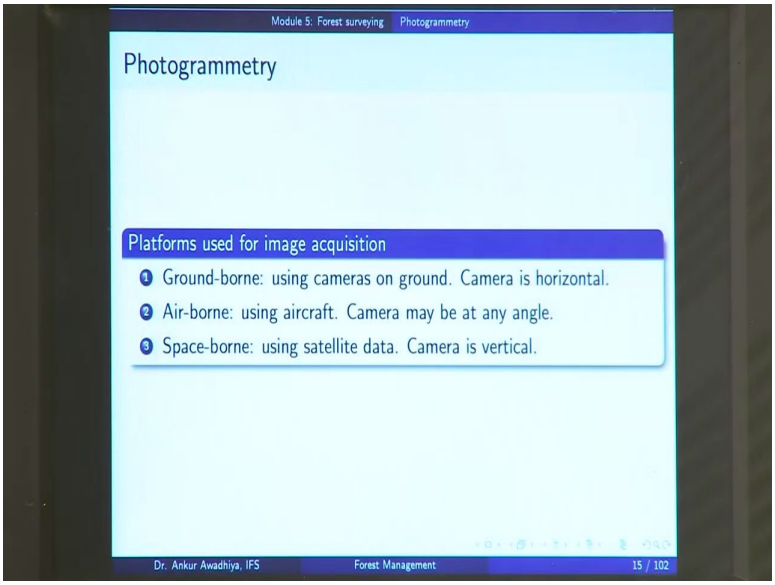

Now, there are 3 platforms that are used in the case of photogrammetry. So, you can make use of a ground -borne platform. So, essentially what this is saying is that you are standing on the ground, and you have a camera in your hand and you are taking different pictures. So, you are based on the ground.

So, in this case, the camera is horizontal.

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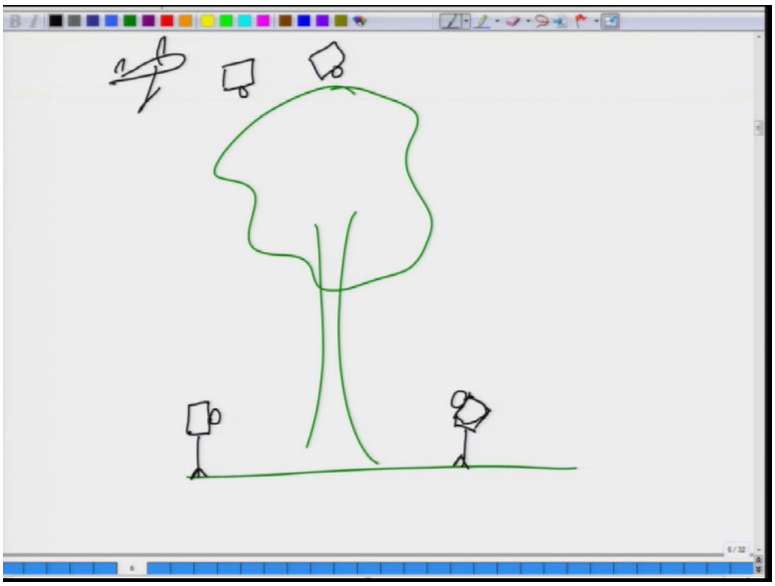

So, you have a tree here and what you are doing in this case, is that you are taking a camera and you are taking pictures. So, your camera might be like this or it might be like this. So, when you are looking at the canopy, but in all the cases, it is based on the ground.

Or, you can make use of air-borne platforms such as using an aircraft or using a drone. Now in this case, you are making use of an aircraft, and you can have a camera that is looking downwards or that is see at in angle.

And, the third one is making use of space-borne platforms such as using of satellite data and in this case the camera is vertical.

Now, when we are taking these photographs, there is there are some things to be kept in mind. So, you require these photographs, but you require them at a good enough resolution.

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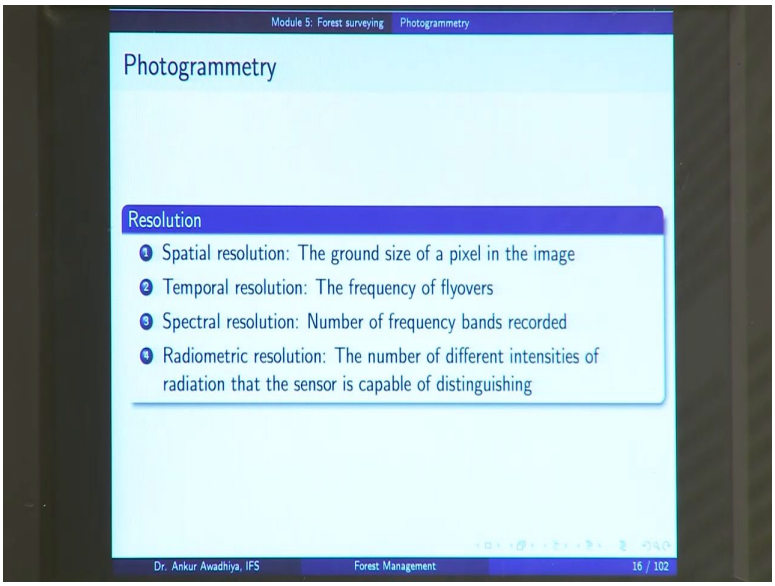

Now, there are 4 different kinds of resolution that we talked about.

One is a spatial resolution or the ground size of a pixel in the image. When we when we were talking about this scale of a photograph; so, every photograph is made up of pixels.

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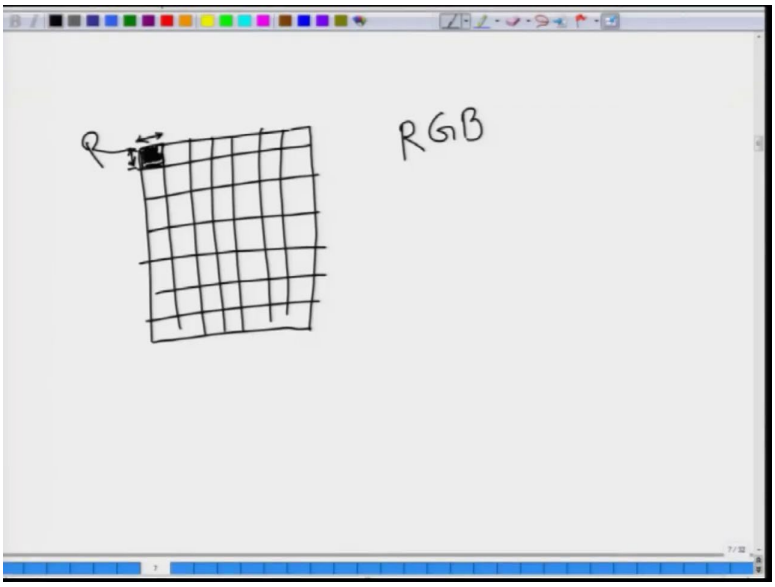

So, in the case of every photograph, you will be having the R, G and B pixels, if you are talking about a true colour image. So, let us look at the R pixels. So, now, when we have a spot of pixel at this location, how much does this much size correspond on the ground? So, that gives you an idea of the spatial resolution. So, if you have a greater amount of

spatial resolution, you have more number of pixels in your photograph, so that each pixel is corresponding to a smaller area on the ground.

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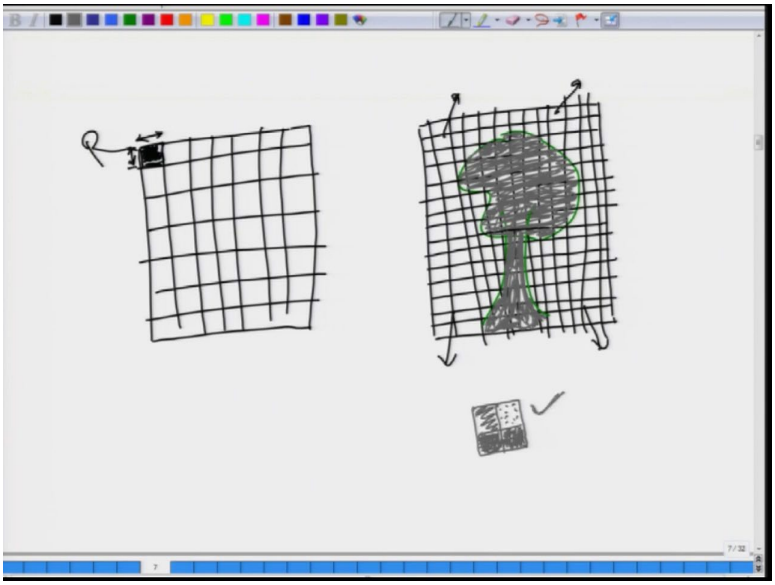

Now, to take another example, suppose you have a tree and this tree is getting represented on your photograph. Now, in one case, this tree is getting represented only as 4 pixels. So, in this case, what will be having is that this pixel is showing some value of gray; this pixel is showing some value of gray; this pixel is showing some value of gray; and, this pixel is also showing some value of gray.

