Forests and Their Management
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Module - 05
Forest Surveying
Lecture – 13
Classical Tools

[FL]. Today we begin a new module and this module is Forest surveying.

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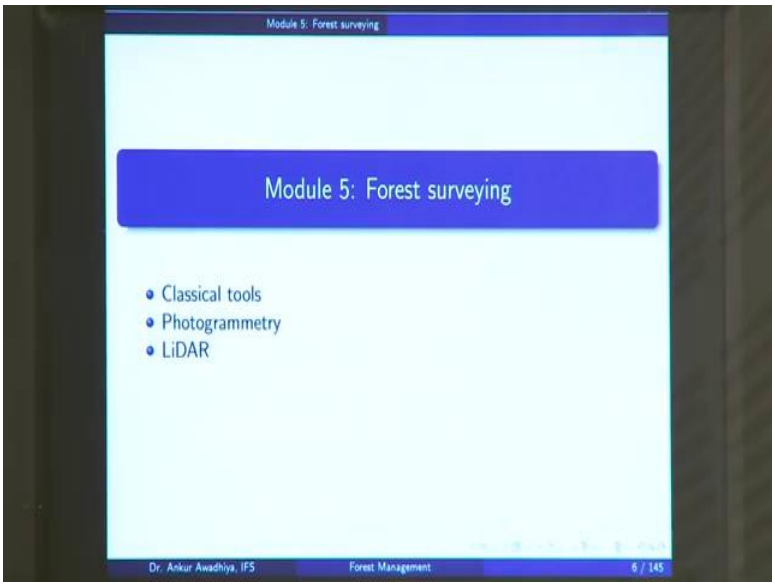

This module will have three lectures - the first one is Classical tools, the second and third are the modern tools of Photogrammetry and LiDAR.

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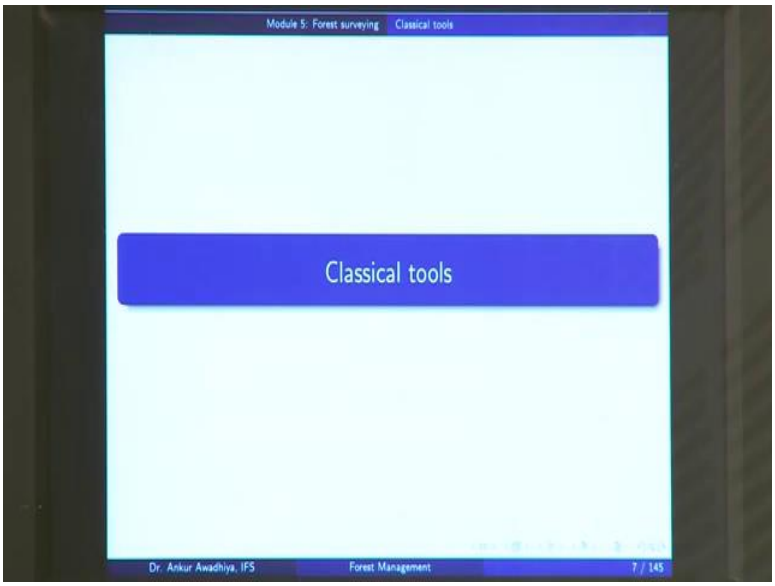

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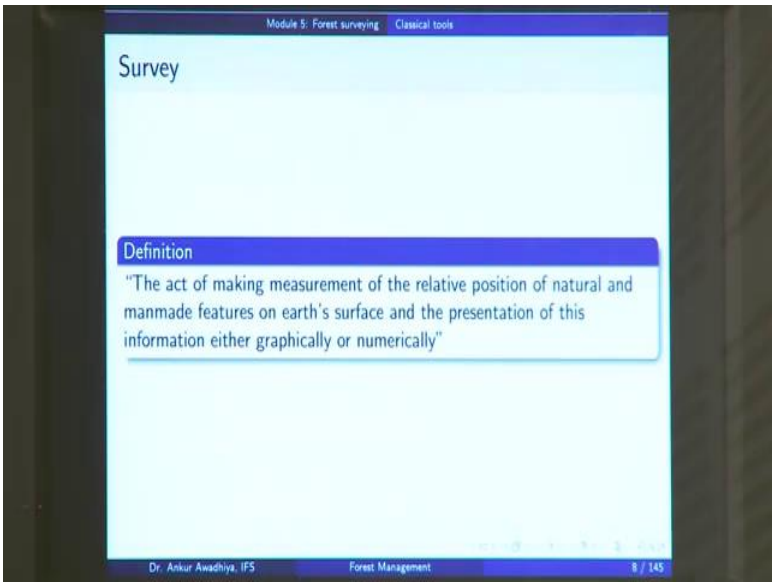

So, let us now begin with the first lecture, and let us look at what a survey is?

So, a survey is defined as the act of making measurement of the relative position of natural and manmade features on earth's surface and the presentation of this information either graphically or numerically.

So, what we are doing in the case of a survey is that we are making measurement of the relative positions of different features on the planet earth.

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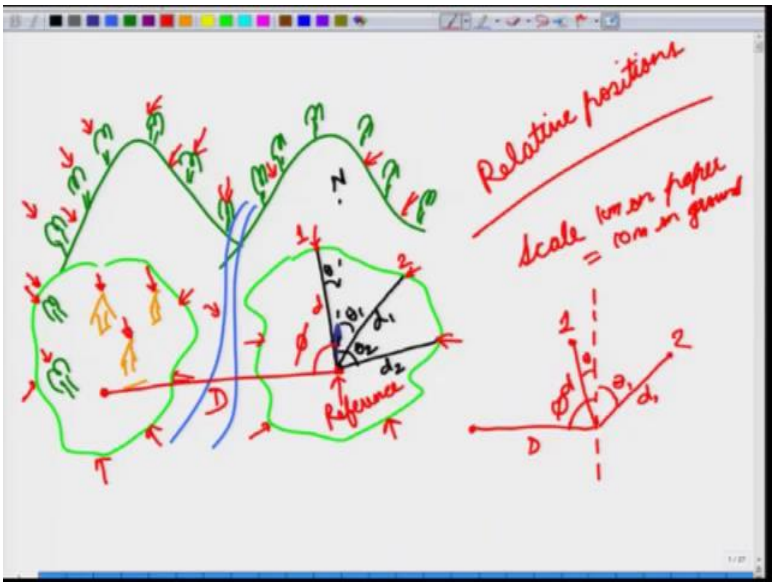

So, what we are saying here is that suppose you have these hills, and then, suppose these hills are all full of forests, and we have a river that is flowing from here. Probably, this area has certain habitations; surrounded by certain fields and this area suppose also has say a pasture. Now, when we say that we are doing a survey; what we are doing is we are measuring the locations of each and every of these features.

So, we in the case of a survey, what we are doing is we are figuring out the exact location of this house, the exact location of this house, the exact location of this house, the exact boundary of these fields. And, if you have say, a few trees here as well, the exact locations of these trees; the boundary of the river; the boundary of the pasture land, and if necessary, the location of these hills, and the location of the trees.

Now, in this case, what we are saying is that we are having certain natural features, such as the river, the hills, the trees. We also have certain man-made features, such as the houses, or say the fields, or the pasture lands. And, what we are doing in the case of survey is that we are making measurements of the relative position of each of these. Now, what do we mean by a relative position? Say, if we take a point as our control point; so, let us say that this is the control point, and we are taking the measurement of this point.

So, what we are doing here is we are finding out the distance of this point from the point from our control point and the angle that it is subtending from; say, if this is the north

direction either the magnetic north or the geographical north. So, depending on your application you could choose one of these, and what we are seeing is we are measuring this angle theta.

And similarly, for each and every of these points; so, for this point what is the distance? what is the angle? For this point - what is the distance? what is the angle? So, once you have a knowledge of the distances and the angles, then you can represent it in on a sheet of paper by plotting these distances at a certain scale and by making use of these angles. So, what we are doing here is that we are measuring the relative positions.

Now, by a relative position, because nothing there is no such thing, which is having a fixed position. Because, even if you take a point on the planet earth this point itself is moving, because the earth is going around the sun. But, in this case, in the case of a survey, we are choosing a point and we say that this is our reference point. And, what is the location of each and every feature with respect to our chosen point. So, we do these measurements and then we present this information either graphically or numerically. So, when we present it say graphically - what we are saying is that will mark this point on a sheet of paper, and with the scale will say that this is one point at a distance of.

So, when this distance was ‘d’ you will say. So, you are drawing this as the north direction and you are saying that for this point this is and this is your reference on the sheet of paper. And, you are saying that there is one point at the distance of d, and at the angle of theta, on a sheet of paper.

So, you are parking the location of this point, and in this case you will make use of a scale. So, in this case, your d on paper is equal to or you will say that 1 centimeter on paper is say 10 meters on ground. So, this is the first point; 1 for the second point you will again draw it like this so, this is at this angle of theta 1 and at a distance of d 1.

So, you have representing this point 1 and the point 2, and similarly your you will be representing each and every feature on the sheet of paper. So, this is a presentation of this information. So, you can present this information either graphically or numerically, and when you do all of these you are taking when you are taking the measurements, and you are presenting this information then this whole process is known as survey.

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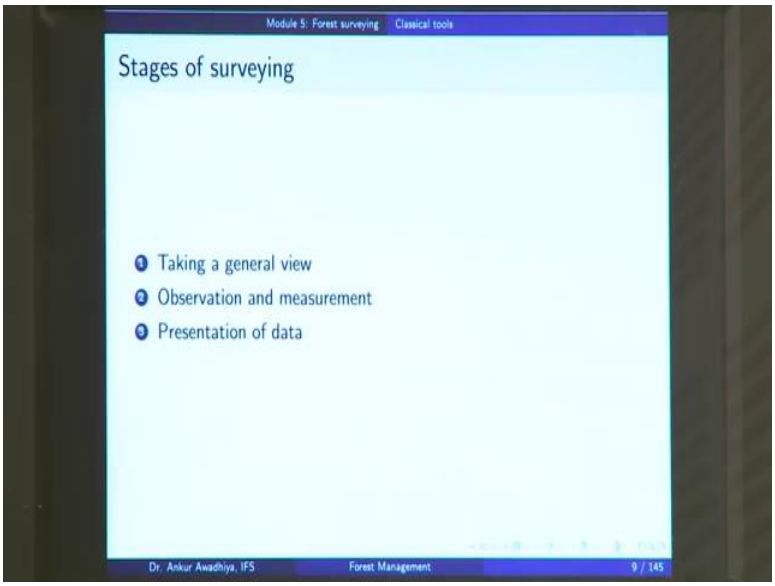

A survey is generally done in three stage. The first one is to have a general view of the whole area; you can also refer to this as 'a reconnaissance.' So, in the case of reconnaissance what you did was you look at the this whole location - so, you saw that there are hills; there is a river; you have the houses; you have the fields; you have the pasture lands. so, first of all you had a general view of the location. Once you have a general view then you decide which is going to be my reference point.

