Conservation Geography
Professor Dr Ankur Awadhiya
Indian Forest Service, M.P
Indian Institute of Technology, Kanpur
Module - 12
Special topics in Geography and conservation
Lecture – 34
Remote Sensing and GIS

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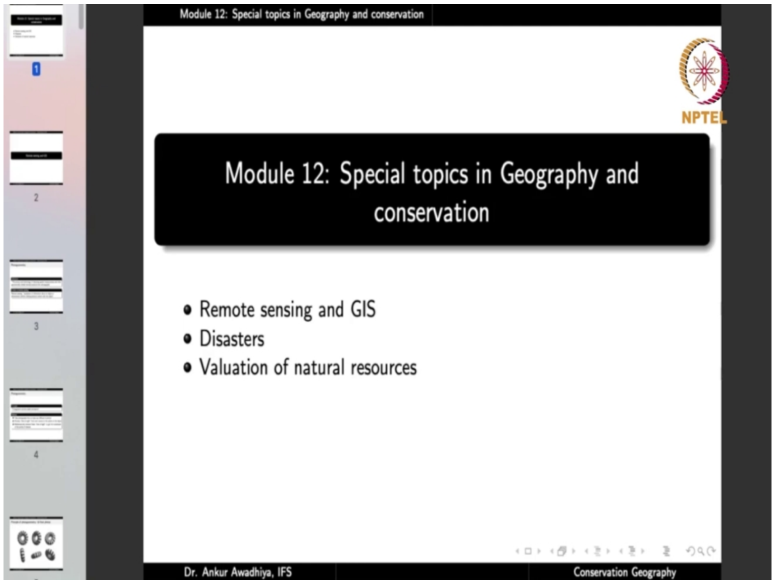

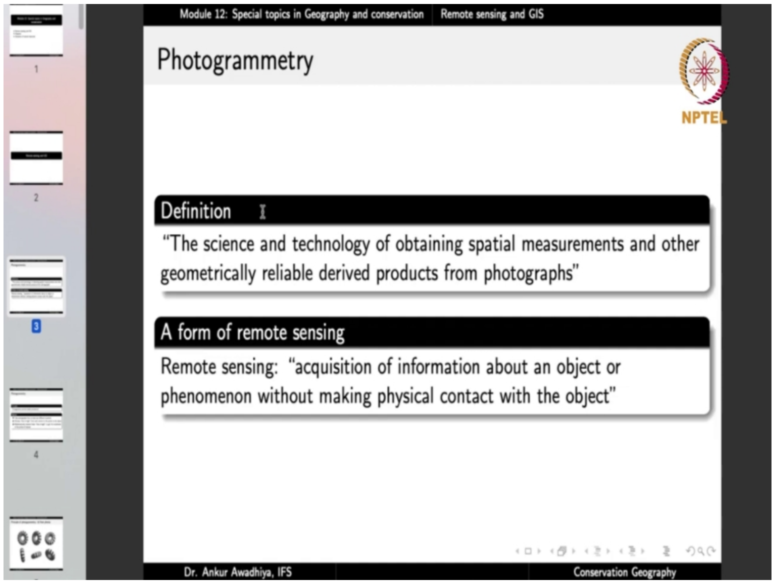

Namaste! Today we begin a new module which is special topics in geography and conservation. This module will have three lectures, remote sensing and GIS, disasters and valuation of natural resources. So, let us begin with remote sensing and GIS. Remote Sensing has got a lot to do with photogrammetry.

Photogrammetry from the words photo meaning light and grammetry meaning measurement. So, this is the science and technology of obtaining spatial measurements and others geometrically reliable derived products from photographs. That is photogrammetry is the science and technology of obtaining measurements using light or using photographs and what kinds of measurements we can have spatial measurements that is measurements of distance measurements of height and so on.

Which are measurements in this space in the two dimensional space or the three dimensional space. So, we need to have these measurements and other geometrically reliable derived products. What are these derived products will have a look in a short file but they include things like digital elevation model or digital terrain model or digital canopy height model. So, all these different kinds of models are the derived products.

Similarly, we can make different kinds of maps using these photographs, we can do an estimation of say the amount of carbon that has been sequestered in different forests. So, all of these different kinds of geometrically reliable derived products from photographs can also be obtained using the science and technology of photogrammetry.

And the science and technology of photogrammetry is a form of remote sensing. Now, remote means distance. So, when say we use a remote controller for our television, we are using a controller that can control the television from a distance, which is why it is a remote controller. Now in the case of remote sensing, we are trying to sense something from a distance.

Now sensing is when you think about your senses, when you think about eyes, or ears or nose, what you are trying to do with these senses is to gain information about your surroundings. Now, similarly, in the case of remote sensing, we try to gain information about something and this information has to be had from a distance.

So, we are not going to touch that object, but from a distance we are going to gather some information about it that is remote sensing, acquisition of information about an object or phenomenon without making physical contact with the object, because if we make physical contact, it will not be remote. And we need to have information which is sensing. So, it is acquisition of information about an object or phenomenon without making a physical contact with the object.

Now if you look at it, when we take a photograph, we are gathering certain information about the object. And we are gathering this information from a distance because in the case of a photograph. You do not touch the object, it is just that the light that has been reflected or that has been emitted from the surface of the object that comes to your camera and that gets recorded.

So, this light is bringing the information about the object, what is the size of the object, what is the color of the object? What are the different properties of the object? Is this something that absorbs heat or is it something that emanates heat, you can have this information by looking at an infrared photograph.

Now, when we look at these information, when we look at these photographs, we get information about the different objects that have been photographed and this information is being had from a distance. So, photogrammetry or the use of photographs to make measurements is a form of remote sensing.

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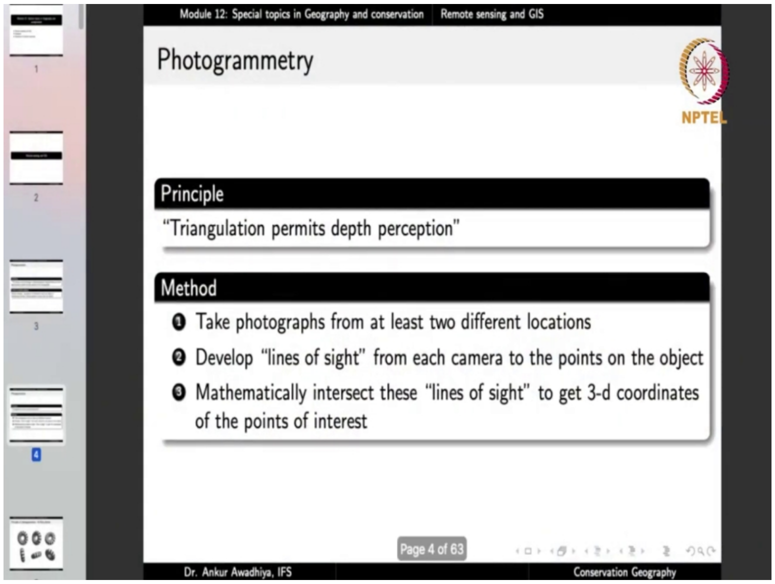

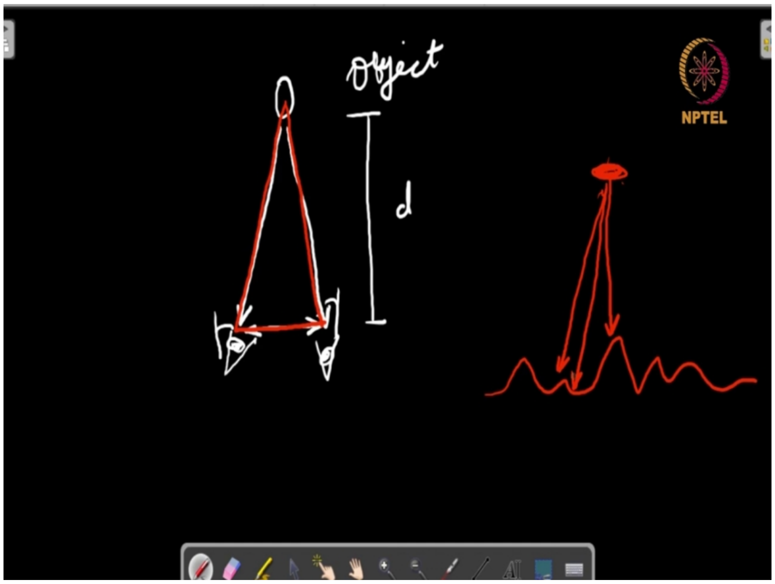

Now, when we need the spatial information, we base it on the principle of triangulation. Now, triangulation is to make triangles and it permits depth perception. What do we mean by that? This is very similar to how we make an estimate about distance of an object using our eyes. Now we have two eyes.

And when we are looking at certain objects the two eyes are gathering information about the object say this is the object and when we look at this object we are getting light from this object that is falling on two eyes. Now, by knowing the distance between the eyes now that is fixed for all of us and by say knowing the angle that these rays are subtending to the normal, we can find out the distance of the object from the eyes.

So, in this case, we are constructing a triangle from the object to the eyes and this triangle is giving us information about the depth of the object or the distance of the object from us. Now, similarly, in the case of photogrammetry we take photographs from two or multiple locations not just one location.

And if we have photographs from multiple locations, we can use the principles of trigonometry or we can use the principles of triangulation to gather information or to arrive at information about the distance of different points on the photograph from the point where the photograph was taken. Now, consider an aeroplane which is flying above the earth and it is maintaining a constant altitude. So, its height is constant.

Now, in that case say this is the location of the aeroplane and you have the ground that is up and down. Now, in this case, if we know the distance of various points in that case, we will be able to construct a three dimensional map of the earth. Now, this is what we are referring to here. If we use triangulation it permits depth perception and so, we can have information not just in two dimensions, but also in the third dimension which is the height.

So, this is the principle of photogrammetry triangulation permits depth perception and how we do it, we take photographs from at least two different locations preferably more because the more the number of locations the lesser is the error. Develop lines of sight from each camera to the points on the object. Now, lines of sight are these lines and mathematically intersect these lines of sight to get 3-d coordinates of the points of interest.