So, in this case your image would look something like, so, if you have this image in the first one looks gray, the second one probably looks a pit more gray, the third one is looking a lighter gray, and the fourth one is looking say deep gray. So, this is the kind of image that you will get. But suppose you have a greater amount of spatial resolution; so, in this case what we are saying is that we have more number of pixels. Now, when you have more number of pixels, you are having more amount of data.

Now, in this case, what the image would look like is this is gray, this is gray, this is gray, this is gray. So, you will be able to see the outline of the tree like this. So, all of these sections are looking gray, the trunk of the tree is also giving you this gray data information. And so, if you now look at this image, you can see the outline of the tree much more clearly than in this image where you were just seeing a few blocks. So, more

the amount of spatial resolution means more the number of pixels that are there in every image.

So, when we talk about say the number of mega pixels that are there in a camera, we are talking about the spatial resolution. More the number of mega pixels, the more amount of spatial information you will be having in every image, because each pixel will be corresponding to a smaller sized a smaller size a portion of the actual substance.

Now, the second resolution is known as temporal resolution or the frequency of flyovers.

Now, when we were talking about the satellite image and the drone image, what is the difference what is the time that elapses between two flyovers of the same area?

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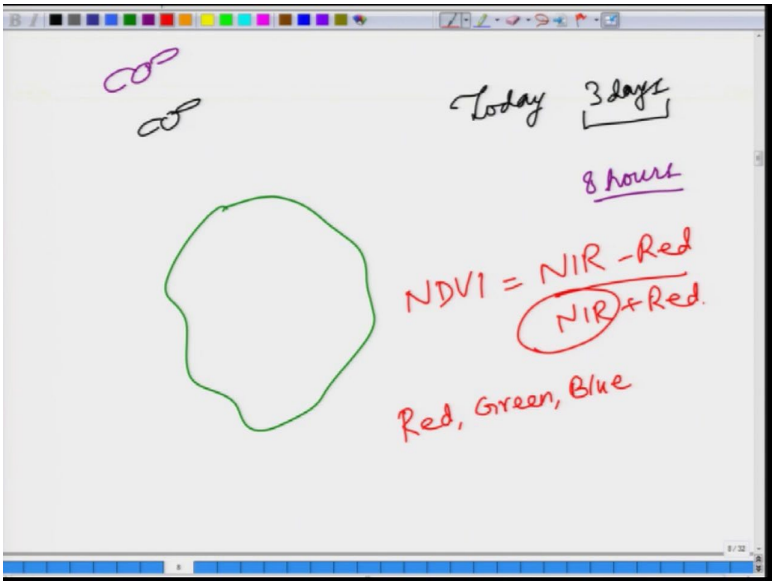

So, here we are saying that you have a forest. So, this is a forest and you want to have information of this forest. So, probably your satellite moved over this area, say today. And, this satellite will come back to this area say after 3 days.

So, you will say that this the temporal resolution of the satellite is 3 days, but probably you are also having another satellite that moves over this area say every 8 hours. So, in this case, the temporal resolution of the satellite would be 8 hours. So, if you have a higher amount of temporal resolution, if your you are having more number of flyovers per unit time, so, in the in that situation if there is any change in your forest you will be able to detect it very quickly.

So, more the temporal resolution, it means that you are taking more frequent number of photographs of that area. So, that you are able to get or discern any changes in a very shorter period of time.

Now, third is the spectral resolution. Now, spectral resolution is the number of frequency bands that are recorded. So, how many frequencies are you recording? Are you taking a black and white image? In which case, you have only 1 band. Are you taking a colour image? In which case, you have got 3 bands; red, green and blue. Or, are you taking even more number of bands? Say in a multispectral image. you are looking at what is the red value, green value, blue value, near infrared, middle infrared, far infrared, probably ultra violet band as well and so on. So, more the number of bands more is this spectral resolution, and more the spectral resolution, in that case, you will be able to discern the objects that are there on the ground in a much better way.

So, for instance, if you want to know where vegetation is there in a in the forest. So, whether your forest has vegetation or not, or whether this vegetation is getting sufficient amount of say water or not, or whether this vegetation is diseased or not. So, if you want to have these sorts of information, we make use of an index that is known as the NDVI index. Now, NDVI is given as near infrared minus red, divided by near infrared plus red. So, in if you want to have the value of NDVI, you require at least these two bands. You require the near infrared band and you also require the red band. Now, suppose you have a satellite that is only taking images in the red, green, and the blue band; but you do not have the near infrared band, so, in this case, you will be unable to find out the NDVI index from your images. So, which is why we always want to go for more and more number of bands, and so, in this case, we want to have a multi spectral image or possibly even a hyper spectral image.

Now, the fourth resolution is the radiometric resolution or the number of different intensities of radiation that the sensor is capable of distinguishing.

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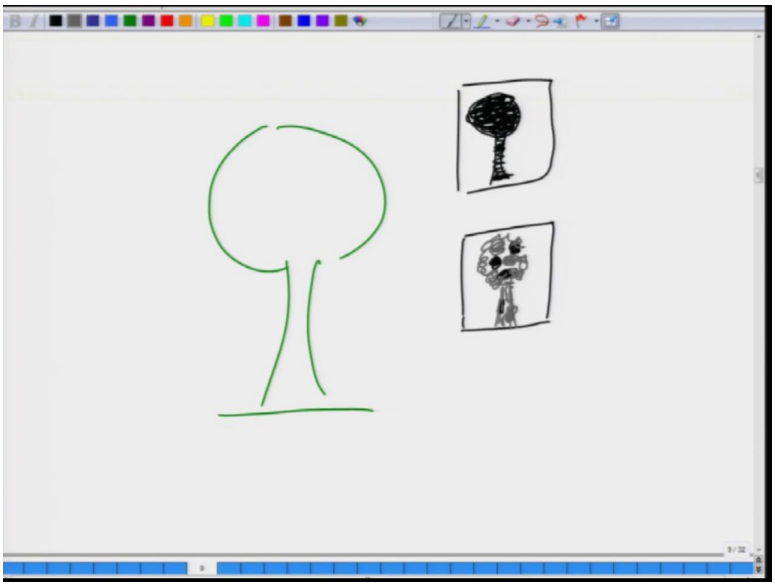

So, what we are saying here is that you had this tree, now if you are taking suppose a black and white photograph. Now, in the case of this black and white photograph, if when we talk about the radiometric resolution, what we are saying is that whether your image is coming only as black and white, or is it also coming as shades of gray.

Now, if you have say a black and white image only, so, in this case, you will have a picture that say looks like this. So, you have the canopy that is looking black in colour, you have the trunk that is also looking black in colour, and everything else is white in the image.

But suppose you are having as an image that is having more number of gray values, or a higher number a higher value of radiometric resolution; so, in that case, what you will probably find is that you will have some locations that are say darker in colour. There are some locations that are lighter in colour, probably some locations that are there in between. And so now, you are able to see more amount of contrast in this tree. You are able to find you are able to see that your canopy is not homogeneous; it is not completely black, but then there are certain regions in which your canopy is say having a darker colour; there are some regions in which it is having a lighter colour; there are some regions that in which it is having an intermediate colour.

So, here what we are saying is what is the number of bits that are there in your image, how much amount of information is there for each and every band. So, that is the

radiometric resolution. The number of different intensities of radiation that the sensor is capable of distinguishing is it only able to see say in a binary fashion - that is black and white, or is it able to see shades of gray, and when we are talking about shades of gray is its say showing it on an 8 bit scale, is it seeing it on the 16 bit scale, is it seeing it on a 32 bit scale.

So, more the number of bits that are there in your information and your image, more is the amount of information that you have in your image, and then, that can be made use of when you are doing the interpretation or the measurements.

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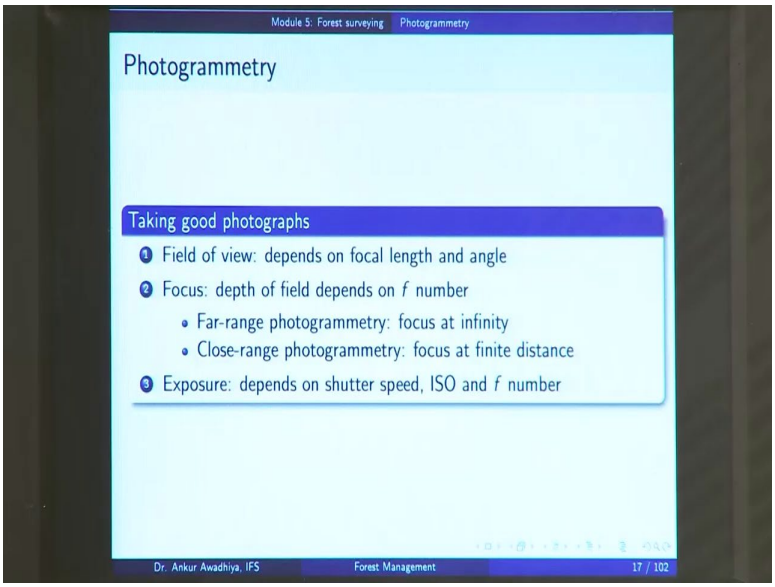

Now, next when we talk about taking photographs there are these 3 things that we need to keep in mind. So, how do you take a photograph?