So, in this case, you choose this point as your reference, probably because this was a point from where it was easy to take measurements of all these different features. Now, in certain conditions, you can even go for two reference points. So, in this case, you will say that this is my one reference point, and I am drawing a straight line and this is my second reference point.

So, when I have to take the measurements of the pasture, I am making use of the first reference point. When I have to take the measurements inside the village, when I have to have measurements of the houses or of the fields, then I will make use of the second reference point. But then, both of these reference points are correlated to each other. So, what we are saying in that case is that you first decide on the first reference point, and you mark the second reference point by taking this distance D and also measuring the angle.

Let us say that this angle is phi with the north; so, that if you have to represent it on the piece of paper, you can directly represent it as - you have this point at a distance D and making the angle phi. So, you get the second difference on the piece of paper, and now you can start plotting the points that are being measured from the second reference. So, the first stage in serving is to have a general view, so that you can figure out what is going to be your reference point, and if you require multiple reference points, what will they be.

The second stage is to take the observations and the measurements. so, in the second stage what you are doing is, you are supposed taking a compass, to take the angular readings; you are also making use of tapes to take the linear measurements, and you make you jot down all of these on a piece of paper. So, this is the second stage that you are doing observations and you are taking measurements.

Now, the third stage is the presentation of this data. So, you can either present it on a sheet of paper, or you can present or you can feed this data into a computer to get a digital representation of the whole area that you are surveying. Now, when you are when we are doing the surveying, there is another thing that needs to be kept in mind. The surface of the earth is not flat. The earth is having a shape which we refer to as a geoid. So, it is circular in shape which is a bit more elongated in towards the equator, and the shape is referred to as a geoid.

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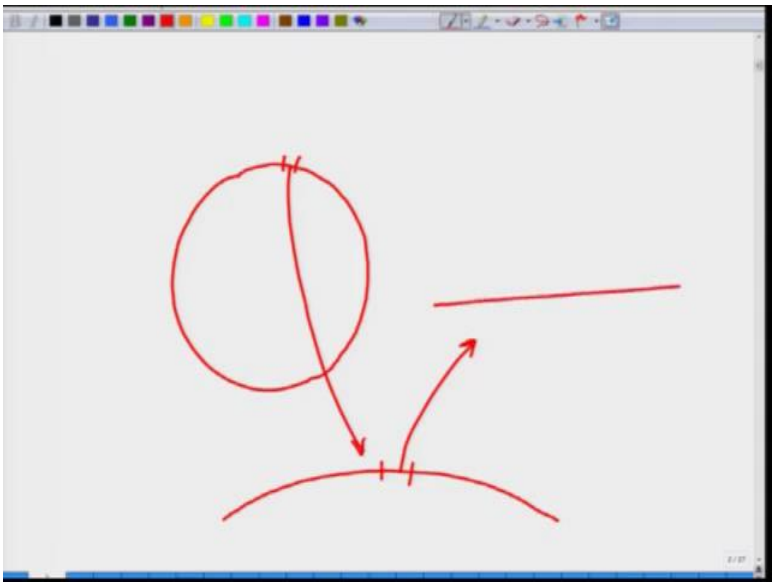

Now, what we are doing here is that, if you represent the earth, you will represent it say by using a sphere. But, if you are taking a very small portion of this sphere, and if you look at it in a magnified view, this will look like this. So, you are getting. So, you are representing it with a section of the sphere; but if you take an even smaller point, then what happens is that you can approximate it as a flat surface. Now, this brings us to different types of surveying.

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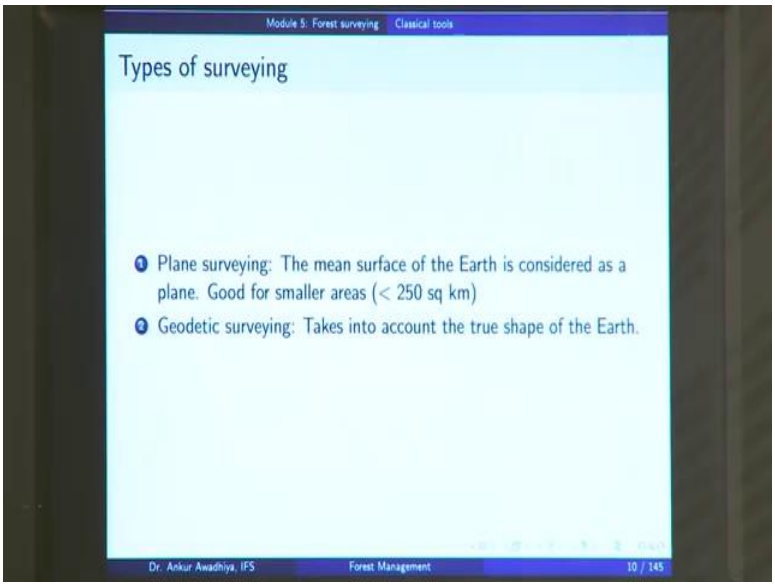

The one is known as a plane surveying. So, if you are doing your survey on a very small area on the surface of earth, then you will make use of plane surveying techniques. Now, the case of plane surveying, you approximate the surface to be a flat plane. So, plane surveying the main surface of the earth is considered as a plane, and it is good for smaller areas that are less than 250 square kilometers.

Because if you start taking areas that are larger than these, then your approximation that you are working on a plane surface has ended. Now, you will have to take into account the curvature of the earth at that particular point or in that region. So, that will bring us to the geodetic surveying, which takes into account the true shape of the earth.

So, these are two different types of surveying.

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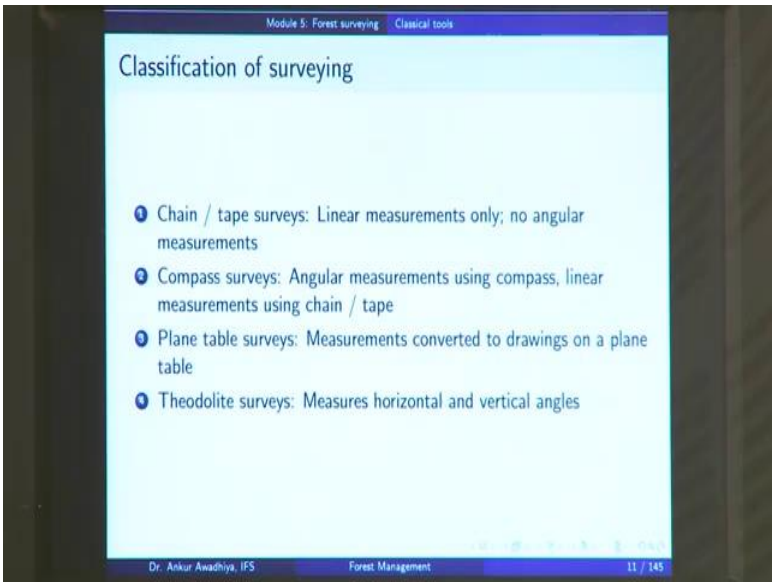

And depending on the instruments, you can have different classes of surveying.

So, the easiest one or the most classical one is 'the chain and the tape survey,' in which you take linear measurements only without any angular measurements. Now, what we are doing here is that suppose, you have a field and that has say this shape.

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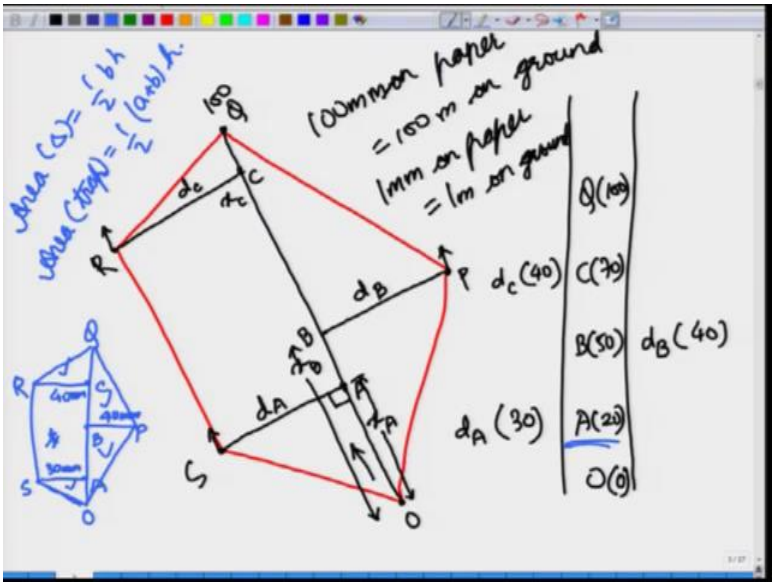

Now, in the case of your chain survey or a tape survey, what you will do is you will first of all begin with a reference line. So, in this case, let us say that this is our reference line. Now, with this line, now you need to have the locations of different points. So, now you

want to say what is the location of this point, this point, this point, because you know two locations that you have chosen as your reference line. So, let us and suppose this the length of your reference line is say 100 meters, so we will say that this is 0 this is 100.

And now, you start moving from 0 towards 100, and you reach a point where the first; so, what you have done is that you have added stakes on all of these points, for which you want to take the measurements. And now, you are moving from 0 to 100, and you reach a point where you find out that the first point is exactly to your left; so, it is making an angle of 90 degrees, and you now have reached this position. So, this is your first position, so let us call it position A.

Now, you will stop at this position, and now you will take a measurement of what is the distance of the first point from the position A. So, you will measure out in this distance; let us call it d A. Once you have taken this measurement, now you start moving and you also note down the position of A so, let us call it x A.