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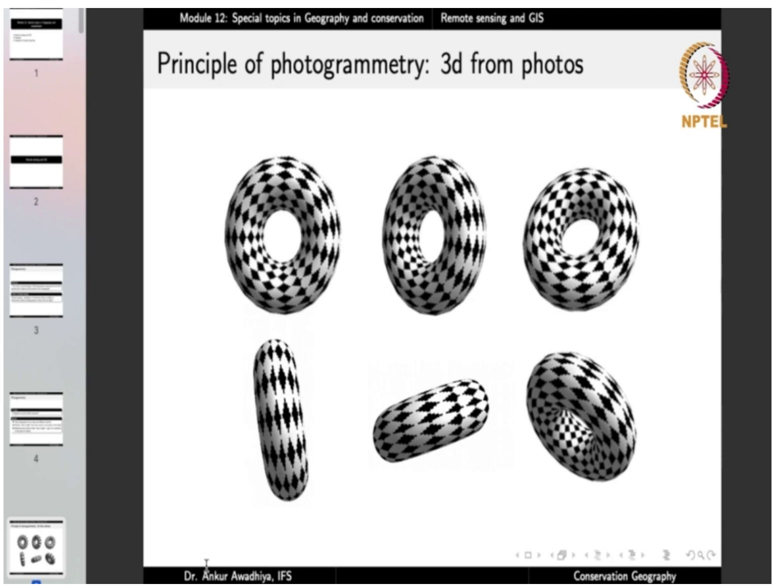

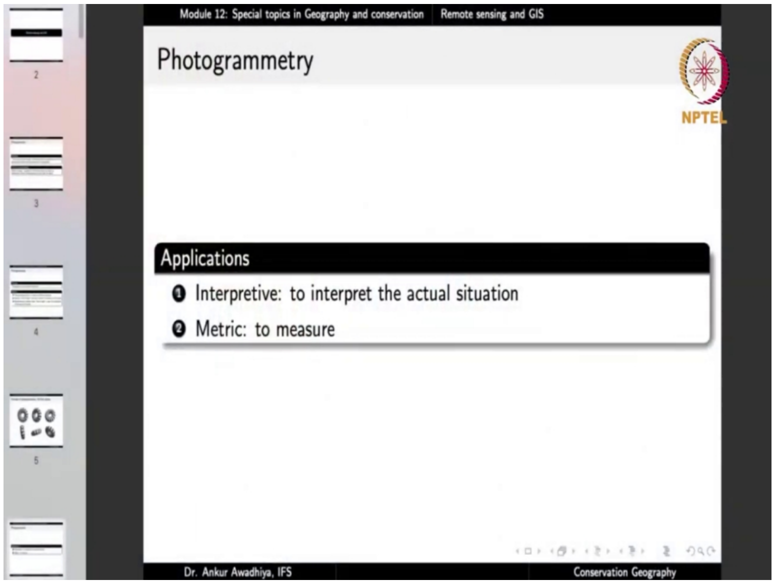

That is, when we are taking photographs from different angles from different locations, then we will have an information about different faces of the object and the distances of various points from the location of taking the photograph. Now, if we know exactly the location of taking the photograph by say using GPS devices or say by using differential GPS devices.

In that case, we will be able to very easily pinpoint the third dimension in the objects and we will be able to create a 3-d model of the object. Now, photogrammetry has two broad categories of applications, why do we do photogrammetry because of these applications, we can have interpretive applications in which case we are trying to interpret the actual situation we are not interested in measurements.

But we are interested in interpreting in making sense of the situation. So, for example, if you create a three dimensional view of say a glacier, you can see that there are certain locations where you have eyes and there are certain locations that are exposed. Now by looking at these different locations that are covered with ice and so have a high albedo or that are not covered with ice and so, are having a low albedo.

We can make a sense about whether this area is going to absorb more heat or it is going to not absorb the heat of the sunlight. And so, in this case, we are just trying to interpret the situation. If you take a photograph of say, an area near a village and we are taking the photograph over several years, and we see the that over the years, the amount of forest is going down and more and more of the land that was earlier forest is now being converted into crop lands.

In that case, we are trying to make an interpretation of the situation what is the kind of land use changes that we are observing in this location. Now these are the kinds of applications that go by the name of interpretive applications. On the other hand, we can have metric informations or metric applications in which case our objective is to make measurements.

Now, when we consider say a glacier, we may be interested in making a measurement of the amount of ice that has been accumulated in that glacier. So, that we can know that when global warming melts up all that ice what will be the volume of water that will be released into the oceans.

Now, in that case, we are interested in not just knowing which areas have ice and which areas do not have ice, but we want to calculate things. So, that is a metric application. Similarly, if you want to know what is the total area that is under forest cover in our country, we are trying to do a measurement of the areas. So, that is a metric application.

So, in the earlier case, we were just trying to understand or interpret whether an area is getting deforested or not. But in the metric end applications, we are trying to measure how much amount of the forest has been deforested. So, these are two different kinds of applications of photogrammetry.

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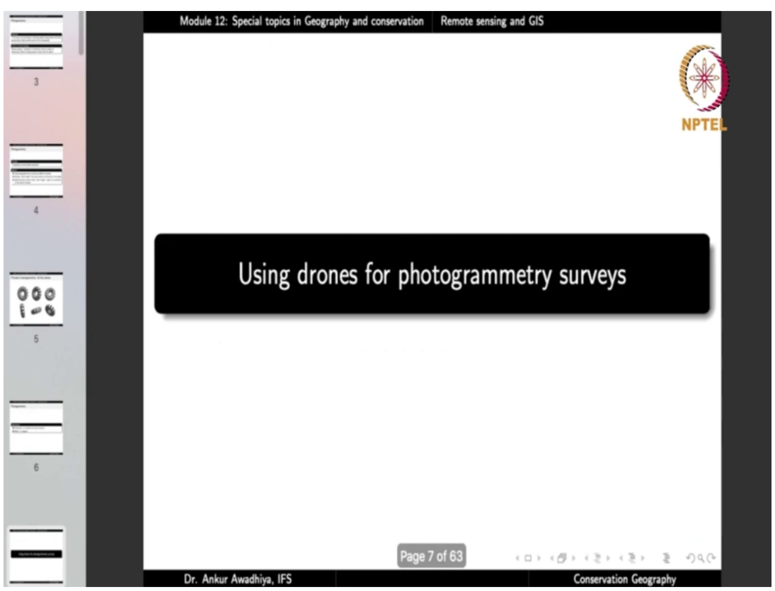

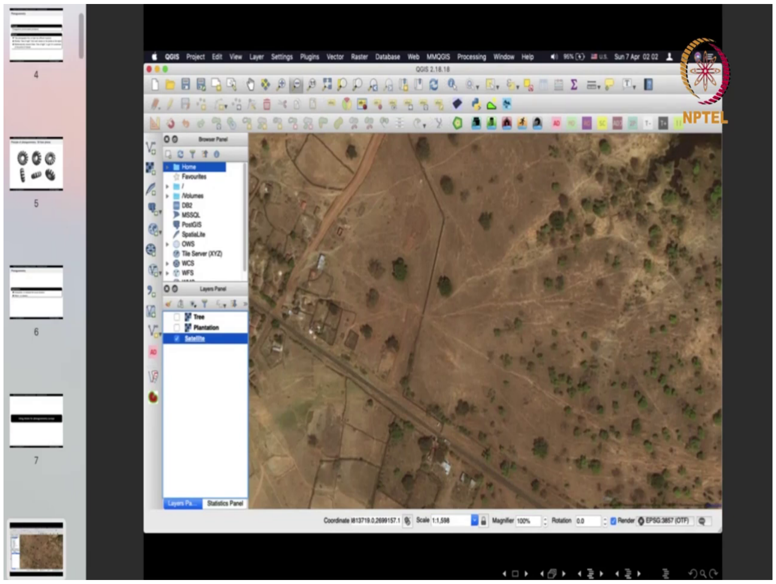

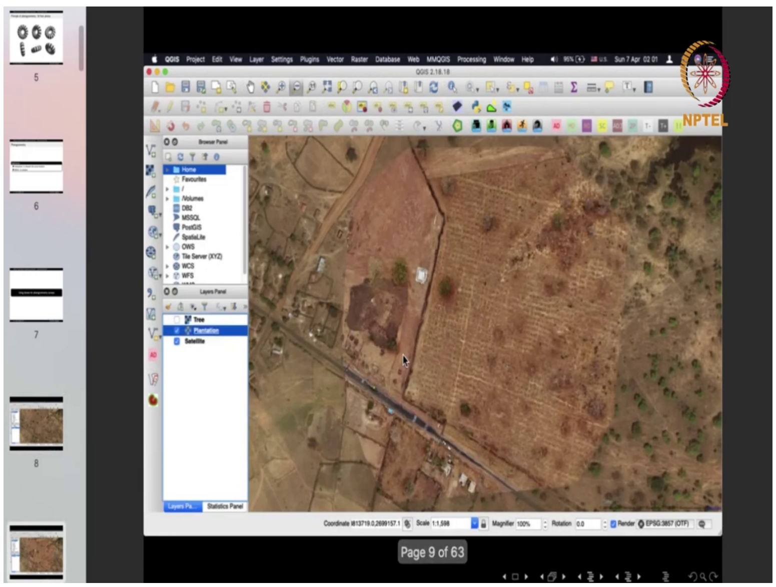

And today, we are making use of drones in a big way because drones have become very cheap. And they very easily permit us to gather these information and especially multiple photographs of an area from different locations to arrive at a three dimensional view, which can be used for interpretive or metric applications.

Now, here is an example. Now, this is the satellite image of an area it is an nor agri wildlife century and this is the drone image that has been superimposed now you can make two different kinds of observations. One is that if you look at this road, in the satellite imagery, and this road in the drone imagery, we find that both of them are just one on top of other.

That is, we are maintaining the geographical attributes in this photograph, we are taking photographs in such a manner that permits us to compare between different photographs, even those that have been taken on two different platforms. Here we are talking about a platform of satellite based imagery and a platform of drone based imagery.

But through the process of geo referencing we are assigning coordinates to both of these photographs, so that we can make comparisons and we can interpret this situation. So, for example, we can see that in the satellite imagery, we do not have any construction here in the drone imagery, we have this construction here.

So, by looking at both of these images, we can now say that, this construction was done after the satellite imagery was taken and before the drone imagery was taken. Similarly, if you look at this area, and the satellite imagery, it is just a plain piece of land and now this area has been excavated.

So, you can see that, this excavation has occurred, before this drone imagery was taken and after the satellite imagery was taken, now, we are trying to interpret the situation, we are now seeing that the human influence has reached near the sanctuary. And these are the indications of the human influence, we are making changes in the land, we are making constructions.