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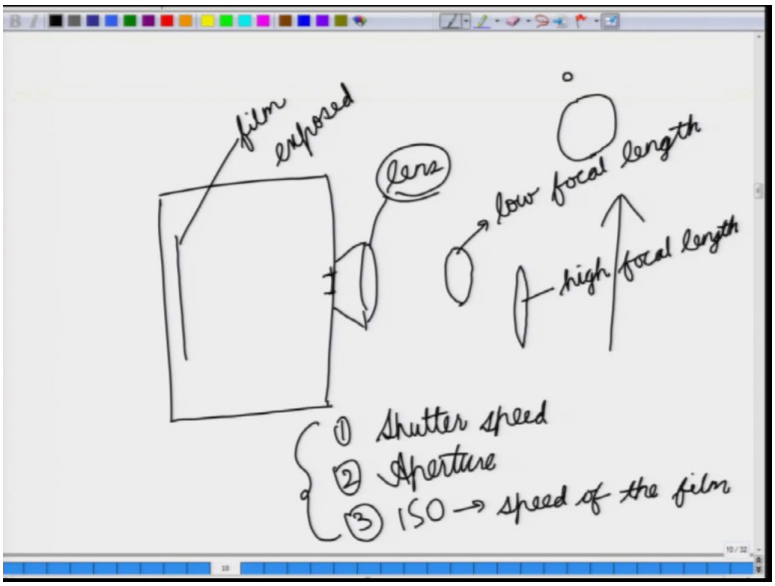

So, essentially you have this camera and let us talk about in early camera. So, we are talking about of film camera. And, here you have a lens and here you have an object. Now, the camera works in this way that you have this film and this film has to be exposed.

So, when we say exposed then what we are saying is that there is a shutter here and this shutter will be closed and then it will open for a very short period of time, and in that period of time, whatever light is coming from your object, is falling onto the film. And, when the light is falling on it there are certain chemical reactions, and we are saying that it is getting exposed. Now, how much amount of light will fall or what will be the impact of that amount of light, will depend on a number of factors.

So, it will depend on say, the shutter speed. So, suppose you have a shutter that moves very fast. So, in that case, it will expose your film to a very short period of time, whereas if you have a shutter that opens for a very law long period of time, and then it closes; so, in that case your film will be able to get more amount of light. So, the amount of light that you are getting here it depends on the shutter speed.

The second thing it depends on is the aperture. So, in this case, what we are saying is what is the size of this hole. If you have a smaller hole, so, in that case, you are allowing smaller amounts of light inside. If you are having a larger sized hole or a larger sized aperture, then you are allowing much more amount of light to get inside. So, the amount

of light that is getting inside depends not only on the shutter speed, but also on the aperture.

Now, the impact that this light will have on the film will also depend on the third thing which is the ISO. Now, ISO or this ISO, which is also referred to as the speed of the film, is a measure of the sensitivity of the film. So, suppose you are adding those chemicals that are very much sensitive to light, in that case, you have a small amount of light, and there is a large amount of chemical reactions or a large amount of impact that happens on that film.

On the other hand, there could be certain films that have less amount of chemicals, or probably those chemicals that do not react with light in a large amount or quickly. So, in that case, even though you are you are exposing your film for a very large amount of time, with a slow shutter speed or probably with a larger size aperture, even then you are not able to make that good an impact on the film. So, the picture will depend on these 3 things - the shutter speed, the aperture and the ISO, but then you also have a fourth thing here which is the lens.

In the case of the lens, that the aim of having this lens is to focus the light that is coming from the object onto the film. Now, you can have a lens, in most cases, these are convex lenses. So, you have you can have a lens that is stouter or with a low focal length, or you can have a lens that is thinner, in which case, we have say that this lens has a high focal length.

Now, both of these lenses will be able to focus the light that is coming from the object onto the film. But then, if you are making use of a short focal length lens; so, in that case, you will be able to see a wider area in your image, whereas if you are using a short focal length are lens, in that case, you will be able to see only a very small amount of the whole field of view. So, the picture that you will get will depend on all of these factors.

Now, when we take good photographs, we need to keep in mind the field of view. So, the field of view will depend on the focal length and also on the angle. So, what you are seeing depends on how your position in the camera. Then, your good picture will also depend on the focus - whether your images are in focus or your images are out of focus.

And when we talk about the focus, we typically in the case of photogrammetry make use of two kinds of focuses: you can make use of a far-range photogrammetry, where you are focusing your camera at infinity. So, in this case, objects that are very far from the camera will look crisp and clear, but objects that are close to the camera will probably look out of focus.

Or, you can make use of close-range photogrammetry, in which case, you are focusing at a finite distance. So, only those objects that are at that distance will look crisp and clear; objects that are far off or objects that are nearer to that distance will probably look out of focus. But then, when we talk about focus, you also have to talk about the depth of field. Now, what is the depth of field?

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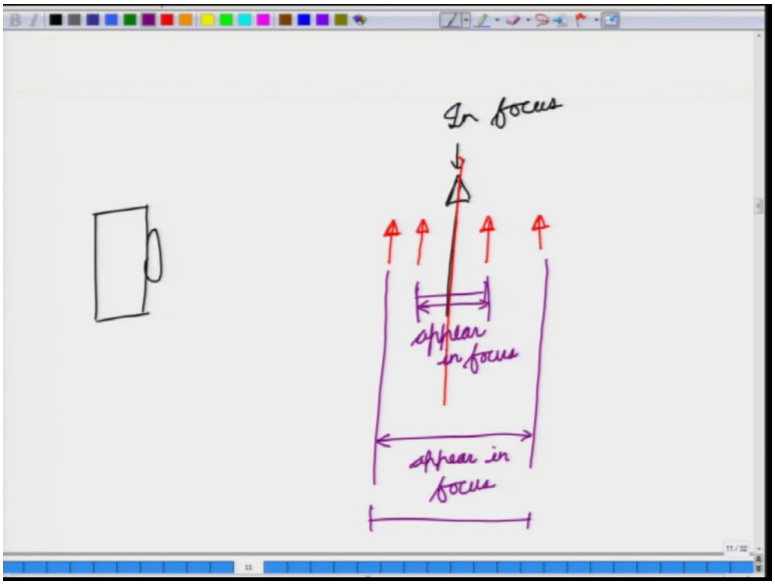

Suppose, you have a camera here and you have the object here, and this object is completely in focus. Now, depth of will asks the question that suppose I you have set your camera such that this plane is in focus, but then if you look at an object that is say here, will this object look in focus or not? Or, if you have an object here will this look in focus or not? So, what is the maximum distance till which this object will keep looking in focus, and not only in the front of the camera, but also at the back does this look in focus does this look in focus or not. So, if you have a camera that is set in a position such that these objects look in focus or these appear in focus, versus another camera that is set

in a way that all of these appear in focus, then will say that the depth of field, in this case is greater than the depth of field in this case.

So, depth of field is talking about how much is the leeway that we have in which case the objects are looking in focus. So, typically in the case of photogrammetry, you want to have a larger depth of field, so, that even if there are some certain objects that are not exactly on the on the plane at which you have focus, even then they appear on the photograph as a crisp and clear representation of the object.

Next, we are when we are taking photographs you also need to keep in mind the exposure that as we have seen it depends on the shutter speed, the ISO, and the f number.

Now, when we are saying exposure, what we mean to say is that because your the amount of light that is getting inside is depending on the aperture and the shutter speed, and the impact that it is it is making is dependent on the ISO numbers. So, if you play with all 3 of these, in such a manner, that suppose you have your film at a very high ISO, and you are keeping the aperture open for to a large extent, and you are keeping it open for a very long period of time.

So, what will happen in such a situation? In such a situation, so, much amount of light will be getting inside, and your film is of such a high sensitivity that everything will look that in the final image everything will look white in colour. Whereas, if you are using a film that is say of a lower ISO, or you are you are keeping a shutter speed at a very fast speed, or you are keeping the aperture so small, that a very small amount of light is able to get inside. So, in that case, the final image will look pitch black in colour, because there was no light that was exposed or that was able to make an impact on the film.

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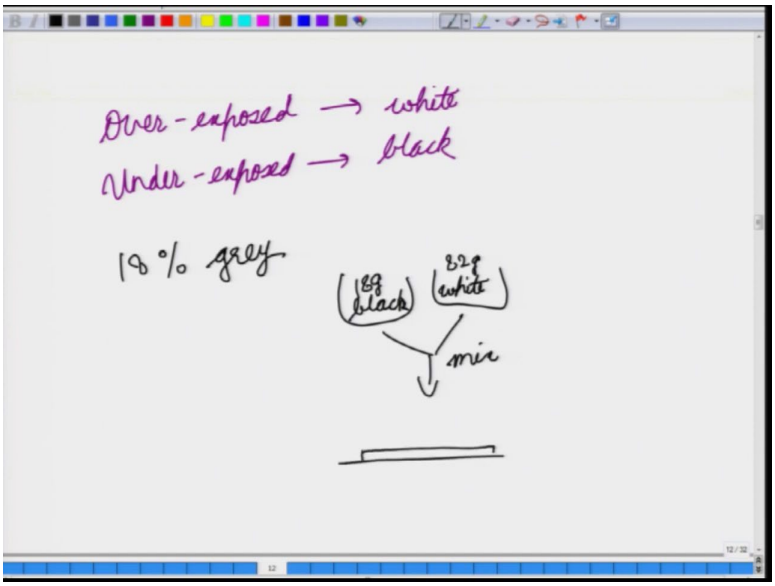

So, you can have a situation where you are having an over exposed film, in which case, it will look white in colour; the final image will look white in colour, or you can have an under exposed film where you have lesser amount of exposure to light, which will in which case the final image will look black in colour.