So, x A is the position is the distance of this point a from the starting point. Now, you start moving even further, and then you reach this point from where, so let us call it. So, you have O P Q R S. So, now, when you have reached this point; let us call it B. In this case, you measure the distance of B from your starting position, using a chain or a tape, and you measure the distance of the point, you measure this distance to the right of B. Now you carry on for further, and you have reached this point C. now, here again you will measure the x C, and you will measure the d C.

Now, in this case, you are only taking the linear measurements. You are not taking any angular measurement. You just go to a point where the next point is either completely to your right or completely to your left. And, you are then measuring where you are standing and you are measuring the distance of the your stakes from this point, either to the right or to the left. Now, in this case, you will make a table.

And, in this table, you say that you began with this point O which was at 0 meters and then there was a point A which was say at 20 meters. Then, there was a point B which was say at 50 meters. You had a point C which was say at 70 meters, and you had this point Q, which was at 100 meters. Now, at position A, you had the distance of d A. Let us say that this was 30 meters at position B, you had d B, which was say 40 meters. At

position C, you had d C which was say - 40 meters, and then you had the final position Q.

Now, once you have these measurements now, what you can do is that you can take a piece of paper and you can draw a straight line. And, you can say that say 100 millimeter on paper is equal to 100 meter on ground, or 1 millimeter on paper is equal to 1 meter on ground. So, what you will do, in this case, is that you will draw a straight line which is 10 meters which is 10 centimeters on the piece of paper, you will start marking these points O and Q, and then the point A is at 20 meters. So, you measure 20 millimeters, and then you draw a line at 30 degree at 90 degrees, which is 30 millimeters.

So, here you have the point S. This is point A. next, you have the point B which is at 50 millimeters, and towards the right you have at 40 millimeters you have the point P. Then, at 70 millimeters you have the point C and towards the left you have 40 millimeters and this is the point R. So, you have represented the whole area that you were surveying on a sheet of paper, and then what remains is just to join these with straight lines. And so, now, you have represented the area on the ground on a sheet of paper. Now what can we, now what can be the use of such a measurement?

Now, you can take you can measure the area of the region that you were serving. So, for instance, now you can convert this and you will either have triangles or you will have a trapezium, and we know that the area of a triangle is half of base into height. And, the area of a trapezium is half of a plus b into h, where a and b are the parallel sides and h is the separation between these parallel sides. So, in the case of plane surveys, you are only taking linear measurements, and just by using a chain or a tape to take these linear measurements. You are representing the region on a piece of paper and using it for instance to take different areas.

Now, the next survey is known as a compass survey. In the case of a compass survey, you not only take linear measurement, but you also take angular measurements. So, you take angular measurements using compass, and linear measurements using a chain or a tape.

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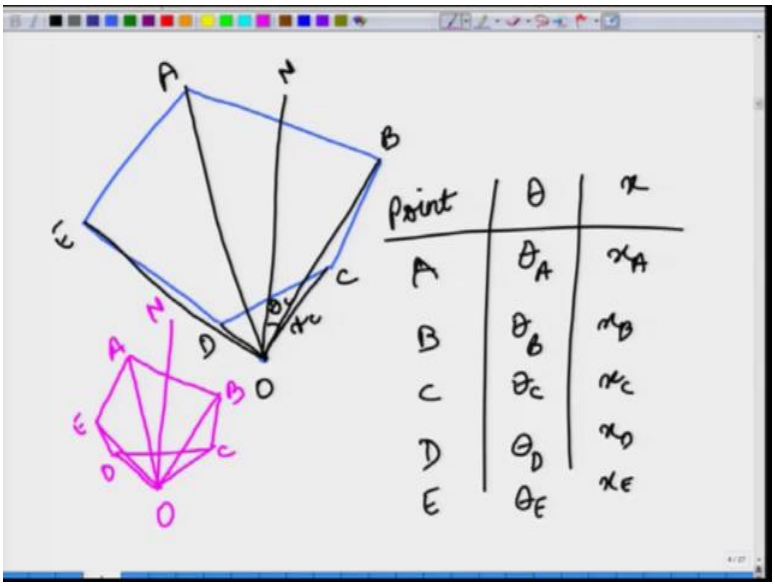

So, what you are doing in a compass survey is that - you are say standing at this location, and here you have your field that needs to be measured or that needs to be surveyed. Now, what you are doing is that you are taking just one position and you are measuring the angles with respect to the magnetic north; let us represent it on other color.

So, this is your north and this is your field A B C D E, now for every point you are measuring the angle. So, this angle let us say that this is theta C, and you measure a you measure the distance of this point C from your reference point. And so, you do it for C, you do it for B, you do it for D, you do it for E, and you do it for A. So, in this case, you have a table where for every point you have the angle that is being subtended and the distance of the point. So, you have A B C D and E.

So, you are measuring theta A, theta B, theta C, theta D, theta E, and you are also measuring the distance is x A, x B, x C, x D, and x E. And, when you have these measurements, now you can do the presentation of this data on a sheet of paper. By just taking a piece of paper, marking out a point called O and marking all of these difference. So, you take O you draw a straight line, and you will say that this is the true north, this is the magnetic north, and then you start drawing these different locations on your sheet of paper; at these angles, and at these distances, and what remains is just to connect these with straight lines, and so, you will get a representation of your region on the sheet of paper.

So, in the case of a compass survey, we are not only taking the linear measurements using a tape or using a chain or say using a rangefinder, but you are also taking the angular measurements. Now, the third survey is known as a plane table survey, in which case, you take measurements and which are converted into drawing on a plane table. Now, what we do in the case of a plane table survey is that we take measurements from two positions.

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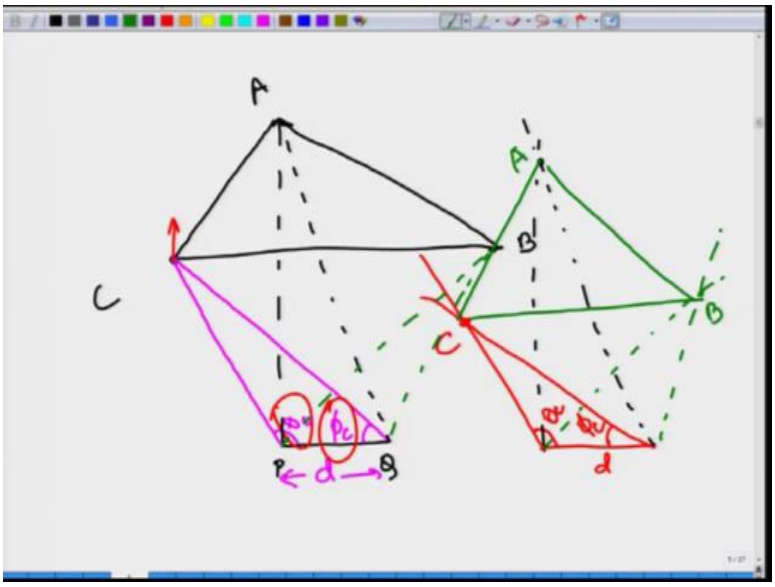

So, here you have your region, and so, let us call it as A, B and C. So, this is a triangular field that you are trying to survey, what you will do here is that you will take two positions P and Q, and you are trying to triangulate these different locations. What you do is you measure this angle. So, this is theta C, and you measure this angle phi of C. So, you are taking the measurements; you are taking the angles. You do not need to have any linear measurements. In this case, just one measurement that is the this distance of P Q so, these are two points that you have fixed.

Now, you go to the first point, and you take the angle of one of your stakes from the first point that is P. So, you had put a stake here; so, there was a stake you went to this point P and you took a reading from here to the first point, and you measured it as theta C. Now, you go to the second point Q, and here you take the measurement from the line to the point and which is your phi C. And then, on your plane table, you draw a line at a

distance of d, and you draw this line at an angle of theta C, you draw another line at the angle of phi C.

And, the point where both of these are meeting you mark it as point C. And, you repeat this for each and every point on your field that needs to be surveyed. So, you do it for A you do it for B. So, in all the cases, you are just measuring two angles. So, in this case, your A is roughly at 90 degrees your from the P, and address add this angle from this. So, now you have this location of A, and similarly you will measured angle her. And, this angle and then you have this location B, and then you draw you join all these three with straight line, and you have a representation of the field on a piece of paper.

So, in the case of a plane table survey, you just take two points know that note down their distances, and now, you only need to take angular measurements of each stake that you have put on your field. And, in this way you will be able to represent or present the points on the field on a piece of paper. And, once you have this or drawing at a particular scale, now you can make use of a graph paper to find out the area of your field. So, this is another way of surveying.

The fourth one is the ‘theodolite survey’, which measures horizontal and vertical angles. Now till now, we were talking about those regions that were lying on a flat plane, but suppose you are measuring or you are surveying a building; so, in the case of a building you might even want to know the height. So, in the case of the height, you are not only taking the angular measurement of the point, but you are also the angular measurement on the horizontal plane, but you are also taking the vertical measurements.

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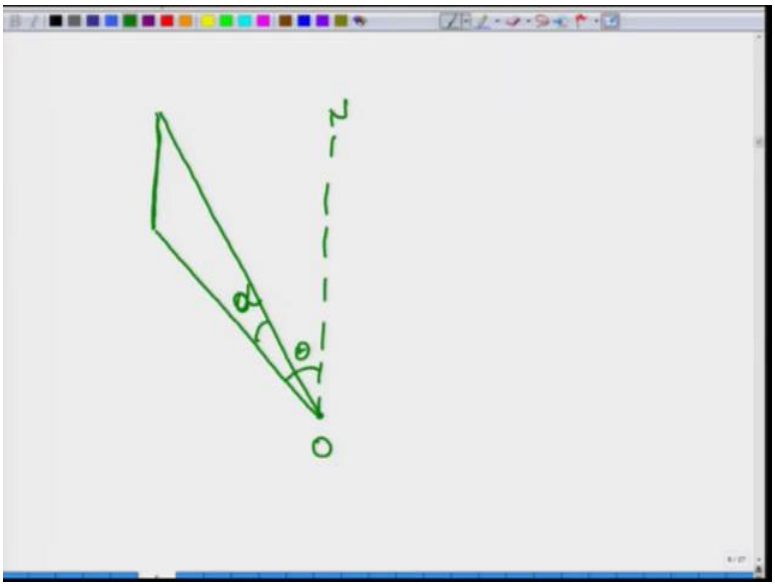

So, if you are; say, this is your reference point. You have a building and this is a wall; so, you take the measurements and you see this is the north. So, you are measuring not only this angle with the north, but you are also measuring this angle. So, let us call this as theta and this angle is alpha. So, now, you are using this instrument to take horizontal angles for the location, and you are taking vertical angles for the height. So, that is your theodolite survey.