So, these are interpretive applications. Similarly, if you look at this portion, here, there was a plantation that was done. And you can see that there are all of these different pits that have been dug, and plants that have been planted. Now in this case, we can do a metric application, meaning that we can try to find out how many trees were planted, what was the average distance between these trees that were planted, and so on.

So, we can do measurements on these images. So, this is a metric application. So, we can have interpretive applications or we can have metric applications. Now to do that, a very important thing is to geo reference the photographs, which is to give them or assign them, the latitudes and longitudes of various locations, so that they can be superimposed one on top of the other.

Now another thing that we can observe is that while the resolution of the satellite imagery is less, the drone imagery gives us a very good resolution, primarily because the drones fly at a lower height. We typically fly drones at a height of say, around 30 or 40 feet, not above that.

So, in that case, we can have a very clear picture of various locations, and how clear pictures if you look at these areas from the drone photographs, if you fly the drones at lower altitudes, you can have an even greater magnification if you fly the drone low enough, you can even count the leaves that are there on different plants.

So, here we can see that this is a pit that was dug, you have a plant and this is the soil that was taken out of the pit to make way for the plant, make space for the plant. So, these are the kinds of applications that we can make use of and these days because drones are very cheap drones are very easy to use, and our regulatory mechanism has become such that we can very freely use the nano drones. So, it is now becoming more and more common to make use of these drones.

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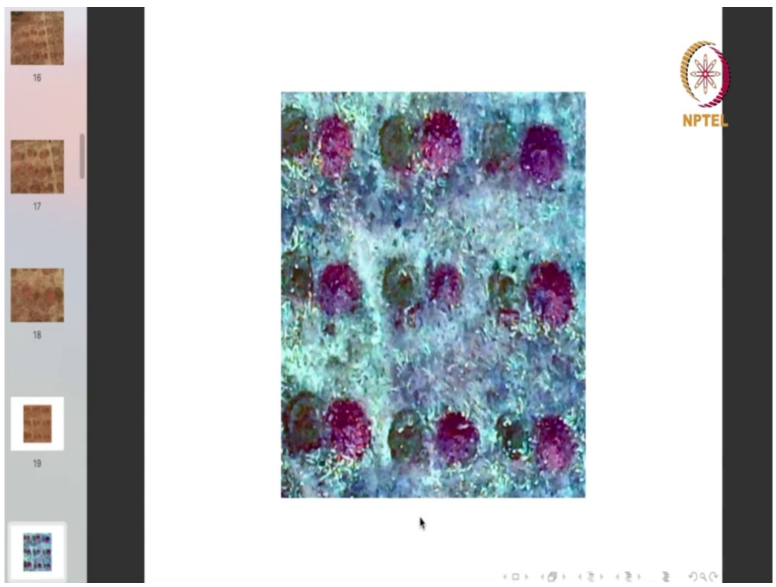
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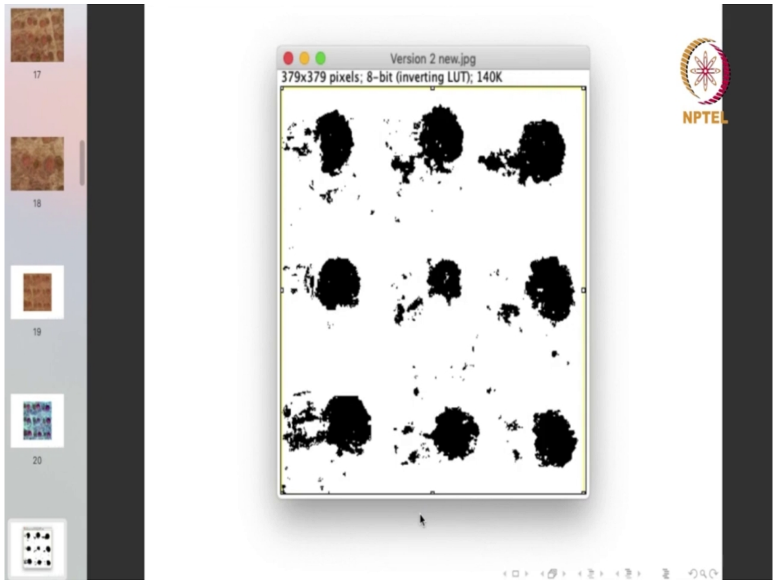

And another metric application is that we can do several kinds of automated computations. So, if we look at this picture, here we have these pits and we have these soils that are around now we can give this picture to a computer and we can ask the computer to do computations about various phenomena.

So, we increase the contrast we convert it into black and white image which is a two bit image and then we can compute the sizes of various pits that have been dug. And in this case, we can understand what is the size of the pit that was dug. Now the size of the pit has got a lot to do with the survival of the plantation.

Because if you have large size pits, then more and more amount of water will be able to enter into the soil from those locations and so, the plants that you have planted they will get a sufficient amount of water in the rainy season. Typically, these plantations are done right before the rainy season and if you have large size pit then you have more water that is available to the plants.

Similarly, when you dig the pits and when you replace the soil, we typically replace it with more fertile soils we even sometimes add things like manure like farm yard manure or the gobar khad. Now, if you have a large size pit it means that you have added more amount of manure to that plantation. Similarly, when you have taken out the soil and when you replace the soil, typically the soil that is added is much more brittle than the original soil. Because it has not been compacted yet.

And in those situations, the roots can grow much easily and the roots also have access to air because this whole area or this pit has been aerated a lot. And so, having information about the size of the pits is very important to make an assessment of the quality of the plantation.

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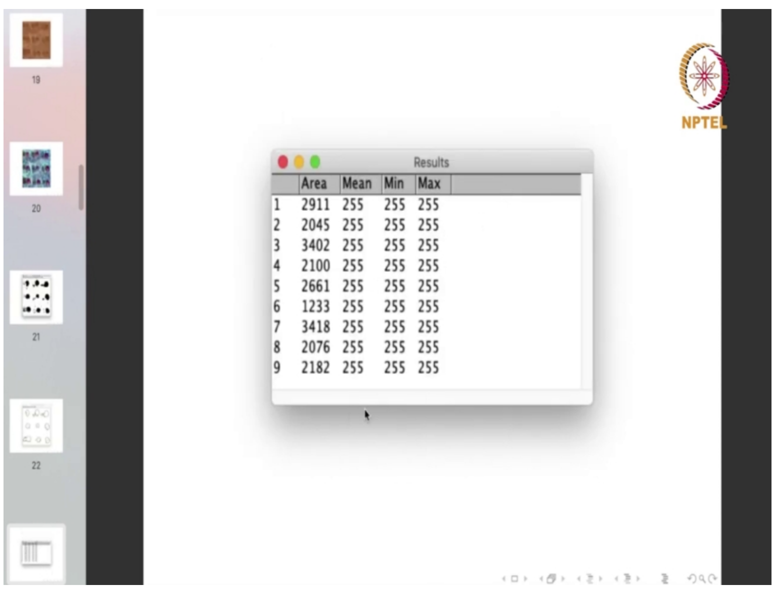

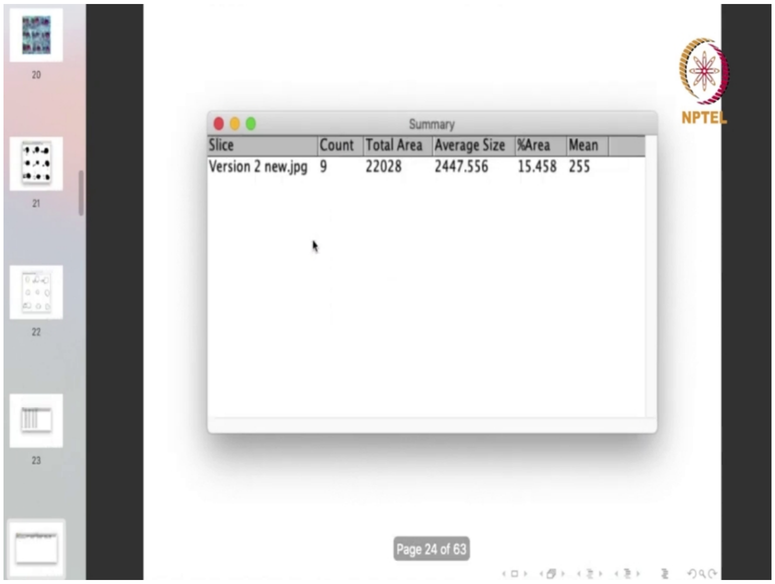

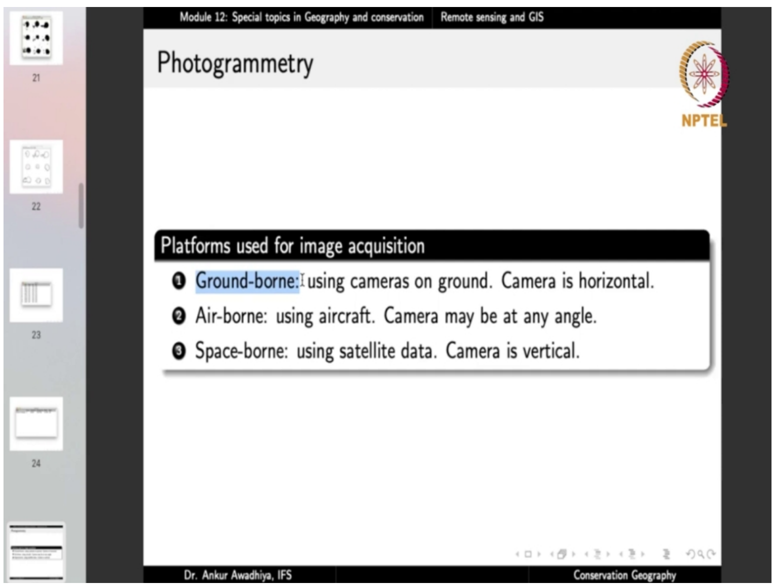

And in this case, we are getting these areas of various pits using a computer. So, we can find out the average size of the pits we can find out the total size of the pits and so on. Now, these are the metric applications. Now to take these photographs, we use several platforms and different platforms give us different kinds of images.

We can use ground borne platforms in which case we have cameras which are there on the ground level. So, if you take a camera into the forest or into a plantation and you take photographs, then that is a ground level platform. And in this case the camera is horizontal. Another platform is this air borne platform which is say using an aircraft or even a drone and in this case the camera maybe at any angle.

And third we have space borne platforms, which use satellite data and typically the camera is vertical. So, we have these three different kinds of platforms that we regularly make use of. Now ground borne platforms are very easy to use when you have to send people to the ground and to gather evidence or together information or data about the projects.