But then, if you have an image that is completely white or an image that is completely black, so that image is worthless, because you cannot get any information out of it. It was not able to record the information about the object. So, you want to have an exposure that is in between both of these. So, it has to be somewhat black somewhat white or it has to be a shade of gray.

And typically, a good amount of exposure is referred to as an exposure that is equal to 18 percent gray, which means that you took for instance eighteen grams of black pigments and 82 grams of white pigments, you mix both of these together and you apply this paste on a piece of paper. So, the exposure that is equivalent to this shade of gray is considered to be a good amount of exposure. So, when you are taking a good photograph, you need to keep in mind the field of view, the focus, and the exposure.

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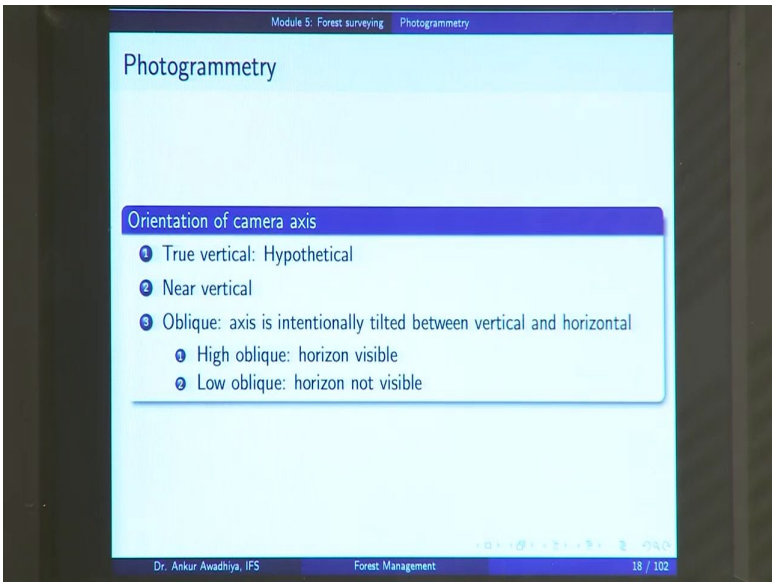

Now, when we are talking about photographs and especially from an aerial or a space platform, then we have different kinds of orientation of the camera axis. So, you can have a camera axis that is true vertical, which is mostly hypothetical or near vertical. So, when we say near vertical it means that the camera is directly looking down upon the earth. So, that is a near vertical image, or you can have a camera that is taking an oblique image, in which case the axis is intentionally tilted between vertical and horizontal.

So, in this case, what we are saying is that when the satellite is moving, the camera is tilted like this, and so, when it is moving it is taking images at an angle. So, it is not taking images vertically. It is taking images at an angle. Now, this angle can be high oblique angle or low oblique angle. So, when we say high oblique angle, you are keeping the axis like this; in a low oblique angle, you are keeping it like this and in the vertical orientation you are keeping it like this.

So, vertical, low oblique, high oblique. Now, low oblique and high oblique are distinguished by whether or not the horizon is will is visible. If the horizon is visible, then it is a high oblique image, you are looking like this, so that the horizon is seen; or, if the horizon is not seen, then it is a low oblique image where the horizon is not visible.

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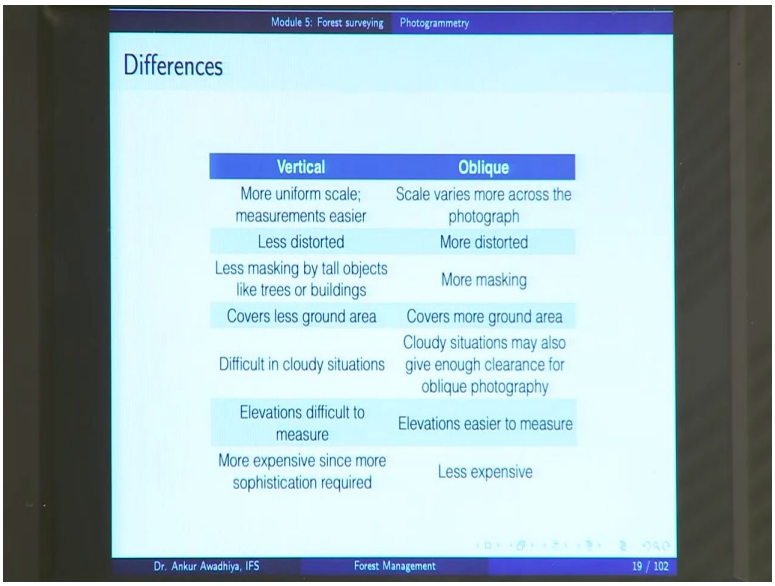

Now, what are the differences between all of these orientations? So, typically we go with either a vertical orientation of the camera or an oblique orientation of the camera. When the case of a vertical orientation, there is a more uniform scale; the measurements are easier. In the case of a of an oblique orientation, the scale varies more across the photograph and so, it is difficult to take measurements. You can make use of these images, for say interpretation purposes; but then, if you want to make use of these images for taking measurements, then it becomes difficult.

So, there is more amount of computation that needs to be done to be able to measure things on an oblique photograph. The vertical photograph is less distorted; oblique photograph is more distorted. In the case of a vertical photograph, there is less masking by tall objects like trees and buildings. In the case of an oblique image, there is more amount of masking.

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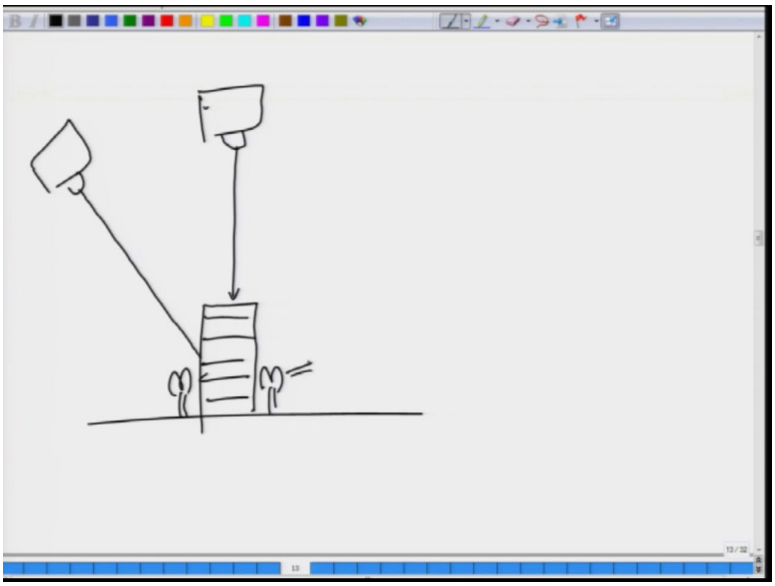

Now, what is masking? What we are saying here is that suppose you have a building. Now, if you are taking the image from a vertical angle, you are able to see the building completely; you are even able to see the trees that are here, you are even able to see the trees that are here. But if you are taking it at an oblique angle, so, in this case the tree that is behind this building will never be seen, because it has been masked by the building. So, it is the your building is occluding this tree. So, this masking or this occlusion is more, if you are making use of an oblique photograph.

Vertical covers less ground area, oblique covers more ground area. Vertical is difficult in cloudy situations. In the case of oblique, cloudy situations may also give enough clearance for oblique photography.

Now, in the case of vertical the elevations are difficult to measure, but in the case of oblique it is easier to measure, because you are getting more amount of 3-dimensional information, in the case of an oblique image.

Now, vertical is more expensive, since more sophistication is required. Oblique, it is less expensive. Because in the case of a vertical photograph, you need to keep your camera in such a position that it is come that is it is completely looking down upon. So, if you because you have to make more amount of adjustments, when you are setting up the camera, it typically is a bit more expensive.

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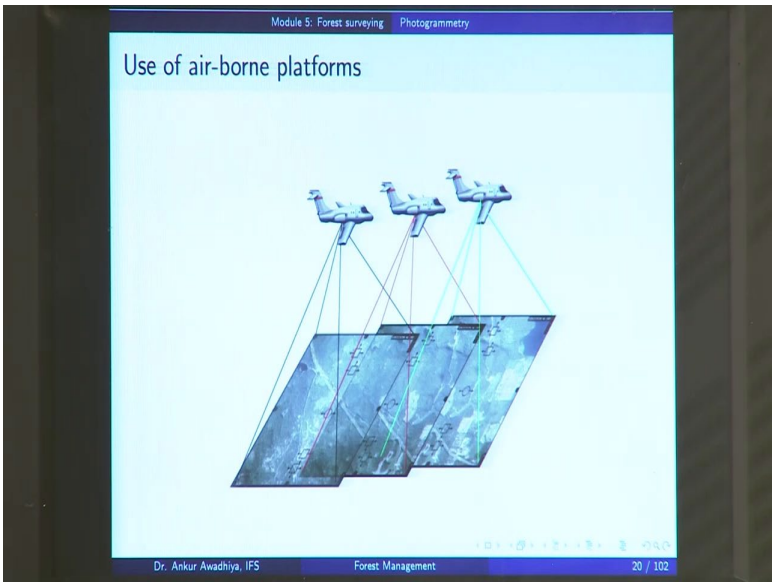

Now, when we are making use of the air-borne platforms. So, this is, for instance, the image of a plane that is moving and then it is taking different photographs. Now, we tend to take photographs, in such a manner that there is a sufficient amount of overlap between each and every of or every corresponding images or every nearby images.