Now, these days apart from these classical techniques, we make a heavy use of things like GPS, which will directly give you the location of different points by making use of the positions of different satellites. Or, we make use of total station surveys, in which case you have an electronic instrument that is integrating different measurements.

Or you can make use of drone surveys, in which case, again your drone is flying and you take the measurements of the position of the drone, and the angles of different points on the ground, and you can very easily represent it in the form of a drawing. Or, we make use of LiDAR or we make use of radar, but these are the classical tools that we have been using since ages.

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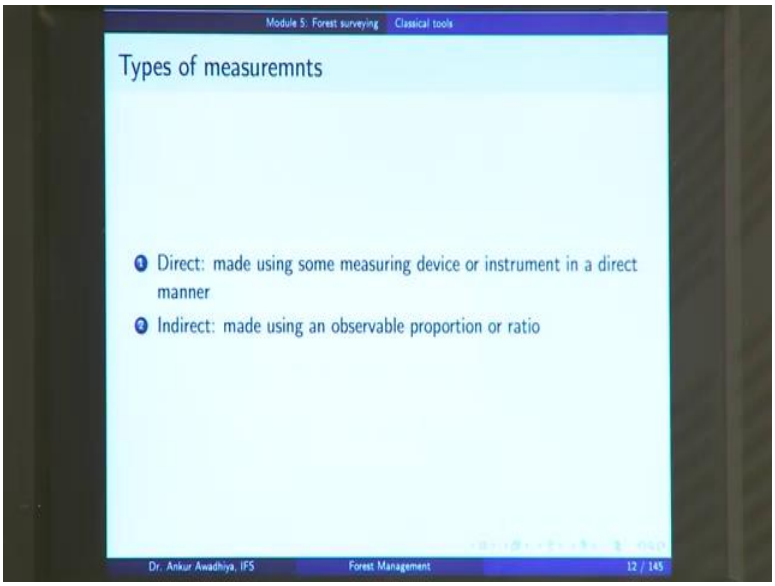

Now, when we are making the measurements, there are two different kinds of measurements. Two different types of measurements. One is known as a direct measurement. So, in the case of a direct measurement, you make the measurement using a measuring device or an instrument in a direct manner.

So, what you say in this case is, for instance, you are taking a tape and you are going into the field with the tape, and you are take you are taking the measurements of the distance between two points. So, that is a direct measurement. We also have a make use of the indirect measurements, which are made using observable proportions or ratios.

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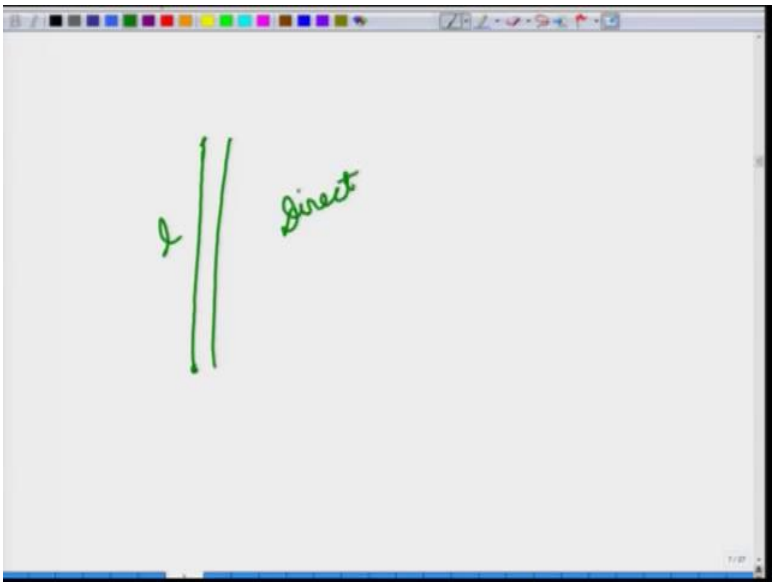

So, in this case, what we are saying is that suppose, you have this building and this is a wall; so, you can take a direct measurement. You can go to the top of this wall and maybe drop a string with a weight attached to it, and the length of this string when the bob touches the ground is the length of the wall. So, this is a direct measurement, because you are directly measuring the length using an instrument. On the other hand, you can also make use of an indirect measurement.

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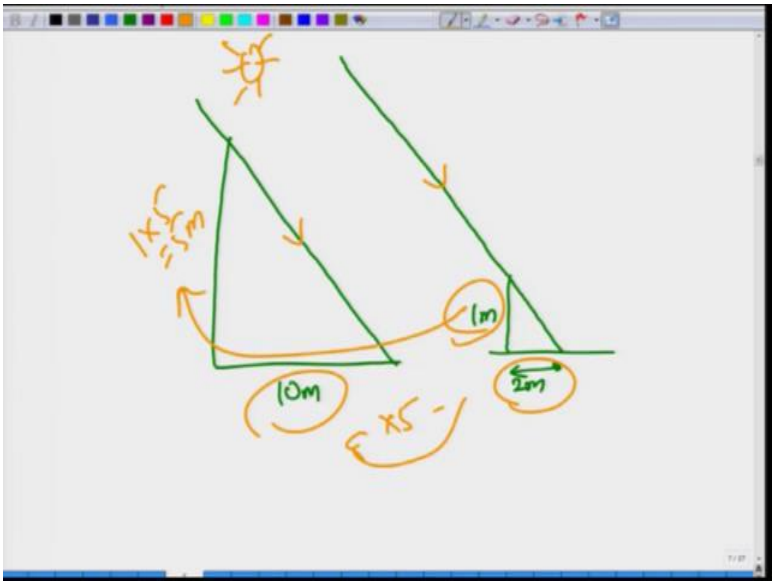

In which case, suppose this wall is making a shadow, that is say 10 meters at the same time, you put a stick on the ground and suppose the height of this is stick is 1 meter, and this is subtending a shadow, which is say 2 meters. Now, in this case what will say is that because both of. Now, what we are seeing here is that because both of these objects the wall and the stick are subtending an angle and making a shadow, based on the sunlight. So, both of these rays are parallel because the sun is at a very great distance, and so, we will make use of proportional measurements. So, this is 2, this is 10 which means that this is 5 times, this is 1 so, this in turn will be proportional so, this is 1 into 5 is 5 meter. So, in this case, we will say that the height of the wall is 5 meters, based on this particular ratio or proportion.

So, if we take a measurement like this, in which case, we are not directly measuring the wall, but we are measuring some attribute of the wall such as a shadow. And, we are using this attribute to calculate the height of the wall, then such kinds of measurements are known as indirect measurements been using an observable proportion or a ratio.

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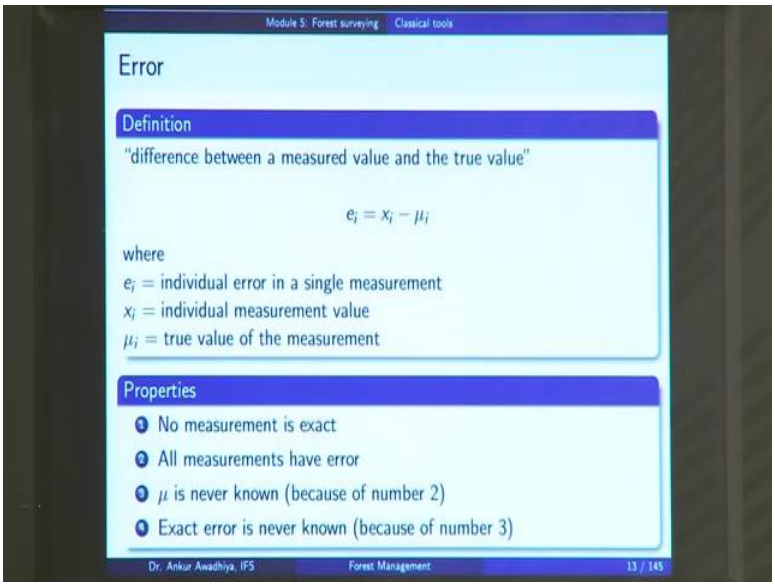

Now, whenever we are doing any measurements, there will be certain amounts of errors. And, an error is defined as “the difference between a measured value and the true value.” That is e i, which is the error is equal to the measured value minus the real value or the true value; so, it is a difference between a measured value and the true value.

Because, when suppose we went into the field, and we said that the distance of point a from our reference point is 10 meter. So, there can be certain an errors. It could be 10.1 meter; it could be 9.9 meters probably, because our scale was not correct; or probably because we did certain errors while we were taking the measurement, or there were certain natural variations that were happening in that at that time. So, these errors will always be there in any measurement. So, if you look at the properties, no measurement is exact and all measurements have certain error.

Now, if you have certain error every time, then mu (μ) is never known, because you can never measure the true value of a measurement. So, mu is never known, and if you do not know mu, you can never have an idea of the exact error, because you can find out an exact error only, if you know mu. But then, you cannot measure mu because any measurement of mu will be having certain errors. So, in this case, we try to minimize the error or we try to take measurements in such a manner that the errors cancel out.