Because and these are some of the cheapest ways of getting the photographic data because you just have to send a person with a camera and the person would go and click photographs and bring them to you. Now, a plus point of the ground based platform is that you are getting information from a horizontal level. And so if you want to make measurements of say the diameter of the trees or if you want to see whether trees are having diseases or not.

In that case, it is very easy to see using the ground based platforms because you are seeing the trees as you normally see them in the forest. In the case of an air borne platform such as using an aircraft. It is typically more expensive than the ground borne platforms because you need to make use of an aircraft so there is an additional cost.

That is involved here, you not only need the camera but you also need an aircraft to take the camera, you also need a person who can fly the aircraft or the drone and the training the procurement the maintenance at up to the costs. Now, in this case the camera can be at any angle, but typically we make use of a vertical or a near vertical angle.

So, that we have a bird’s eye view of the area. In the case of a space borne platform, which uses satellite data, the initial costs of putting the satellite are very high, because you need a rocket to put the satellite in location. But once you have the satellite that has been put up now, the photographs are very cheap to get in this case the camera is vertical and so we have a top down view of the location.

Now, typically the space borne platforms have a lower spatial resolution because the satellites are at a very great distance from the earth. The air borne platforms or the drone borne platforms are having a much greater spatial resolution because they fly at a lower height. Whereas the ground borne platforms have typically the highest spatial resolutions because they are very close to the object about which you need the information.

So, as we have observed that in the case of satellite imagery, we were just able to see the trees, but in the case of drone imagery, we were able to even see the leaves of the trees or the leaves of the plants. So, that is what we are talking about in the case of a ground borne or an air borne platform, the resolution is typically much greater than that of the space borne platform.

But again, in the case of the space borne platform, you can have data at a very regular interval because the satellite is going around and around the earth and every few hours or every few days, you can have another picture of the location without practically doing anything because all of the things are mostly automated. Whereas in the case of ground borne or air borne platforms, if you want to have multiple images of an area at different points of time you have to go to those locations or you have to take your aircraft to those locations and that involves a lot of work.

So, typically the temporal resolution in the case of satellite data is much better because you are having data at a very regular interval. But the temporal resolution in the case of air borne or ground borne platforms it varies. So, it is possible that you go to that location every day and you take a picture that is also possible, but in most of the cases it so happens that you take you go to the location once in a few months and in that case the temporal resolution goes down.

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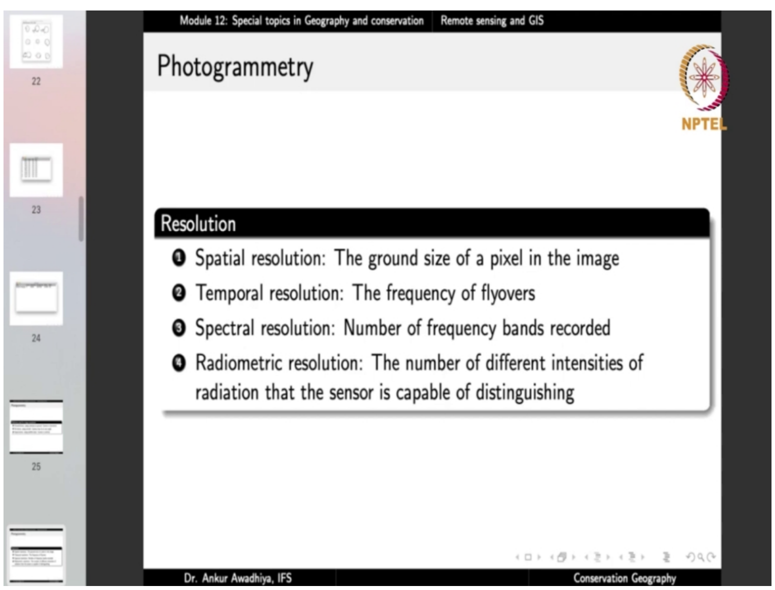

Now, in this case, there are four different kinds of resolutions, you have spatial resolution, which is the ground size of a pixel in the image. So, when we talk about the spatial resolution, we are asking the question, what is the smallest size thing that we can resolve on the picture if the spatial resolution is high.

In that case you will be able to see very small objects that are there on the ground, very small objects such as say insects or even leaves. In the case of low spatial resolution, you are only able to see large sized objects. So, you are able to see the trees but you do not see the branches or the leaves. So, that is about the spatial resolution.

Typically, we look at spatial resolution in terms of the megapixels. If you have more megapixels in a camera, you have greater spatial resolution as compared to if you have a lower number of megapixels, but that also depends on the quality of the lens, it also depends on the distance of the camera from the object and so on. So, that is the spatial resolution. Temporal resolution is the frequency of the flyovers, how frequently are you getting data about your object?

Are you getting information or data every month or every week or every day or every few hours. Now, if you are getting the data every few hours, then you are having a very high temporal resolution. If you are getting data say once in a year or once in a decade, then you have a low temporal resolution.

The third is the spectral resolution, which is the number of frequency bands that are recorded. And a good way to understand spectral resolution is by asking the question, how many colors do you see in the photograph. So, for example, if you have a black and white image, you see only two colors black or white or shades in between which is grey.

Whereas if you have a colored picture, then you have multiple bands, you have the red band, you have the green band, you have the blue band and so now you have more number of bands earlier you only had one band in the case of a black and white image which was either telling you that this is bright or this is not bright.

Now you are seeing three different bands red, green and blue. And for each band you are getting the information is it bright in the red band or is it not bright in the red band is it bright in the green band or not is it bright in the blue band or not. So, more the number of colors more is the spectral resolution.

Now, typically in our cameras, we only have these three different bands red, green, and blue. But in the case of satellite imagery, we can also have other bands we can have bands such as the infrared bands or we can have the ultraviolet bands. Even in the case of infrared bands, we can have things like near infrared or middle infrared or far infrared.

So, in that case, you are having you are gathering information in a large number of bands and that increases the spectral resolution, now more is the spectral resolution more is the kind of information that you can get about the object. For example, if you only have a black and white image of a tree, you will not be able to tell what is the color of the leaves is it say just green in color or has it turned brown. Because both will look dark in the case of a black and white photograph. But if you have a color photograph, you can see, this is green, this is brown, but you do not get other information. If you have say the infrared bands or the ultraviolet bands, you will be able to see much more information in much greater detail, what are the kinds of pollutants in the air that we have?

What is the level of smoke in the air? What are the kinds of aerosols that are there in the air? What are the locations that have water? What are the locations that are drier? What are the plants that are having stress, say a water stress or a diseases stress. Now, these kinds of information we do not get from a color picture, but we get them once we have information in the infrared, ultraviolet and other bands.

So, more than number of bands more is the spectral resolution and the fourth is the radiometric resolution. Which is the number of different intensities of radiation that the sensor is capable of distinguishing. In the case of radiometric resolution, we asked the question, how many shades of brightness are we able to record for each band.

Now, if you have a two bit image, you will only be able to record say bright or dark, nothing else in between. But if you have a multiple bit image, then you will be able to record that it is bright, then it is less bright than even less bright and even less bright than dark, darker, darkest and so on. So, if you have more number of bits in the image, you record a much greater amount of variation in the intensities.

And that is the radiometric resolution, the number of different intensities of radiation that the sensor is capable of distinguishing. So, typically, in the case of spatial resolution, we are asking how many megapixels and what is the sharpness of the image. In the case of temporal resolution, we are asking the question, how frequently are we taking the image of the object?

In the case of spectral resolution, we are asking the question, what are the number of colors that we are able to capture in the image? Or what are the number of bands that we are able to capture in the image and in the case of radiometric resolution, we are asking the question, what is the number of bits in each channel or for each band of the image. So, these are the four different kinds of resolutions.

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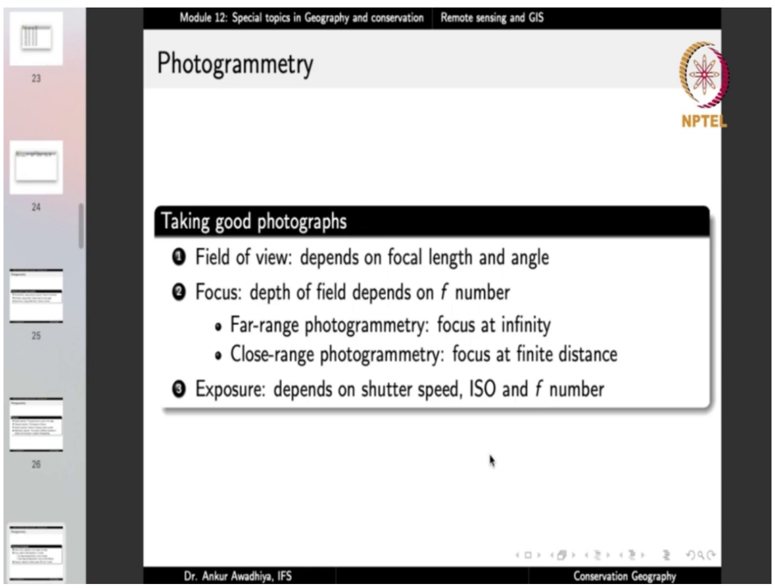
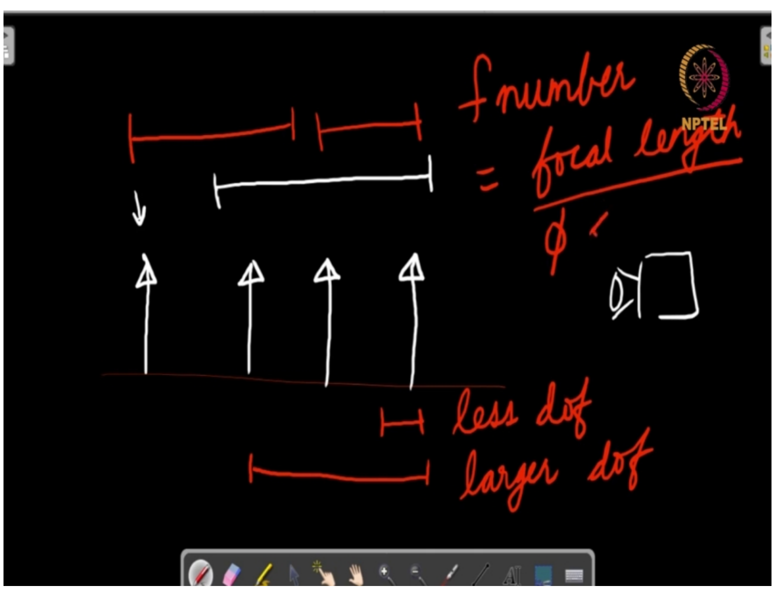
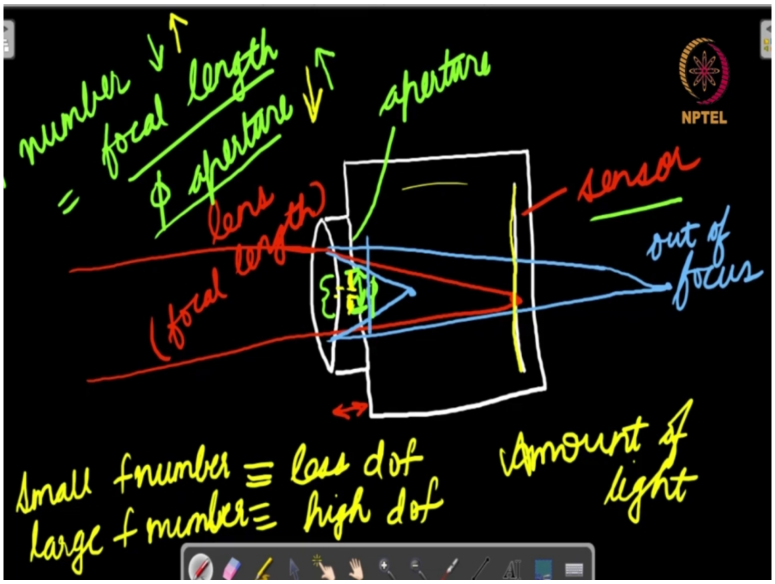