So, if you have certain amount of overlap, in that case, you will be able to process this these images in our fashion that they can be joined together into one big photograph.

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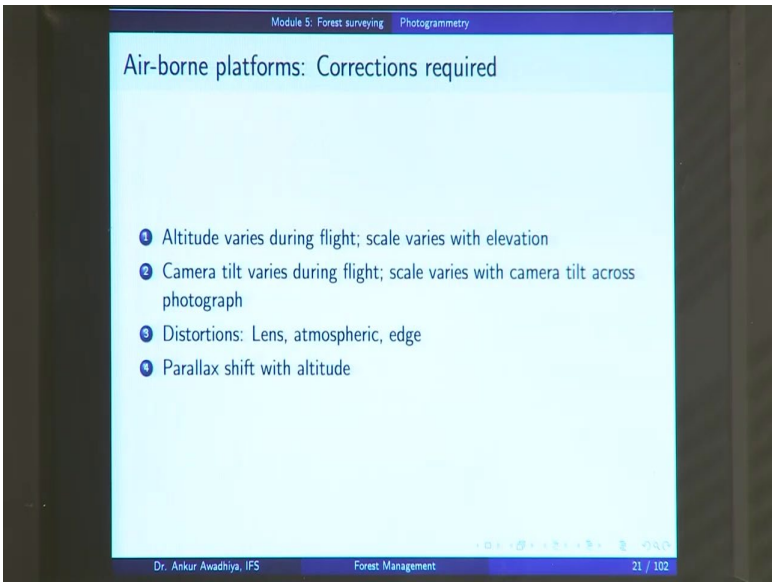

Now, when you are making use of air-borne platforms, you need to perform certain corrections to the image the if the altitudes varying according to the during the flight, then the scale is varying with a elevation. Because if you are looking at things from a greater distance, then they appear smaller in size. So, the scale is different as compared to when you are looking at the images or looking at the objects from a closer distance.

Then the camera tilt may vary during the flight, in which case the scale, will vary with the camera tilt across the photograph. There could be distortions because of the lens, because of the atmosphere, or at the edges, and there can also be parallax shift along with the altitude. So, all these corrections need to be incorporated when you are processing the images.

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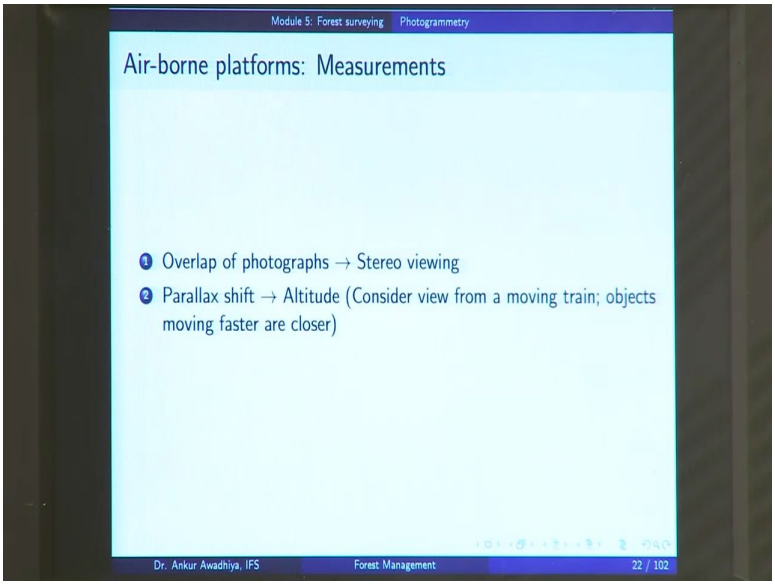

Now, take to take measurements, you require two things: one is that you require overlap, so that you are able to have a stereo viewing, in which case you are able to see a 3 dimensional view of the object, and you also make use of parallax shift to discern the altitude.

Now, in the case of parallax shift, you can consider that when you are moving on a train journey. And, you look outside the window the trees that are closer to view appear to be moving at a much faster speed as compared to the trees that are at a far of distance. Now, this sort of an information is made use of when you are processing the images, because when the aircraft is moving over an area, and if there are more number of or if there is a

greater amount of change in the photograph, then probably that object is closer to the aircraft, whereas if there are lesser number of changes in the object or in the images, then those objects are at a greater distance from the aircraft.

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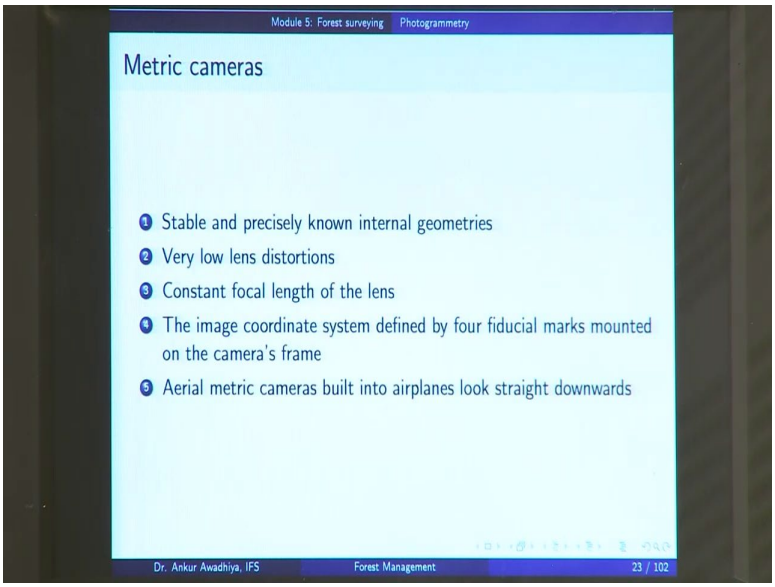

Now, we also make use of metric cameras. So, metric cameras are those cameras that are designed to take the measurements. So, you know each and every thing about these cameras and these are very standardized cameras. These are stable with precisely known internal geometries. There is very low amount of lens distortion, constant focal length of the lens, the image coordinate system is defined by 4 fiducial marks mounted on the cameras frame.

So, that you know the coordinate system, and the aerial metric cameras built into the airplanes look straight downwards. There is a completely vertical orientation of these cameras. So, metric camera is a camera that is designed to take measurements. So, the images are very standardized and it is easier to take the measurements.

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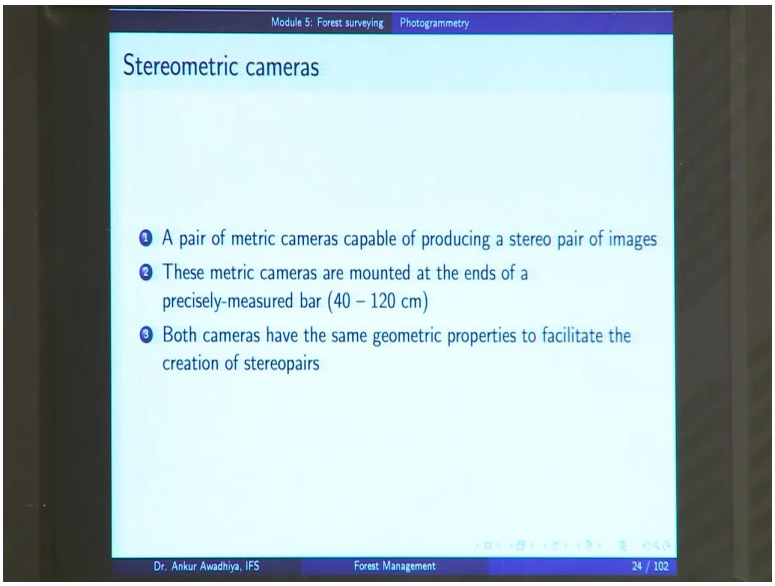

At the same time, so, so, we also make use of stereometric cameras, in which case, you have two cameras; so, stereo image is anyways, in which case, you have two cameras that are taking the image, and stereometric camera is two metric cameras that are being used. So, it is a pair of metric cameras capable of producing a stereo pair of images.

So, you will get a 3-dimensional view from these images. These are mounted at the ends of a precisely measured bar - 40 to 120 centimetres in length, and both the cameras have the same geometric properties to facilitate the creation of stereopairs.