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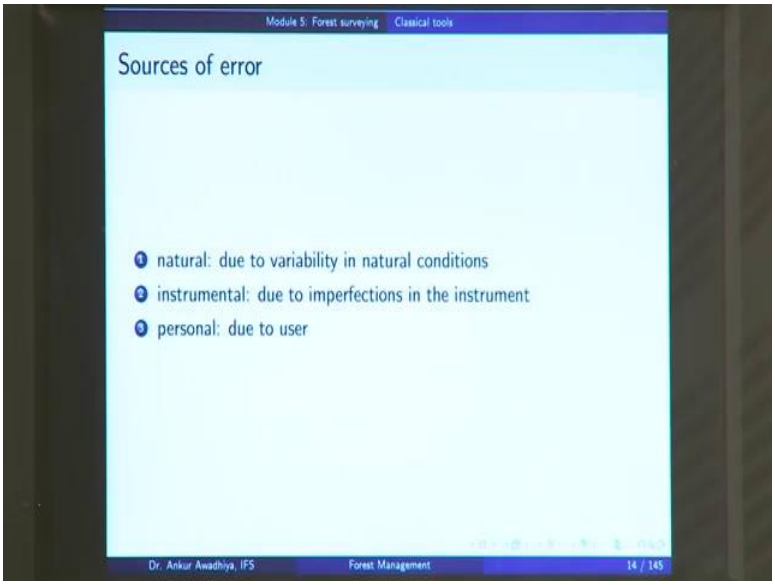

When there are three sources of error. You can have natural errors due to variability in the natural conditions, and a good example is the expansion of things because of heat.

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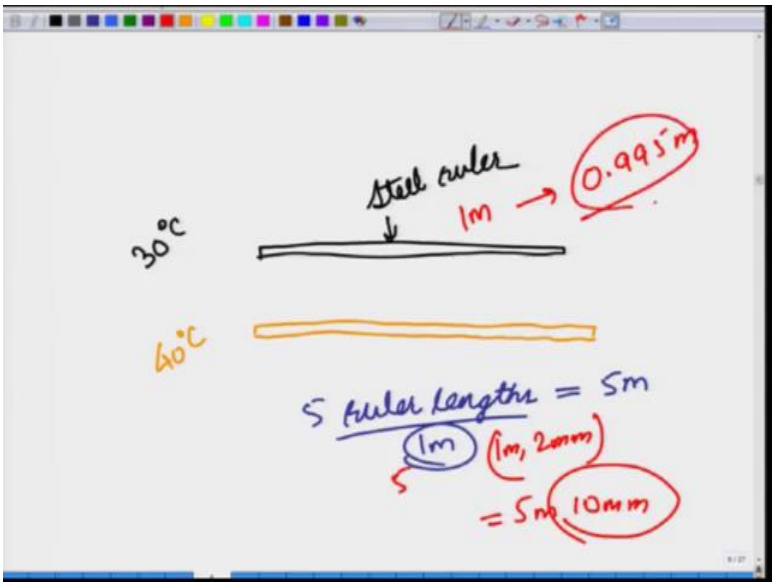

So, for instance, you were make - you were using a ruler made out of say steel, and you were using this ruler at a temperature of say 30 degrees Celsius. Now, when you went into the field, you were taking measurements on a plain field, and there you had a temperature of say 40 degrees Celsius. Because, now you are exposed to the sun. Now when you are exposed to the sun, there will be a slight increase in the length because the ruler is getting heated, and there is there is an expansion because of this heat; so, there is a thermal expansion in the linear direction.

So, you are using the same ruler, and you were measuring 1 meter. So, suppose your ruler is 1 meter and you say that this distance is 5 times of 1 meter. But then, in place of 1 meter, it was 1 meter and 2 millimeters. So, when you are taking these 5 measurements, so you would your measurements were 5 ruler lengths. And, because 1 ruler length is 1 meter; so, you said that this is 5 meter, but actually your ruler length increase of 1 meter, it was 1 meter and 2 millimeters.

So, if you multiply that with 5, you get 5 meters and 10 millimeter. So, in this case, you are getting this error of 10 millimeters of 1 centimeter because of a natural variation; because your ruler is not kept at the same temperature. When you are using this instrument, you are taking it to different locations and there might be a difference in temperature, because of which there will be an expansion or contraction of the ruler. So,

these are the natural variations, because of our variability in the natural conditions. You can also have an instrumental error due to imperfections in the instrument.

In this case, what we are saying is that when you were even taking the measurement at 30 degrees and suppose your ruler was calibrated for 30 degrees. But, at 30 degrees, in place of being 1 meter, this actually is 0.995 meters. So, when this ruler was constructed at that time the manufacturer did not, did not take into account the very exact measurements, and in place of being a 1 meter ruler, it is slightly shorter.

So, the errors that will creep into your measurement because of this, are known as instrumental errors, because your instrument itself is faulty. Then, there is a third source of error that is the personnel error due to the user. Because, when you are using this instrument you are not careful and in place of taking the.

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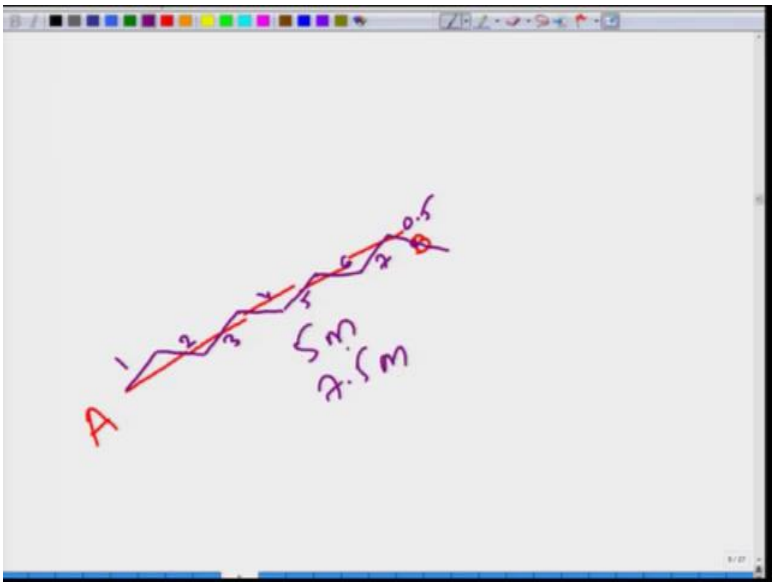

So, suppose you have you are measuring the distances between two points A and B, and these were supposed to be 1 – 2 – 3 – 4; so, these were supposed to be 5 ruler lengths. So, these were supposed to be five meters, but actually what you did in the field was that you were using the instrument; so, you take took one reading like this. U=/You then kept the ruler like this then like this, like this; so in this case, you are saying that this is 1 2 3 4 5 6 7 and half.

So, you are measuring 7.5 meters, when actually it is 5 meters, and this is because you did not keep the ruler these rulers on the straight line. You are keeping them at certain angles. So, this sort of an error is not coming because of changes in temperature or changes in the natural conditions; these sorts of errors are not creeping in because your instrument is faulty; but these sorts of errors are getting in, because the user is not using the instrument in a correct fashion. So, these sorts of errors are known as the personal errors or user errors.

Now, whenever we are taking any measurement and we know that every measurement is having certain amounts of error. We want to have a measurement that is as close to the true measurement as possible. And in this case, we come to the concepts of precision and accuracy.

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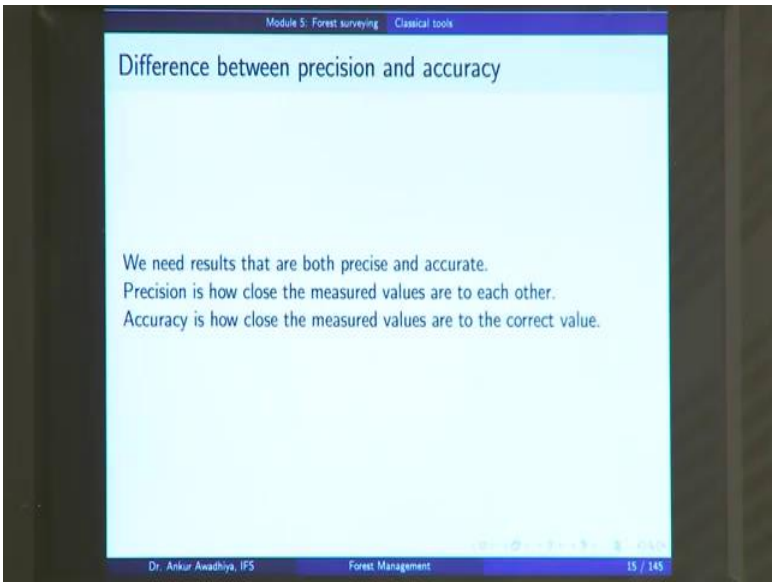

So, you precision is defined as, 'the closeness of the measured values to each other.' So, if you take this example, suppose you were taking the measurement between A and B and when you took the measurements.

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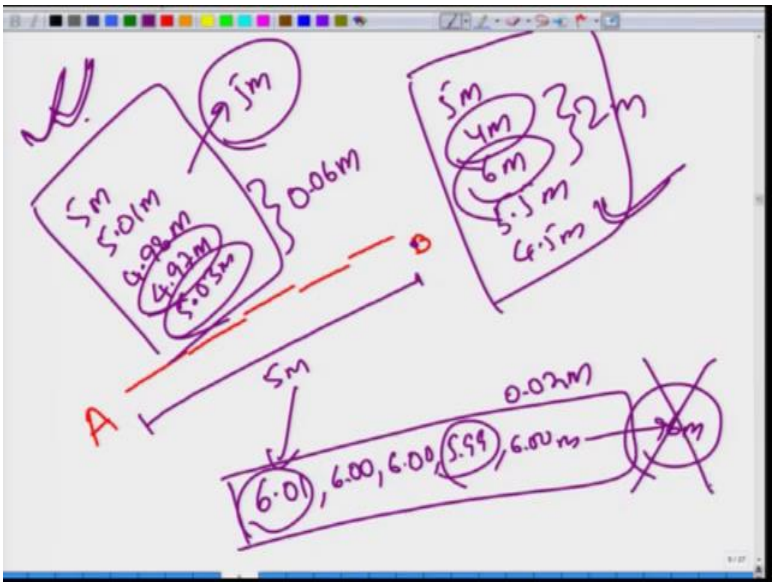

So, you were measuring the distance between A and B, and suppose you measured it as 5 meters; 5.01 meter; 4.98 meter; 4.97 meter, and 5.03 meters. So, these are the 5 measurements that you took of the distances between of the distance between A and B. Now, the this is one reading, now the second reading by taken by some other person is say 5 meters, 4 meters, 6 meter, 5.5 meter, and say 4.5 meters.

Now, in the case of this set of readings, what we are seeing is that the minimum value is 4.97 the maximum value is 5.03 so, there is a difference of 0.06 meters between the highest and the lowest values. But in the case of these second measurements, the lowest reading is 4 meter; the highest reading is 6 meters so, there is a difference of 2 meters, where here you only had 0.06 meters. So, we will say that these measurements are much more precise as compared to these measurements.