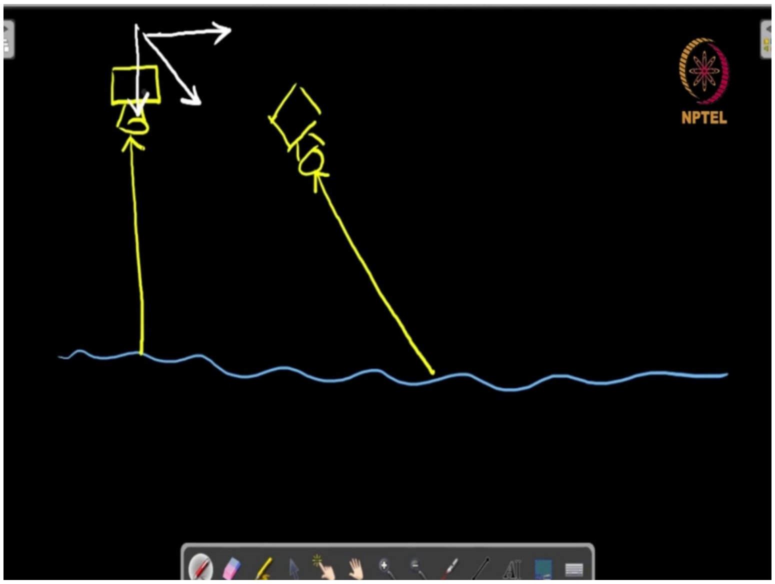




Photogrammetry

Orientation of camera axis

1. True vertical: Hypothetical
2. Near vertical
3. Oblique: axis is intentionally tilted between vertical and horizontal
   1. High oblique: horizon visible
   2. Low oblique: horizon not visible



Now, let us talk about how we take a good photograph. In taking good photographs, several points are important. The first is the field of view. What are you trying to see in your image? Do you want to have a field of view that see observes the object as about sees it? What you want to have a field of view that sees the object as an insect would see it that is down from below, what you want to have a field of view that is say as a dog would see it as height from the ground.

That is the field of view. Now, depending on the field of view, you can have different kinds of photographs. And you can make use of different focal lengths of lenses to get different fields of view. So, field of view would depend on the focal length of the lens and it would depend on the distance or the position of the camera with respect to the object.

The second is focus. In the case of focus, we asked the question what are the points that are sharply represented in the image that is for which points on the object the image is right there on the photographic film or the image sensor those points will be called as the points in focus. Now, typically we have a range of points that are in focus that is to say, if you have several objects so, you have say an object here an object here you have an object here you have an object here and so on. And here you have your camera.

Now, in this case is this object in focus and everything else is not in focus or you can have a situation where only this object is in focus and everything else is not in focus or you can have a depth of focus, which would mean that for a certain depth, so, you can have a situation where all of these are in focus, but this one is out of focus or you can have a situation where say, these two are in focus and the rest of these are not in focus.

So, in this case, we are asking the question what is the depth of field now depth of field is the depth of those points that are in focus in the final image. So, if you have only these points that are in focus, we have a less depth of field if you have these many points that are in focus, you have a larger depth of field.

Now, this depth of field depends on the f number and f number is defined as the focal length of the lens divided by the diameter of the entrance pupil or the diameter of the aperture. That is, when we talk about a camera you can represent a camera like this. So, in a camera you have a lens with a definite focal length.

Now, this lens can typically be moved to the front or to the back for certain distances to permit the light that is coming to focus on the sensor or on the photographic plate. So, if these points come right on the sensor, so, this is the sensor, then we say that it is in focus, but you can have a situation where these rays of light they join here and in this case this will be out of focus or if they join behind the sensor.

Then again, we will say that this is out of focus then the next thing that you have is an aperture. Now, aperture is this much free space that is available for light to enter into the camera and the third object is the sensor. So, these three things make a camera. Now, the f number is a ratio of the focal length divided by the diameter of the entrance pupil that is this diameter or the diameter of the aperture.

Now if you have a large diameter of the aperture, it means that you have a large entrance for light to enter inside. And when you have a large sized aperture it would mean that the f number would go down. Now a small f number is typically related to a lesser depth of field. So, we can write it as a small f number, it corresponds to a less depth of field that is.

If you use your camera, you will find that objects that are at a certain distance from the camera they will be in focus, but objects that are slightly in front or objects that are slightly to the back, they will be not in the focus, they will not be sharply focused. And in this case, you will have a situation where your object that is in focus that will be very crystal clear, but rest of the areas will appear a bit hazy or bit out of focus that is for a small f number.

On the other hand, if you have a large f number a large f number would arise if you have a smaller aperture so, if the aperture size goes down, that is you permit light to enter from only a small window and you close down the aperture. So, all of this area is now close and the light can enter from only this small portion.

In that case, the size of the aperture is less and the f number would increase and a large f number corresponds to a high depth of field which means that objects that are close to the camera will be in focus and objects that are even very far from the camera they will again be in focus. So, you use a very small aperture to have a high depth of field and you have a large aperture for a shallow depth of field.

So, the depth of field depends on the f number. And in the case of focus, we can talk about far range photogrammetry in which case we focus at the infinity. So, when we say focus at the infinity, it means that objects that are very far from the camera, they will be in sharp focus. When we take those images when we use those images, we say that we are using far range photogrammetry.

On the other hand, we can also have close range photogrammetry which is focused at a finite distance. Now, typically, when we make use of a space based platform, or when we make use of aircraft borne platforms, we make use of far range photogrammetry because the objects that we need information about that are at a very far off distance.

Whereas when we make use of drones or when we make use of ground based platforms, we typically go with a close range photogrammetry because the objects are close by and if we want to separate the object from the background or the foreground, we make use of a shallow depth of field.

Whereas if we want to have information about everything, we make use of a large depth of field. So, we can tinker with different parameters of the camera to obtain the kind of image that will give us the maximum amount of useful information. Then we also have another thing which is the exposure. Exposure depends on the shutter speed, the ISO and f number.

That is when we talk about exposure, we are asking about the amount of light that should enter into the camera fall on the image sensor. So, that we get a good image, the image should not be so bright that most of the things just look white in color. And it should not be so dark that everything looks black in color, it should have a sufficient exposure so that we are able to understand the subtle differences between different objects.

So, that has got to do with the amount of light that should get into the camera. Now the amount of light that enters into the camera depends on a number of things. One, it depends on the aperture. If you open the aperture to a larger extent you will allow more amount of light to enter into the camera. So, larger the aperture size, or the smaller the f number you have more amount of light that enters inside. It also depends on the shutter speed.

So, in this case, you have a shutter that is behind the camera that is behind the aperture and this shutter will open for a short period of time to permit light to enter inside and then it will close. Once you have the good image once you have a good photograph you can make use of it in photogrammetry.

In this contest, we can also look at the orientation of the camera axis. This is especially important when we talk about the aerial photographs, now in the case of ground based photographs your camera is mostly horizontal because that is the only option that you have you just take a camera to the ground and you are taking a picture.

So, it will be nearly horizontal in the case of space based platforms it is roughly vertical at all times. But in the case of airborne sensors or airborne platforms, you can change the orientation of the camera and in this case, you can have a vertical orientation or a horizontal orientation or an oblique orientation. Now, a true vertical is just hypothetical. So, in most cases we talk about a near vertical orientation.

So, in the case of a near vertical orientation, you are looking at the ground from top down approach in the case of an oblique photograph, you make the axis tilted between the vertical and the horizontal. That is to say, in the case of if this is the ground in the case of a vertical or a near vertical orientation, your camera will be looking like this. So, it is looking at the earth from top down in the case of oblique orientation, your camera is at an angle.

So, it is looking at the earth like this. So, the light rays that are coming at an angle will strike the camera. Now you can vary this angle so you can wait from say a vertical which is a 90 degree orientation to a horizontal which is 0 degree orientation to anything in between. So, you can have different orientations of the camera and different orientations can give you very different kinds of images in the case of oblique orientation, the axis is intentionally tilted between the vertical and the horizontal and here you can have a high oblique in which case the horizon is visible or a low oblique where the horizon is not visible.