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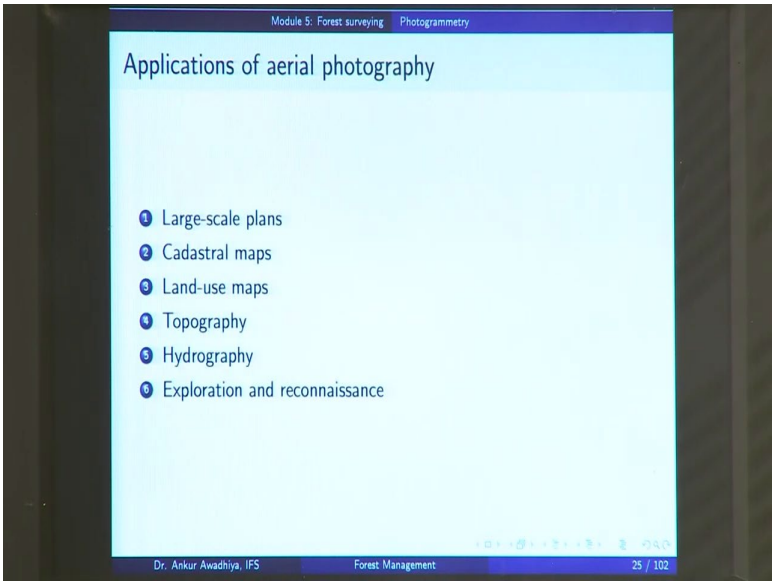

Now, why do we make use of this aerial photography? You can use it to make large scale plans, say of your area. You can use it to make cadastral maps, in which case, you are looking at what is the property that is belonging to each and every person. So, where does a field start? where does a field end? for instance. So, you can make a use of it for cadastral maps; you can use it for land use maps.

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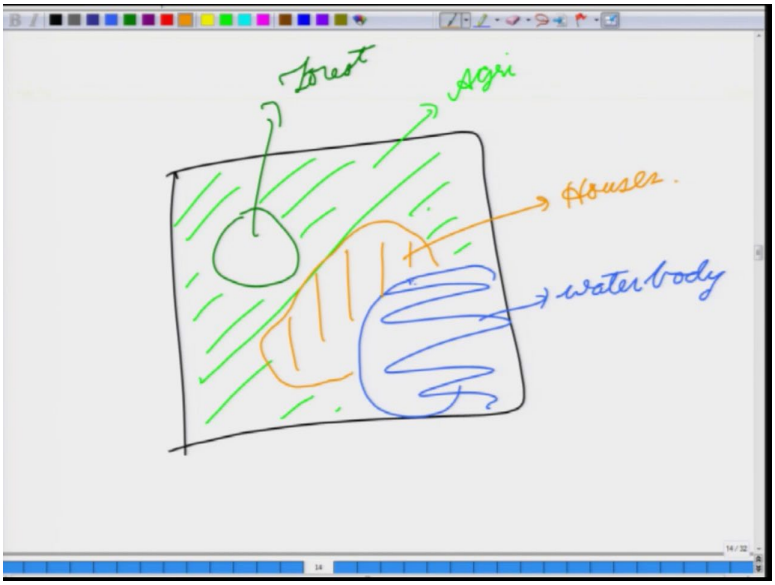

So, land use map is a map, in which say you are constructing this map and you say that this area is a forest and this forest is surrounded by fields. So, this is an agricultural land use, then you also have a water body here. So, this is a water body and these areas where your agricultural fields, and see in this section you have say houses. So, this is a land use map in which you are using a map to depict what are the different land uses that are there on the ground.

So, that is a land use map and you can you make it very easily using the aerial photography. You can even make topography maps which give you a 3-dimensional representation. Say in the form of contour lines, you can make a hydrographic map, which gives you an idea of where water is going to flow on the terrain, you can also make use of or you can also construct exploration and reiki maps.

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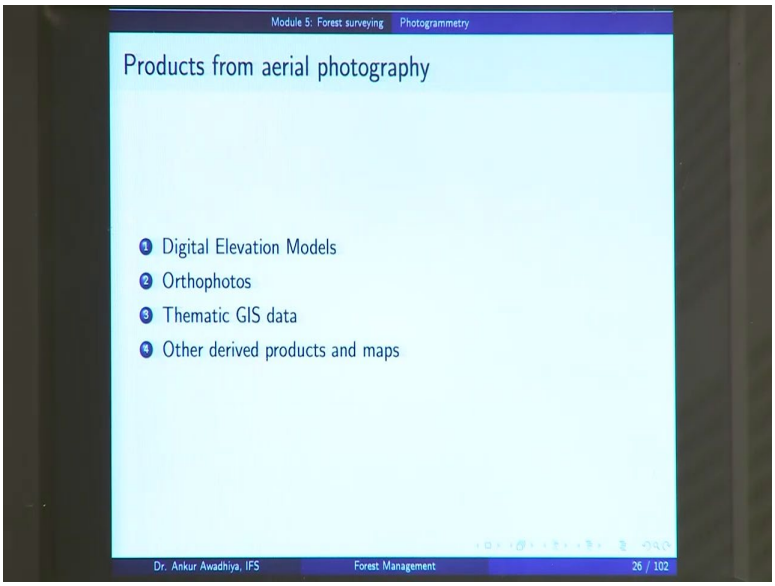

And using these aerial photographs, you can construct digital elevation models. In this case, we have an elevation model that is constructed digitally.

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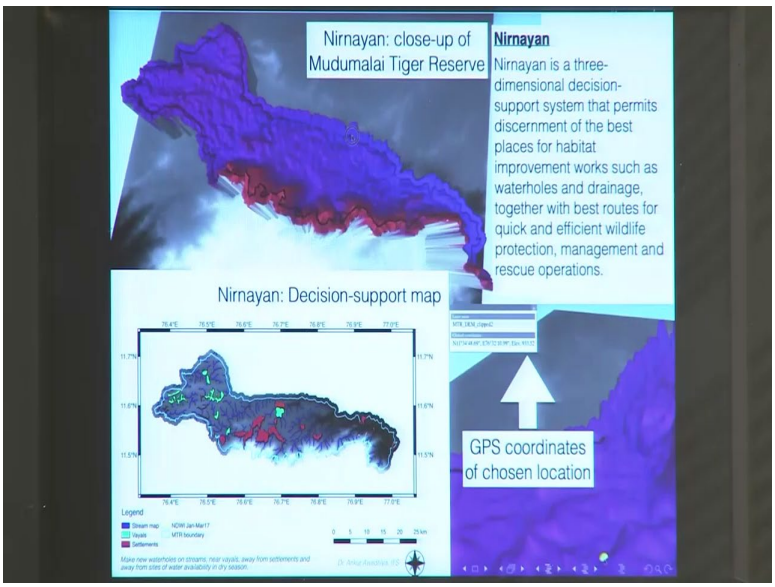

So, for instance, this is a digital elevation map of the Mudhumalai Tiger Reserve. So, in this map, what we are seeing is that what are the elevations of different points on the ground, by making use of the area of the photographs. And, in this case, we are seeing a hydrographical map, where we are saying where are the streams that are located.

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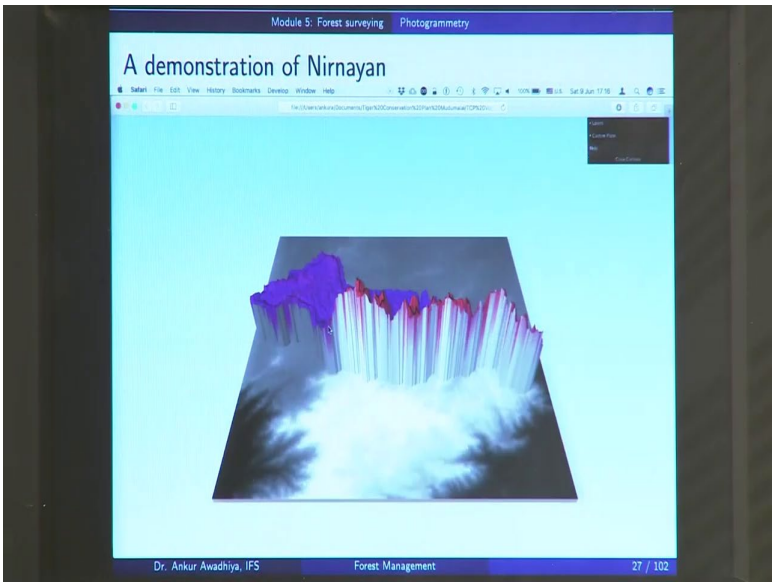

Now, a digital elevation map can also be made use of to give you a 3-dimensional representation of the area.

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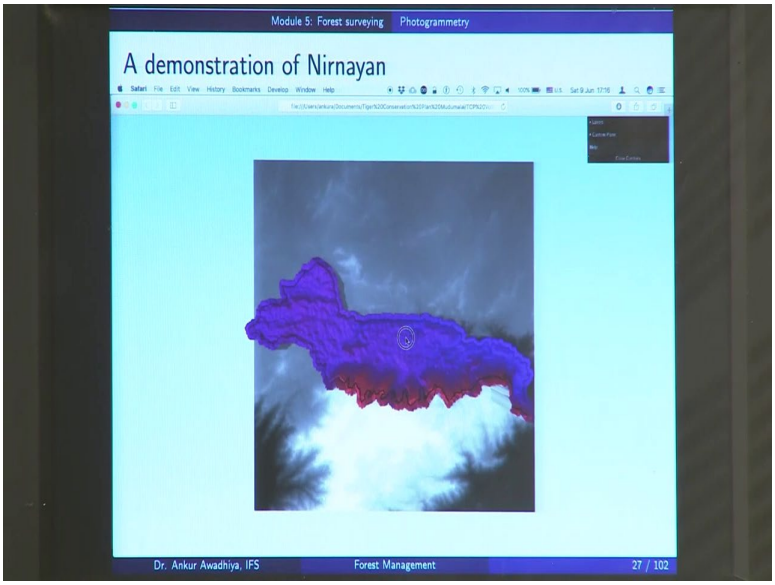

So, here we are seeing Mudhumalai Tiger Reserve in a 3-dimensional view.