So, precision is 'how close are the values to each other.' If these values are coming together with very small variations between them, then we say that these are precise measurements, and when these values are too far apart from each other then we say that these are not precise measurements. These are imprecise measurements. Now, the second thing is accuracy. Accuracy is "how close the measured values are to the correct value." Now, in this case, what we are saying is that suppose the actual distance was 5 meter. And, you are taking, so one person is has to has taken five readings, which are say these and the second person has taken five readings that are very precise.

So, let us say that he measured 6.01 meter, 6.00 meter, 6.00 meter 5.99 meters and 6.00 meters. Now, these readings have extremely precise because the difference between the lowest and the highest values is 0.02 meters. But then the if you take the average of these it will be very close to 6 meters, if you take the average of these this will be close to the to 5 meters. So, these readings are accurate these readings are not accurate. So, you can have readings that are precise, but not accurate. You can have readings that are accurate, but not precise and so on.

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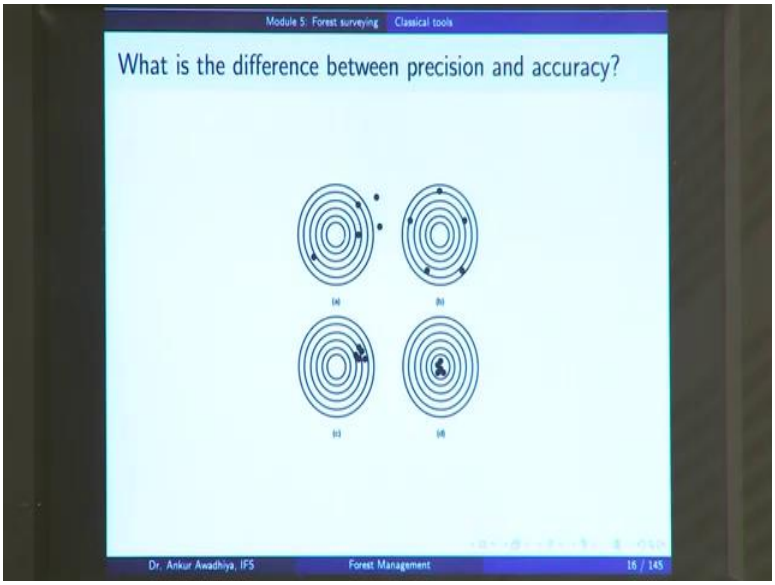

So, if we were to represent accuracy and precision by say this representation. So, here you have a target board and different people are shooting on at this target board. So, these are the shots of four different people, now if we look at. So, the target was to shoot at the center location the bulls' eye. So, if we look at these measurements (D), then we will say that these readings are extremely precise because these are close together and these are also accurate, because the person was able to hit the bulls eye.

But we if we look at this shooter (C), then even though these readings are extremely precise; they are close together, but the these readings are not accurate, because he was unable to shoot at the bulls eye.

(B) These readings on average are accurate, but these are not precise, because if you take the average you will come to the central location; but these are very imprecise, because there is a huge amount of spread between different trainings.

Whereas, in the case of this one (A), this is neither precise nor accurate.

So, whenever we are taking the readings, we want to take readings in such a manner that we should have not only the precision, but also the accuracy.

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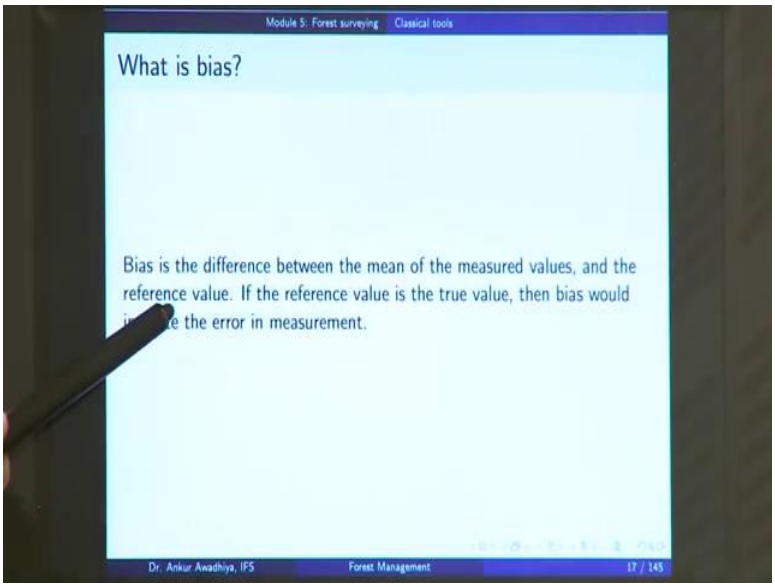

Now, here we also come to another concept which is known as ‘bias.’ Now, bias is the difference between the mean of the measured values and the reference value. The mean of the measured values and the reference value. What we are saying here is that suppose your reference value is at the center, and the mean is here what is the difference? And, if the reference value we are taking to be the true value, then bias is equal to the error in the measurement.

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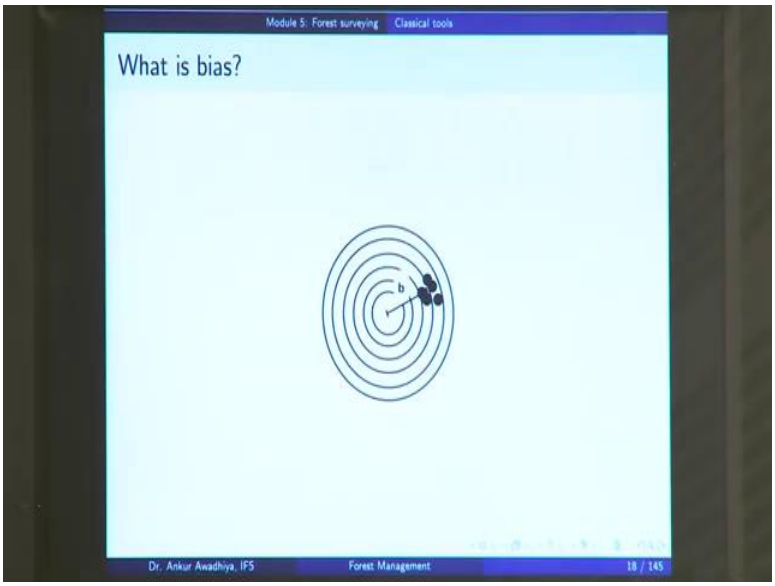

So, what we are saying here is that in the case of these shorts, you have the readings here. So, these are the measured values; this is the reference. The difference between both of these is the bias, and to remove the bias we may need to calibrate the instrument.

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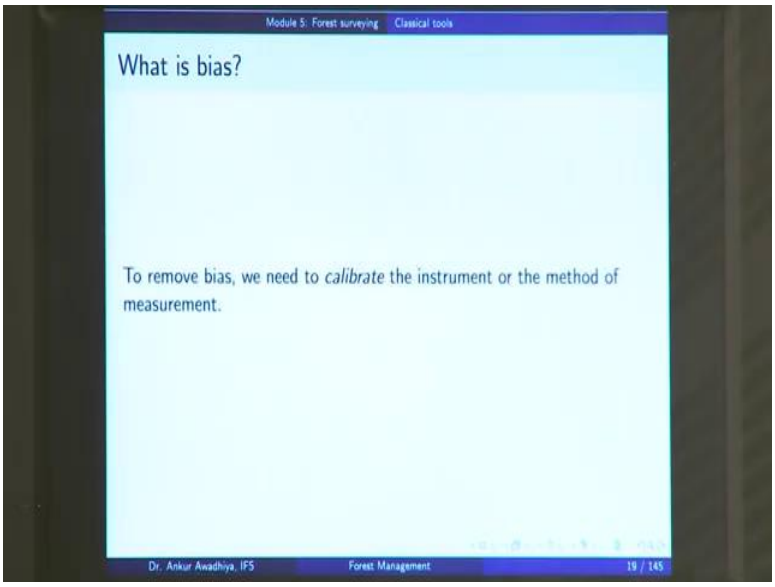

So, in this case, what is happening is that the shooter is taking very precise shots, but probably, the bore of the gun was such or the barrel of the gun was such that it was giving a bias; it was always shooting towards the top right. So, in this case, if the shooter calibrates the instrument, he or she will be able to get not only precise values, but also

accurate values. So, bias can be removed by calibration of the instrument or the method of measurement.

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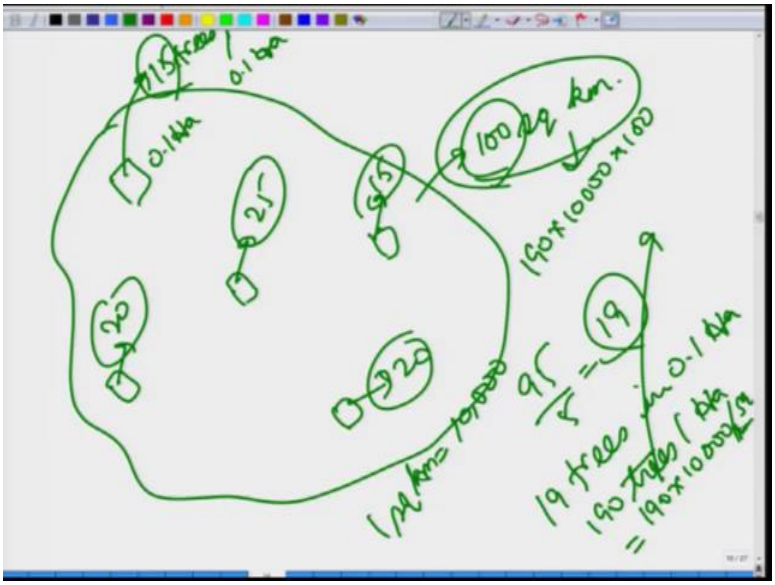

Now, in the case of forest areas typically, so, suppose you have this large area you have done a survey. And, now you want to measure say the number of trees that are there in your surveyed area. So, suppose you have an area of 100 square kilometers and you want to figure out what is the number of trees that are there in this area. So, they now you have got two options - one is that you survey the whole of this 100-kilometer area. You look at each and every tree; you mark them out and you count the number of trees that are there in your area.