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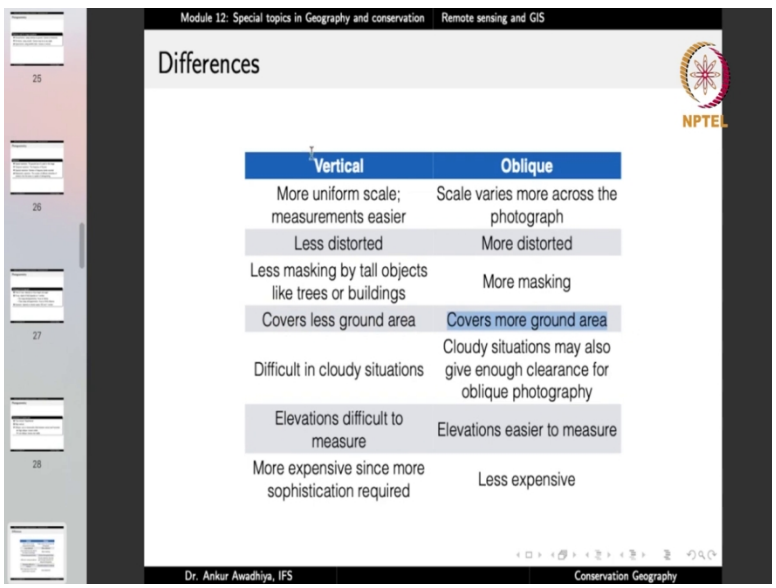

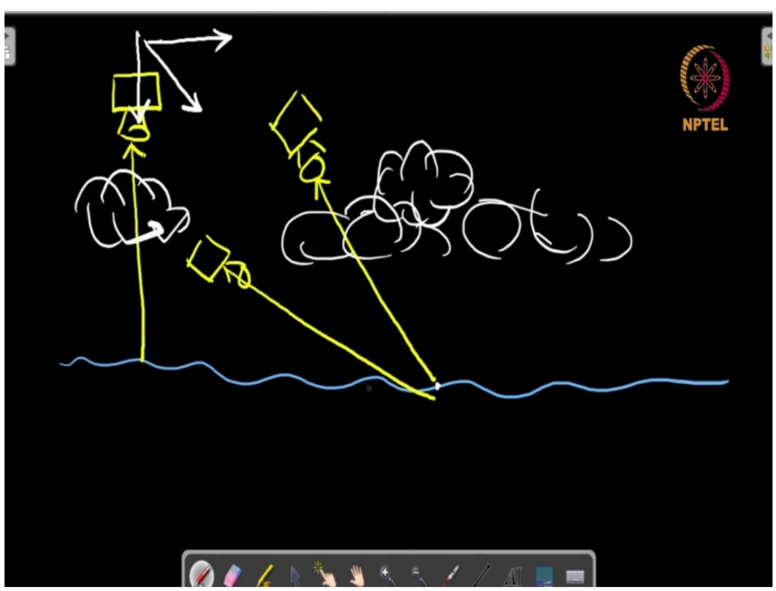

Now, why should we be concerned about these we are interested because of the different kinds of photographs that we can make in the case of vertical photographs, they are useful, because they have a uniform scale and so, the measurements are easier to make. Whereas in the case of an oblique photograph.

The scale varies more across the photograph that is near the center, you will have a different scale of measurement near the edges you will have a very different scale of measurement. Whereas in the case of a vertical photograph, the scale of measurement is the same everywhere.

And so you need to perform lesser amounts of computations to gather the metric information from the photograph. Now in that case, you will ask the question, why do not we just make use of the vertical photographs will oblique photographs are useful specially in the case of cloudy days.

Because if you have a cloud say, if you have a cloud here, then the vertical photograph will not give you any information. But if this is your object, and if you have a cloud right on top of it, then too you can have a picture that has been taken obliquely. If you have more amounts of cloud in that case, if you have clouds everywhere like this, in that case you can make use of a camera that is even more tilted.

So, you can make use of a camera that is say something like this even more tilted to get information about the object of interest. So, oblique photographs also have their own utility, but we need to understand their differences so that we can make use of them in a proper manner. Vertical images are less distorted, oblique images are more distorted.

In the case of vertical images, there is less masking by tall objects like trees or buildings. But in the case of oblique photographs, there is more masking. Then vertical photograph covers less ground area oblique photograph covers more of the ground area. Vertical is difficult in cloudy situations oblique as possible even in the case of cloudy situations.

In the case of vertical photograph, elevations are more difficult to measure. Whereas in the case of oblique photograph, elevations are easier to measure, because you are looking at the objects of interest from the side and so you are also capturing information about their heights. So, elevations are much easier to measure in the case of oblique photographs.

But then, the amounts of computations that are required to gather the correct heights are much greater because of a difference in the scales at different locations of the photograph. Vertical is typically more expensive, since more sophistication is required, whereas oblique is typically less expensive. So, we can make use of vertical photographs or we can make use of oblique photographs or even horizontal photographs depending on the situation, but we need to be mindful of their strengths and weaknesses to make them a part of our photogrammetry exercise.

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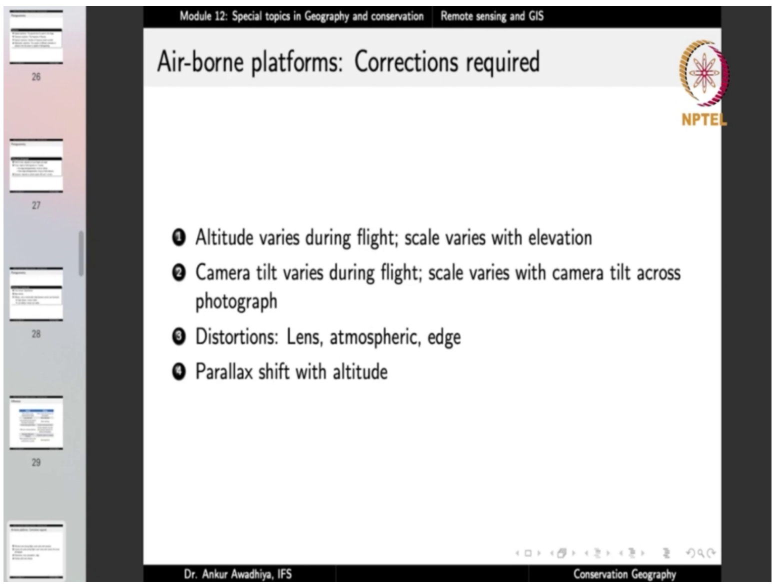

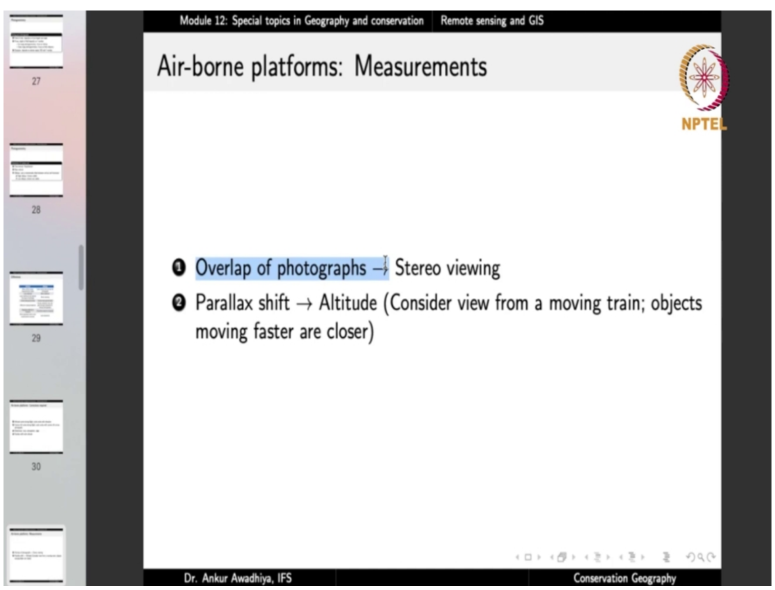

Now, in the case of air borne photographs, we typically require several corrections to be made, we may require corrections of altitude, if altitude varies during the flight, then we will have a situation where in certain locations, the objects are close to the camera and in certain other locations the objects are very far from the camera.

And in that case, the scale of measurement will vary. So, typically when we make use of an air borne platform, we also keep data about the altitudes of the aircraft at different points of time to be used for the computation of scales of different images. So, that you can convert all the images to the same scale and then you can stitch the images together.

So, the scale varies with elevation and if the altitude varies, then you require a correction to compensate for that camera tilt if it varies during the flight, you will have a scale that varies with the camera tilt across the photograph. So, you also have to keep data about the orientation of the aircraft, if the aircraft is turning to the side or not, if the aircraft is dipping or not.

So, you need to have these information about the tilt about the yaw of the aircraft. You also need to make corrections about the distortions you can have lens distortions such as a stigmatism or you can have spherical aberrations or you can have chromatic aberrations or you can have atmospheric distortions or you can have edge distortions and all of them have to be corrected for when you are making use of the images.

Now, similarly, there is a parallax shift with the altitude. That is, if you say consider if you are looking outside of a train window and you look at different trees. Now if the train is moving, the trees appear to be moving in the opposite direction. Now the trees that are close to you, they will appear to move back at a higher speed as compare to trees that are far off from you, they will typically appear more stationary.

Now, this is the difference in parallax that we are observing. Now, parallax is something that gives us an information about the distance of different points on the object from the point of viewing or in this case the point of the camera. But the parallax varies during the flight it shifts with the altitude if the aircraft is moving at a higher altitude with respect to ground, the parallax would reduce if the aircraft is moving at a lower altitude the parallax will be higher.

And so, we need to make corrections for this parallax as well to have a clean image once you have these images, you can overlap these images for a stereo viewing which is viewing in the three dimensions. Typically, in this case, we make use of two cameras and we project the image of the right camera to the right eye and we project the image of the left camera to the left eye.

And in that case, we are able to see a stereo view of the area that is we trick our eyes to think that they are observing the ground from that particular height and we are able to discern the three dimensional information from these two photographs. So, the overlap of photographs can be used to get information about the heights of different objects. Similarly, the amount of parallax shift can also be used to gather information about the altitude or heights of different objects.

Now, we have considered the view from a moving train if the objects are moving faster than they should be closer. Now, if we look at a series of images that are taken from an aircraft, then those things that are moving faster, they are typically closer to the camera which means that they are having a larger altitude they have a greater height.

Because of which they are appearing closer to the aircraft whereas those objects that have a lesser height they will appear far from the or they will be far from the aircraft and so the amount of parallax shift will be lowered. Now we can use the information from either these stereo viewing or we can use the information from the parallax shift to gather information about the heights of different objects.