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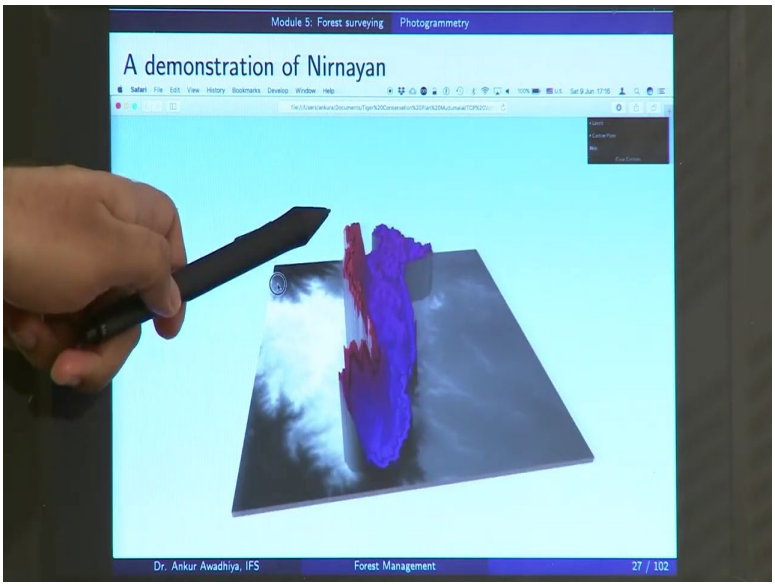

So, if you move this object, you can see that, on the southern side you have taller areas, and on the northern side you have a valley.

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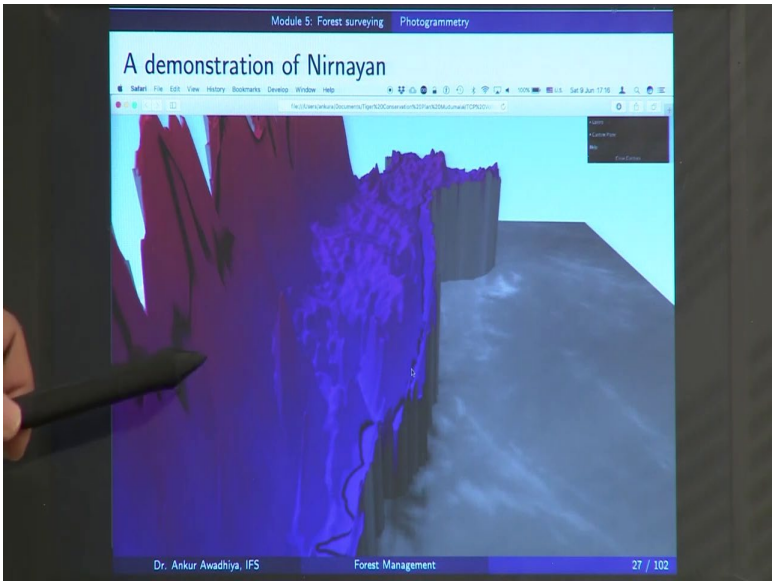

So, here now we are looking at a valley. So, this is a valley and here you have tall mountains. So, in this case, we can very easily see that if you have an animal, and if a person who is on this side is saying that the animal is crossing the valley, it is very difficult; probably they are getting confused, if they are saying that the animal is moving like this that is also very difficult. But if we say that the animal is moving in the east-

west direction, that is probably much more easier. So, it gives you a very good indication of what the surface looks like.

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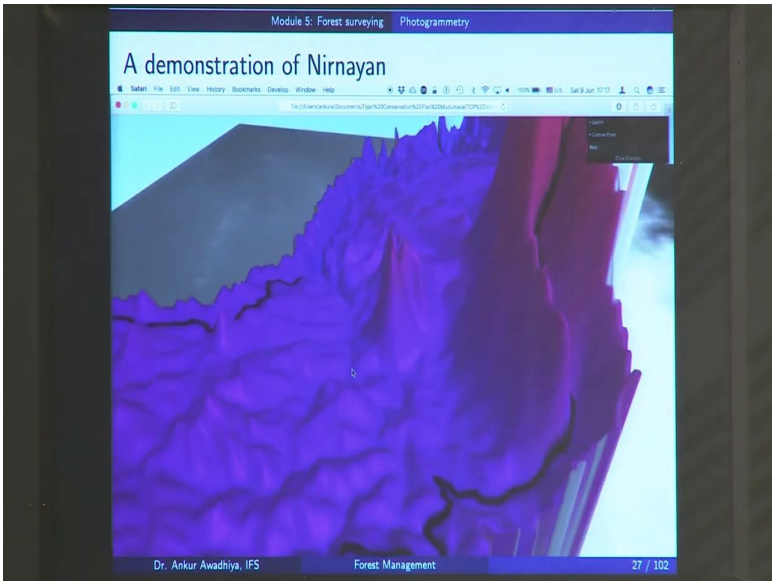

Because, if you are moving on foot or if you are moving in a vehicle, it is difficult to see how tall are the mountains or how deep is the valley. Now, you can also make use of these maps to say find out an area where you should be making a dam.

So, a dam should be an area where you have say, these two hillocks and what is moving like this in the valleys. So, in this map, when you click on a point you get the coordinates. So, this makes it easy for you to do planning about where to make the maps, for say, water retention for the animals or for water recharge. So, now, we are clicking on another point we are getting another set of coordinates. So, these are the kinds of applications that we can make using photogrammetry. So, this was the digital elevation model.

Now, you can also make use of aerial photography to make orthophotos to get thematic GIS data, or other derived products and maps.

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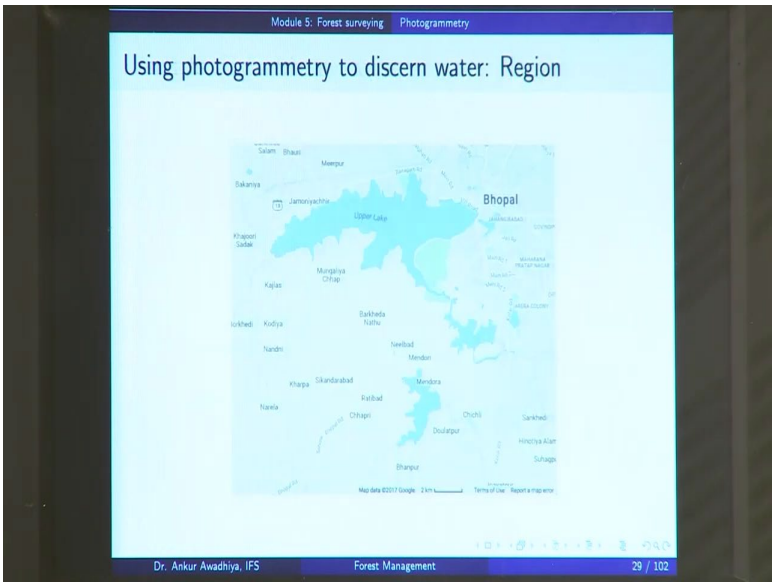

So, for instance this is another study that we did in Madhya Pradesh. So, we have this upper lake in Bhopal. And, this is how it looks on the Google map.

Now, the question is, if you are using this water reservoir, for say protection of biodiversity, because you have a very good bird population that is coming to this reservoir or to this lake. So, in this case, we want to know what is the boundary of this lake, so that we are able to perform protection in a better manner. So, to discern the boundary we started by looking at the transition classes.

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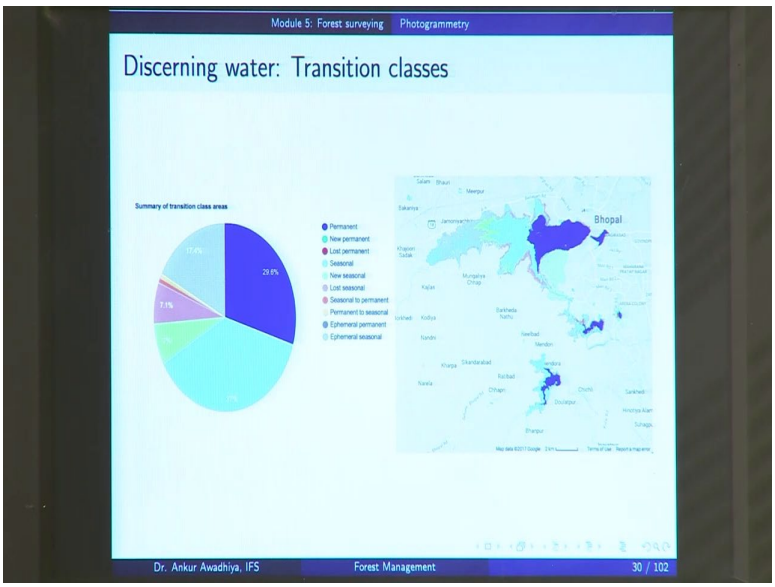

So, we are looking at 30 years data and we are trying to figure out what are those areas that have had a permanent amount of water in all these 30 years? how much of the area is something that has become a new permanent water reservoir? or how much or what are the areas in which earlier we were having a permanent look location of water? but now it is becoming seasonal? what are the areas I have shifted from seasonal to permanent? and so on.