But then, because we are having certain errors in any measurement when even when you are doing this counting, there is a chance that you will miss out a few trees. So, because there is an error, you can try to economize your measurement by taking samples. So, you can say that in place of measuring 100 square kilometers, you will measure, say a small area of 0.1 hectare here another area here, another here, another here, another here and for each of these, you find out the number of trees per unit area of land. So, in this case, suppose here you got that you have 15 trees in 0.1 hectare; here you have say 20 trees here; you have 25 here; you have 15; and, here you have 20.

So, in this case, you can take an average of all of these readings. So, you have 15 plus 15 is 30, 30 and 40 is 70, 70 and 25 is 95, we have 95 by 5 is 19. So, on an average, you are

having 19 trees in 0.1 hectare, or you are having 190 trees per hectare. Now, because 1 square kilometer is equal to 10000 hectares; so, this is equivalent to 190 into 10000 trees per square kilometer.

And, because you have an area of 100 square kilometer; so, you multiply this by 100 and you say that you have 190 into 10000 into 100 trees, in the complete area of 100 square kilo meters. Now when you do such, when you make use of such a method of taking samples - taking measurements in those samples and then generalizing it to the whole area, then this is known as the technique of sampling.

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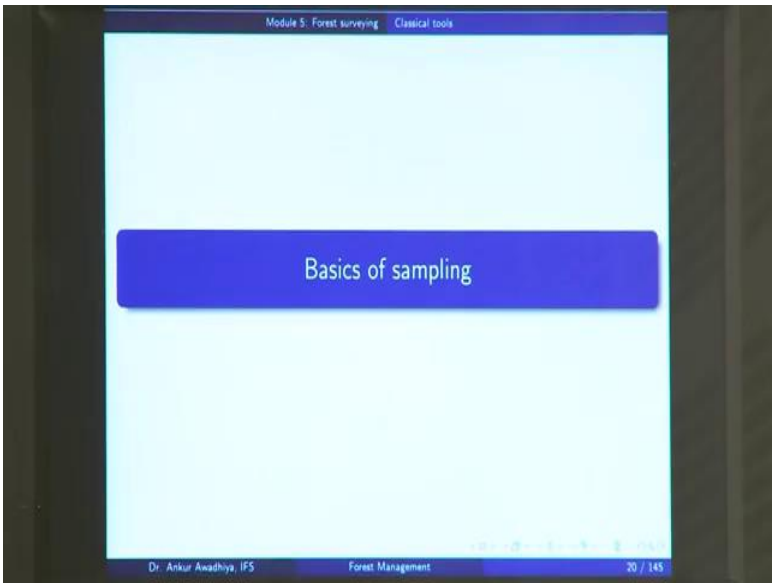

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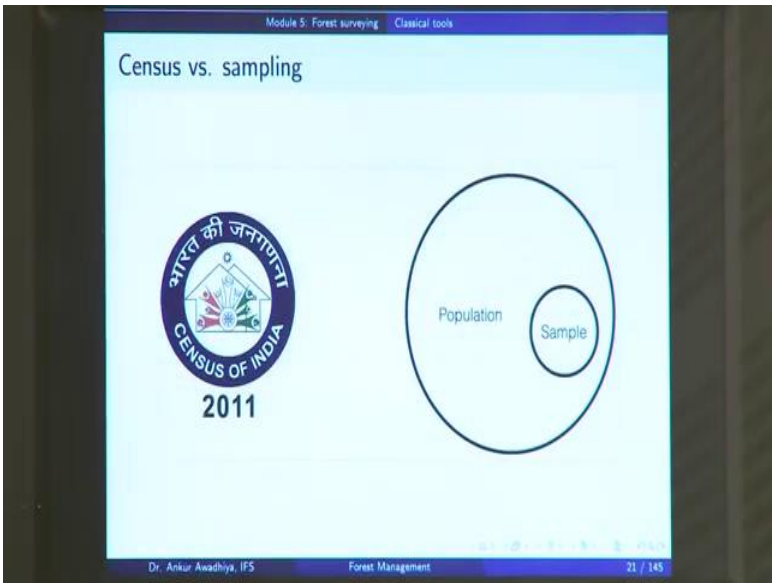

So, we will now have a look at the basics of sampling. Census is different from sampling. So, if you were measuring each and every tree in your area, then you would call this method to be a census. So, in a census you measure each and every individual; but in the second case, when you are taking small samples, then this is the method of sampling. So, you are not measuring the whole population. You are only measuring a small sample.

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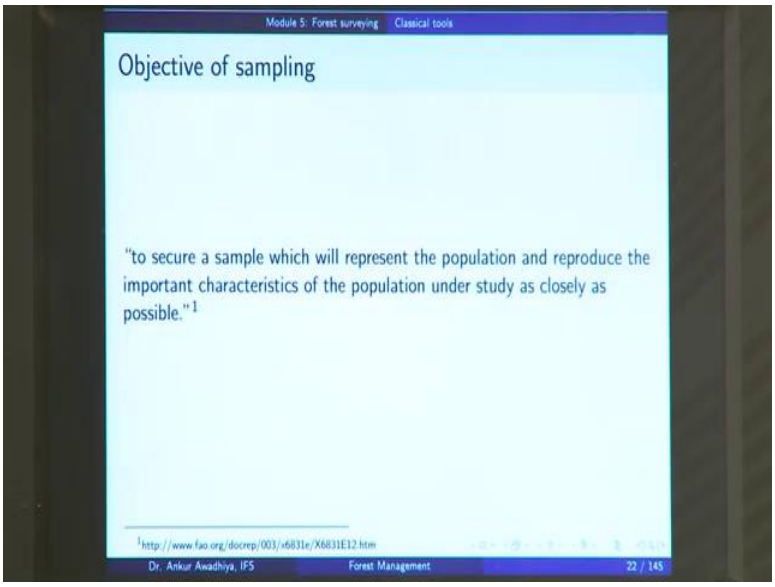

Now, the objective of sampling is to secure a sample which will represent the population, and reproduce the important characteristics of the population under study, as closely as possible. So, what you are doing in the case of sampling is that you, say that in place of

doing the measurements all over 100 square kilometers, I take small samples and in those samples, I do the measurements, and then I generalize it to the whole population.

So, that I am able to get a representation or a reproduction of the important characteristics under study, as closely as possible to the actual reading of all the trees in my area, but at a much reduced cost and in a much quicker timeframe.

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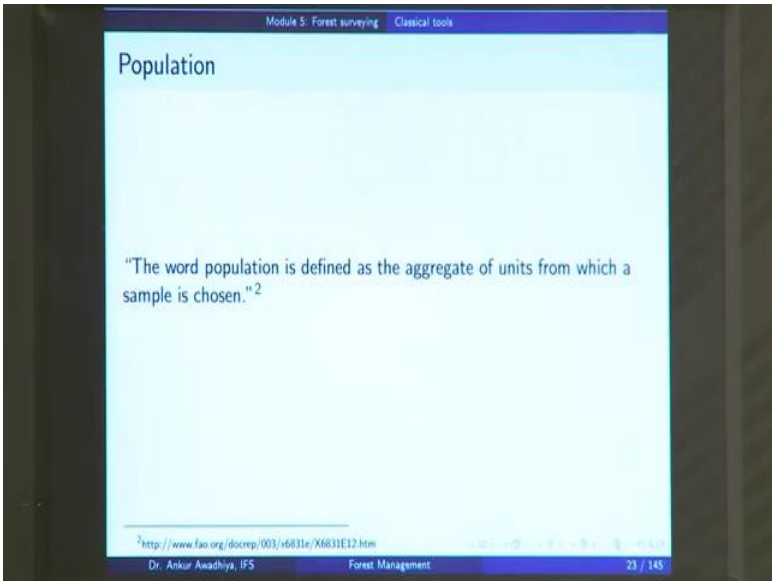

Now, in the case of sampling, we define things like population. So, population is defined as, 'the aggregate of units from which a sample is chosen.' So, in this case, all the trees in your 100 square kilometer forms the population.

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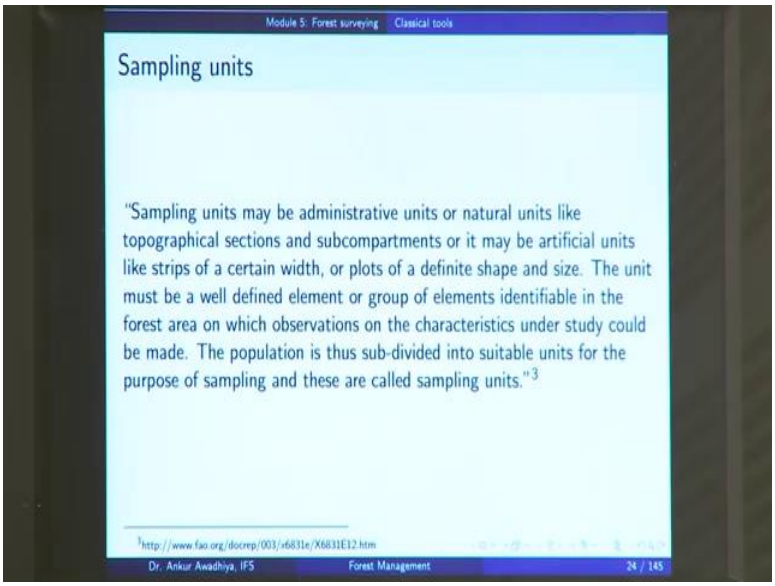

Now this population is divided into sampling units. So, sampling units may be administrative units, or natural units like topographical sections and sub compartments, or it may be artificial units like strips or plots of certain shape and size. The unit must be a well-defined element or group of elements identifiable in the forest area, on which observations on the characteristics under study could be made. And, the population is thus subdivided into suitable units for the purpose of sampling, and these are known as sampling units.