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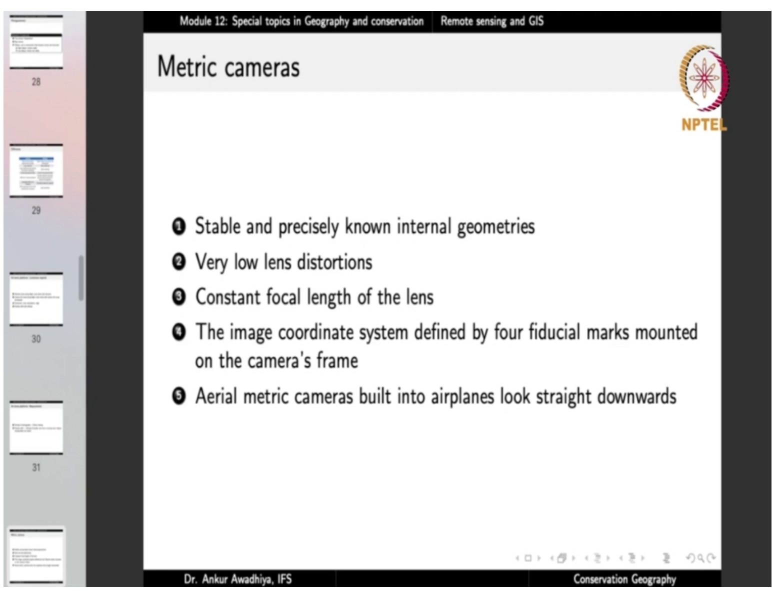

And to make reliable measurements we make use of metric and stereo metric cameras. Metric cameras are stable and have precisely known internal geometries, which means that we know everything about those cameras, what is the length of the camera? What is the width of the camera? And they are made of such materials that do not change in their characteristics.

Now typically, if you look at any metal if you heat the metal it will expand. Now, when the aircraft is moving at different altitudes, the air temperature will be different. And if the camera is made off of material, that expands and contracts with changes in the temperature, then we will have differences in the camera characteristics and that would make measurements very difficult.

So, these metric cameras are made of such materials that do not expand or contract very much. So, they have stable internal geometries, which are very well known. They have lenses that have very low less lens distortions, they have a constant focal length of the lens and the image coordinate system is defined by four fiducial marks that are mounted on the cameras frame.

So, in this case, whenever we take a photograph we will have in the photograph these four points, which will tell us the exact scale that has to be used for this particular photograph. And aerial metric cameras are built into airplanes that look straight downwards. So, metric cameras metron is to measure so these are cameras that are made for measurement.

And if they are made for measurement, then we should be knowing everything about the camera, everything about the camera should remain constant. So, the size of the camera should remain constant the focal length should remain constant, the distortions in the lens should be very small.

And we should have way to cross check things and to cross things we make use of the four fiducial marks with them we can very easily ascertain what is the scale that we should be using for a particular image. And we make use of metric cameras to make measurements for photogrammetry.

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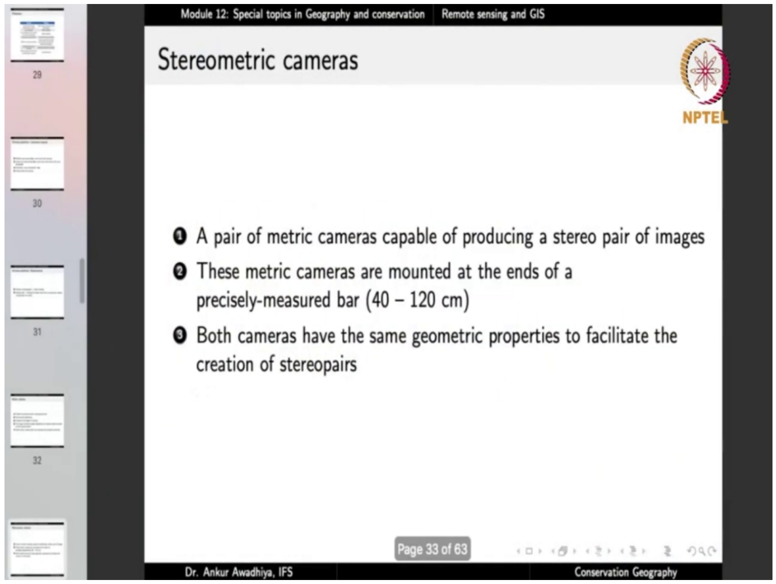

And we can also use stereometric cameras. Now in the case of stereometric cameras, we have metric cameras that are arranged to form a stereo which is a pair. So, these are a pair of metric cameras that are capable of producing a stereo pair of images they are mounted at the ends of a precisely measured bar which is typically 40 to 120 centimeters in length. And both the cameras have the same geometric properties to facilitate the creation of stereo pairs.

Now, when we talk about to stereo pairs, we are referring to two images that can be projected one each into our eyes to be able to see the location in the three dimensions just as the eyes would see it. So, in the case of stereo cameras, or stereometric cameras, we have two metric cameras that are arranged and that are installed in a manner that you are able to make stereo measurements from both of these cameras.

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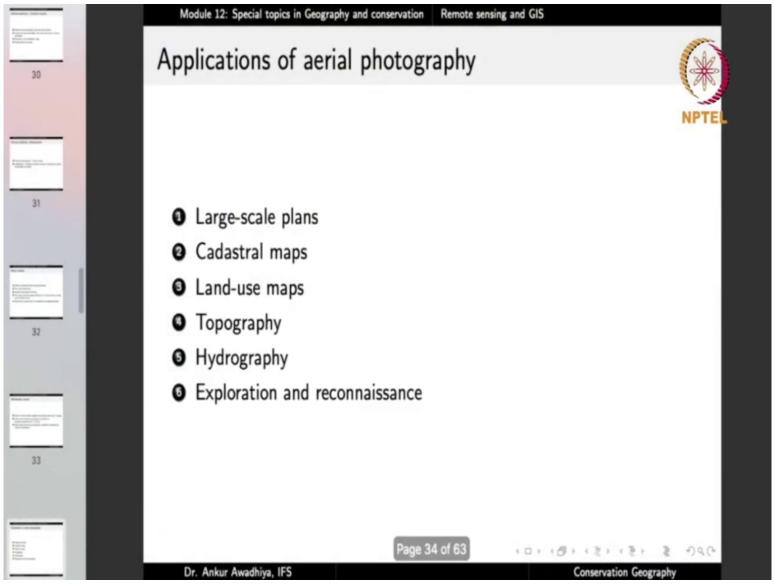
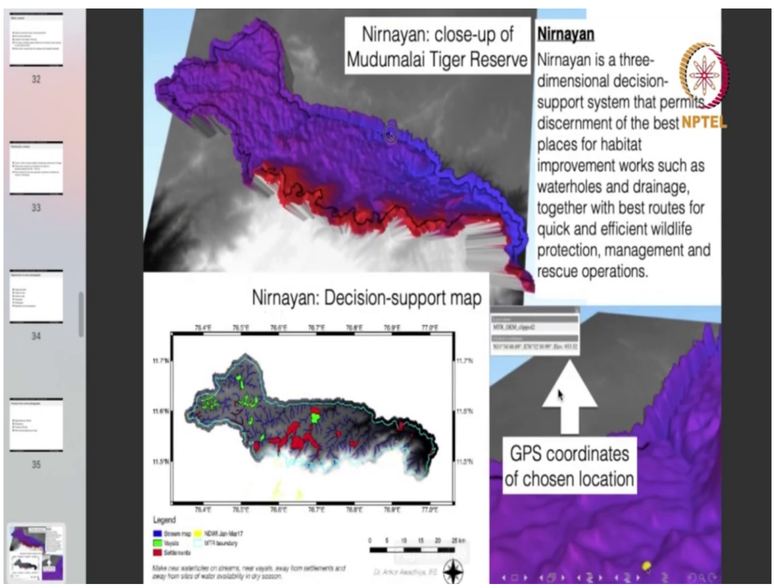
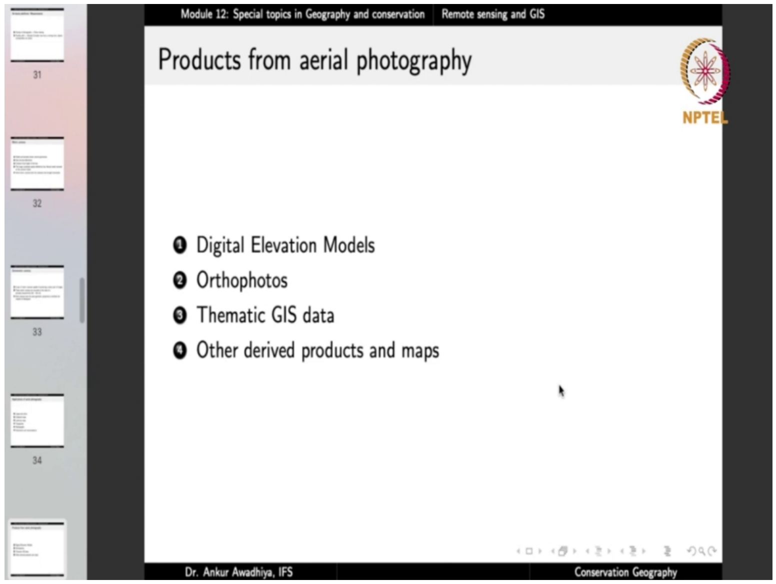
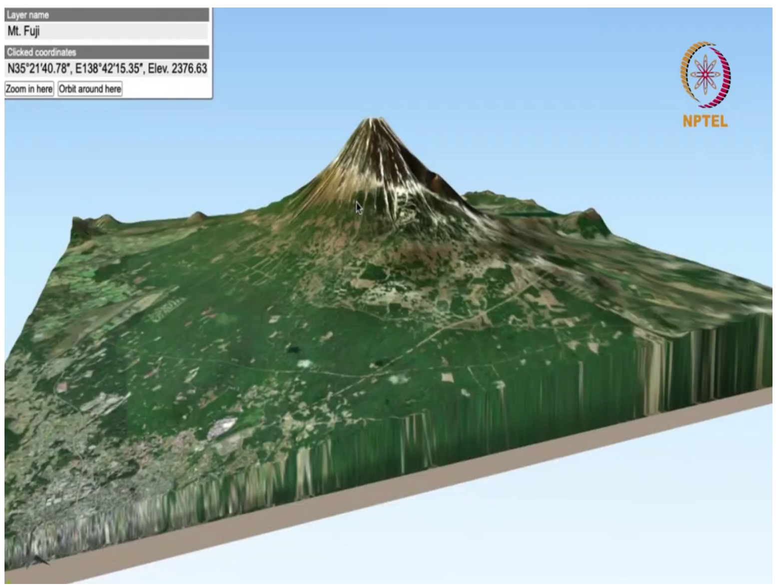