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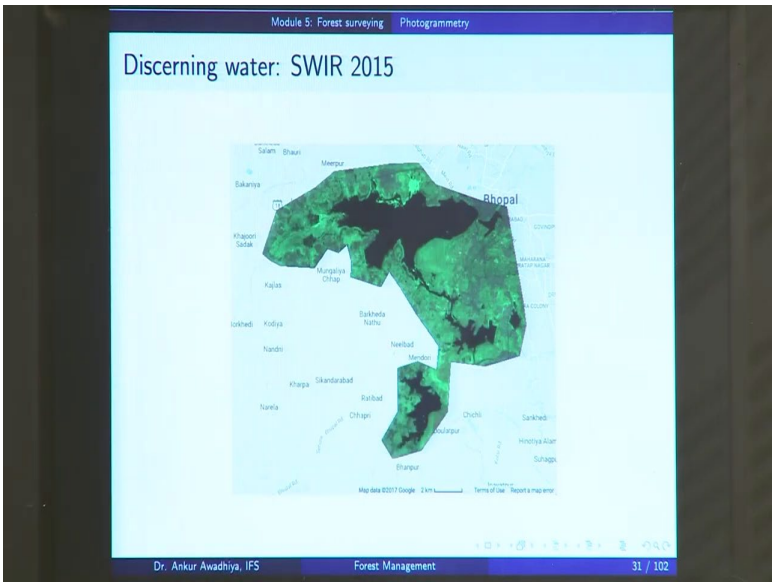

So, we can get these transition classes, but to make the boundary we can also make use of things such as the shortwave infrared bands. So, this is an image in the shortwave infrared band. Say for every year say 2015, we can make an image like this, from which we can get where the water is located by making use of the normalized difference water index.

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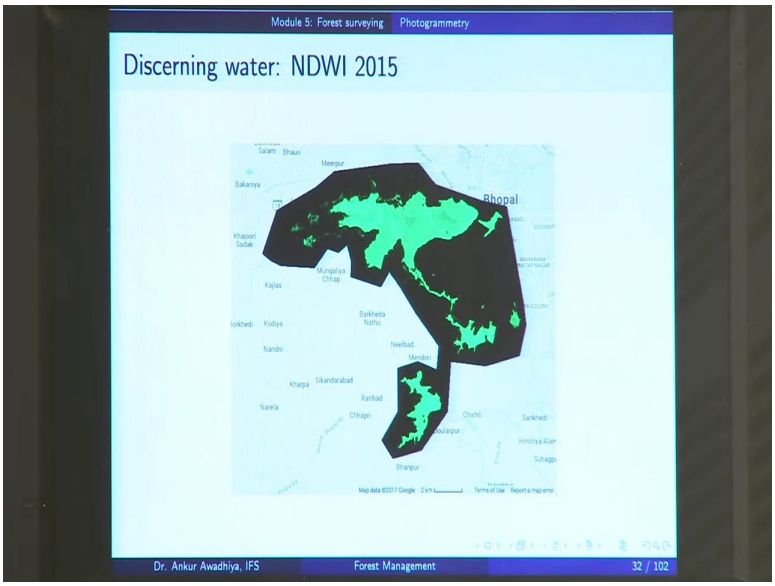

So, now in this picture what we are seeing is what are the locations where you have water, where you do not have any water - this black in colour; where you are having water is shown as green in colour, and now, you can make use of the data that you have over the past 30 years.

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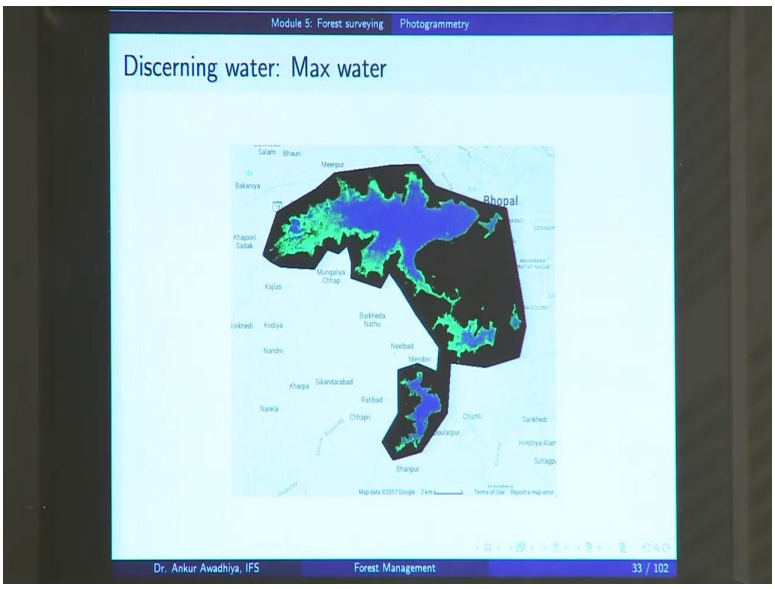

Now, in the last 30 years what are those areas in which you had the water? So, this is the maximum water image. So, these are the areas which in the past 30 years there was some period where it was a part of the reservoir or a part of the lake.

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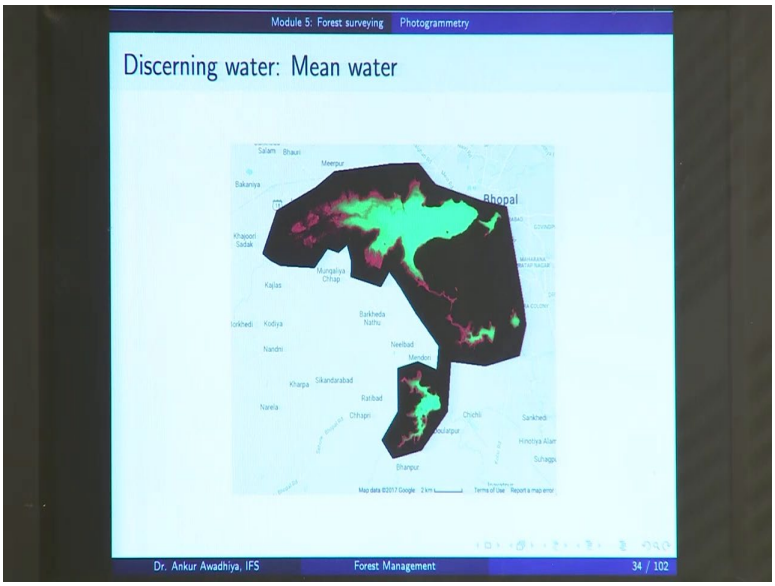

Then, we can also construct another image which is telling us the mean water. So, on an average you had water in these areas in these 30 years.

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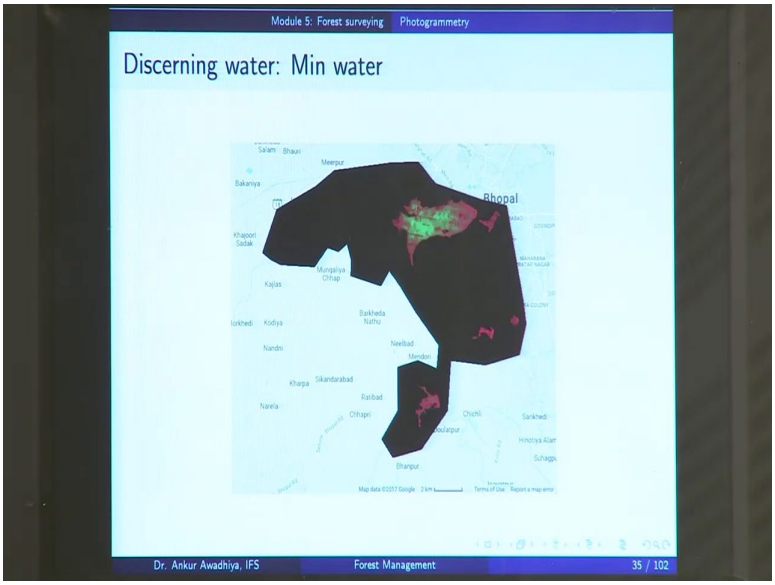

Or, you can even make use of this image to say what was the minimum water that was available in a year. So, there was no year in which this portion did not have any water. So, we are making use of these aerial photographs or the satellite photographs to construct these kinds of maps which are giving us thematic information.

So, all these kinds of applications can be done, and today or in today's context, in the case of forest management, they are becoming more and more prominent to enable us not only to interpret things; not only to measure things, but also to make planning about what needs to be done for the future. So, that is all for today.

Thank you for attention. [FL].