Module 12: Special topics in Geography and conservation
Remote sensing and GIS
Products from aerial photography
NPTEL
1 Digital Elevation Models
2 Orthophotos
3 Thematic GIS data
4 Other derived products and maps
Dr. Ankur Awadhiya, IFS
Conservation Geography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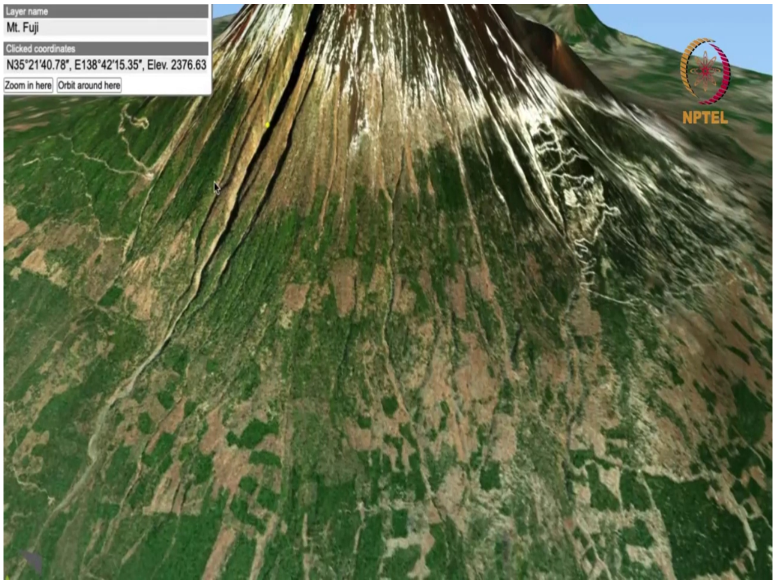

Now, once you have these photographs, you can use them to create large scale plants of your area. So, if you are looking at say, a protected area, you can see what are the areas that are say more suitable for a particular species or what are the areas where you have more amount of biotech and interference and so on, you can use them to make cadastral maps.

Which are essentially maps that tell us about the property rights of various people, they can be used for tax applications or say for the relocation of villagers? So, if you have the cadastral maps you can determine what is the amount of compensation that needs to be given for two different people.

If they are willing to move out of the protected area, we can make use of these photographs to create land-use maps, which tell us what are the areas that are say under the land use of forest or under the land use of cultivation or under the land use of pastures and so on. And how they are changing with time we can construct topography maps, we can construct hydrography maps or we can use them for exploration and reconnaissance of the area.

So, there are several applications and we get different derived products from this aerial photography product such as digital elevation models. Now, throughout this course, you had looked at different digital elevation models. So, one of them was the mount Fuji that we saw, and in this case, we are using different photographs. So, we are making use of the satellite imagery to construct a three dimensional view of Mount Fuji.

And in this case, you can say click at any point and you can very easily know the coordinates of the point the elevation of that point. So, these are the kinds of metric information that we are gaining from this photograph. Now, to make this photograph or to make this model we made use of several satellite imageries and we also made use of other technologies of remote sensing such as radar information.

Now, similarly, in the case of our photogrammetry exercises, we can construct a three dimensional model of see virtually anything on this planet. So, this is a three dimensional model of Mudumalai tiger reserve. In this case, we can see that on the southern side we have the hills, on the northern side we have a valley.

So, we are looking at different heights of different points. If you click at any point we get the GPS coordinates we get the elevation and we can use such information to construct decision support maps, what are the areas that have drainage? If there is any flood in this tiger reserve what are the areas that will face the floods in the first instance then how will the floods spread from one area to another area.

If you have to say rescue an animal what is the shortest route to reach that point. So, such kinds of information can be had by you making use of these 3-d models, which are known as the Digital Elevation or other digital terrain models. Or we can get orthophotos which are the stereo photos. Or we can get thematic GIS data, which is the GIS data based on different themes.

Themes such as, say water availability in your protected area, or say the amount of carbon that is sequestered in different areas, or say the accessibility of various locations. So, we can use these maps to construct thematic maps that can be used in GIS applications. Or we can make them to construct other derived products and maps. So, we can have several products, either direct products or derived products that we can make from these aerial photographs.

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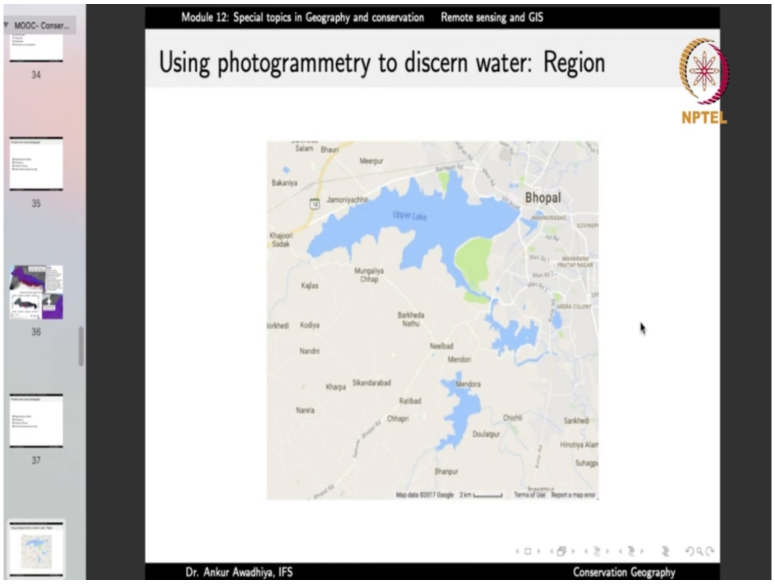

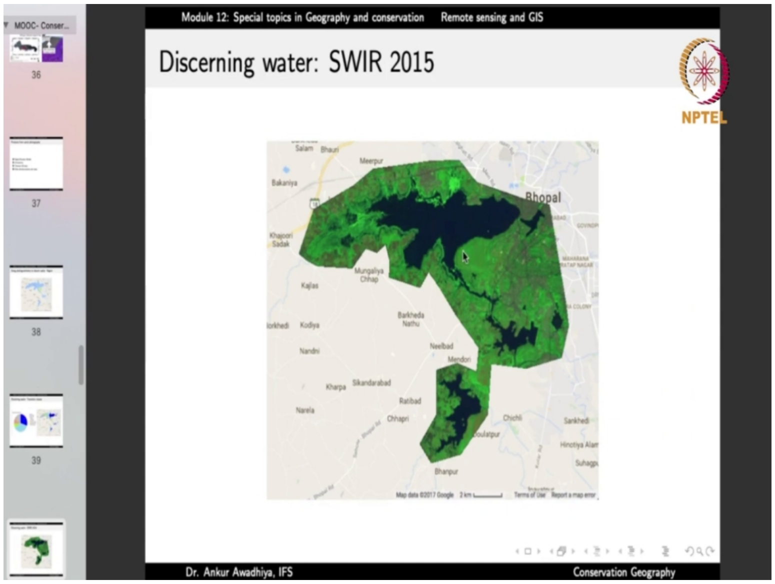

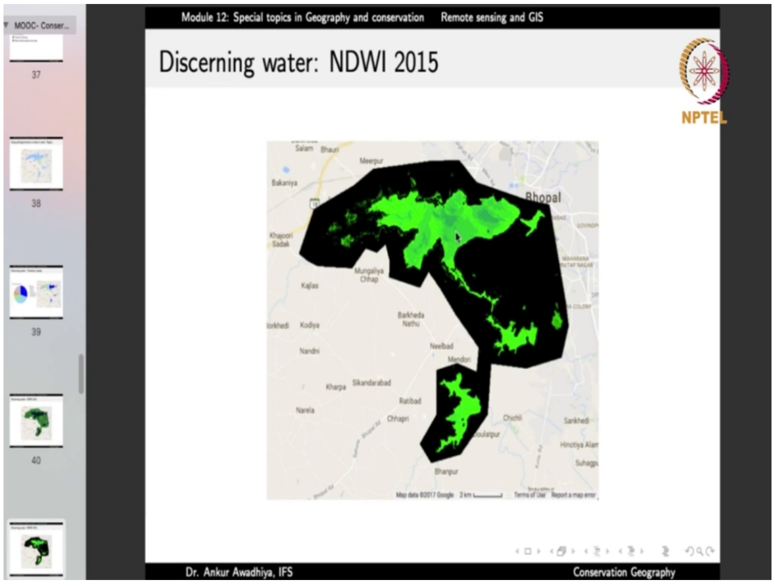

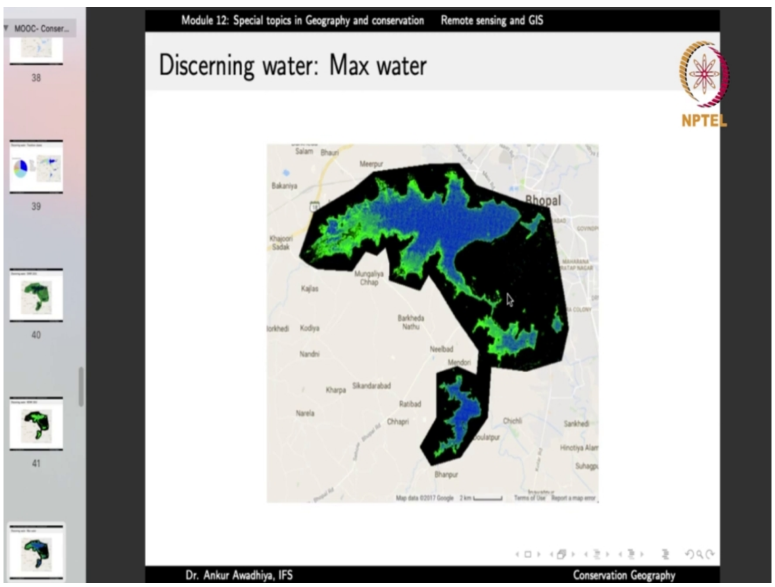

Examples include the use of photogrammetry to discern water. So, this is a study that was done for the Bhopal wet lands and we can discern different water classes, we can discern the areas that have water by using the shortwave infrared radiation. We can use that to construct normalized difference water indices that give us the areas that have water.

And we can collate information or data from several years because we have satellite imagery that goes several years to get those areas that have had the maximum coverage of water. We can look at the mean coverage of water, we can look at the minimum coverage of water. And in these ways, we can understand what are the areas that can be classified as a wetland.

What is the average of area that will be covered under this wetland over several years. And what are those areas that will have water even in the driest of years. So, we can use photogrammetric data to make all of these different thematic maps, we can make measurements. So, these are different uses of photogrammetry so that is all for today. We will carry on this discussion in the next lecture. Thank you for your attention. Jai Hind!