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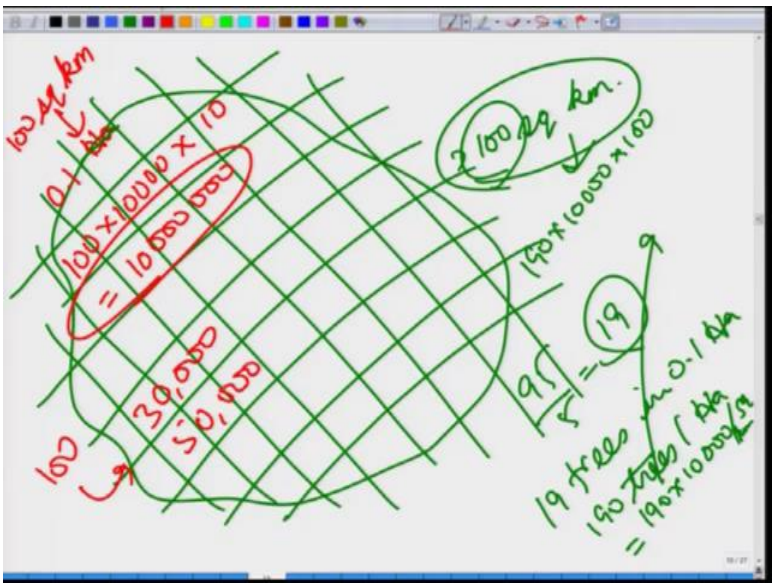

So, what we are seeing here is that we are taking different sampling units. So, what we are doing here is that we have divided this whole population into several subsections, and we ensure that all of these are of the same shape and size. So, we say that all of these are square in shape. Now, when you are dividing the whole population into these smaller areas, then you are making sampling units out of the population.

So, suppose you divided your 100 square kilometer in to say our 10000 units or 100000 units, then we will say that we have divided the population into the sampling units.

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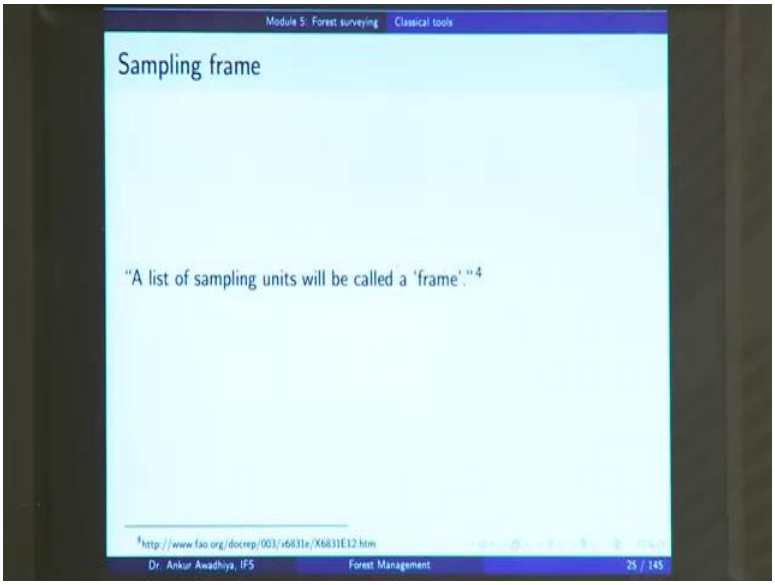

And then, if you make a list of these sampling units, you call it a frame. So, in this case, the frame will comprise of the list from 1 to 100000 of each and every of these sampling units.

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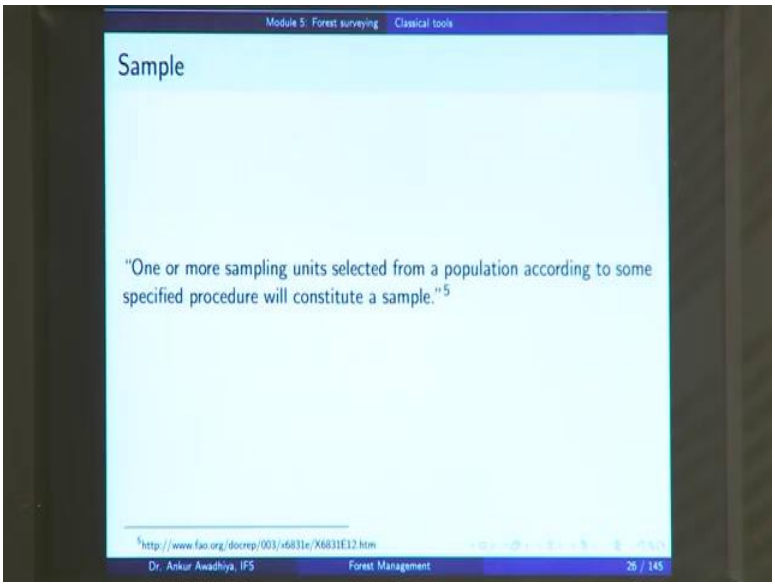

Now, out of these sampling units, we or out of this frame, we choose one or more sampling units according to certain procedure and we call it a sample. So, in this case, we are saying that we had this area of 100 square kilometers. We divided it into units of 0.1 hectare. So, 100 square and 100 square kilometer, we had 100 into 10000 into 10, which is equal to 10 million units.

So, we have these 10 million small fragments into which we divided the whole of the population. We made a list of these. So, you have this number from 1 to 10 million, and out of this whole frame of 1 to 10 million, you are selecting certain indeed you are selecting certain fragments to form your sample.

So, suppose you will say that am I will randomly take 100 samples, and so, when you are doing it randomly suppose 1 is say a 30000 frame, 50000, 30000, unit 50000 unit, and so on. So, you are taking 100 units out of these 10 million units, and these 100 units will form your sample.

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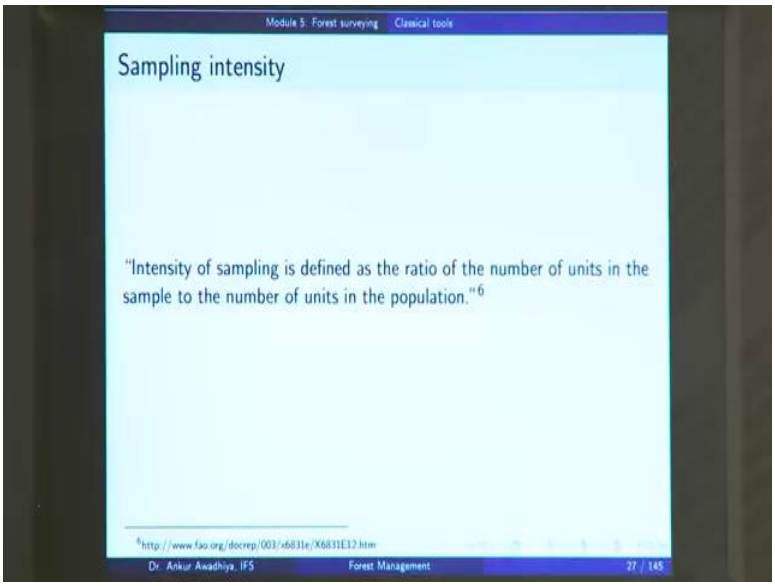

Then, we have the sampling intensity is which is defined as the ratio of the number of units in the sample to the number of units in the population.

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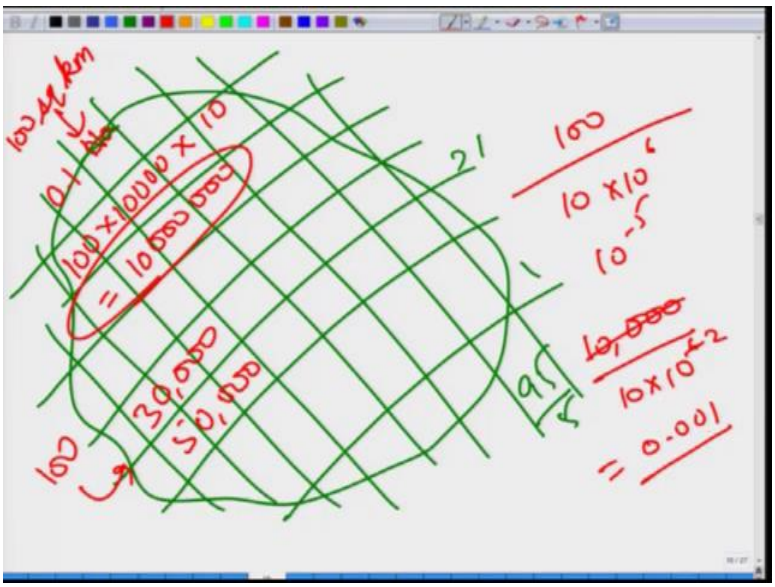

So, here we are saying that out of 10 million units, we are out of 10 million units, we are only taking 100 units. So, this is the sampling intensity in this particular case, which is 10 to the power minus 5. Now, in place of taking 100 units, suppose we went for 10000 units; so, in that case the sampling intensity would be 10000 divided by 10 into 10 to the power 6; so, which is 0.001. So, the sampling intensity has now gone up.

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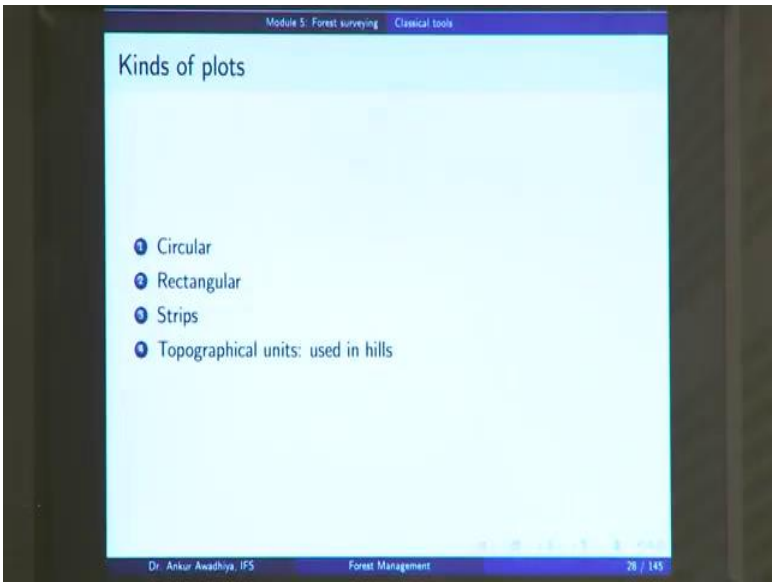

Now, the plots are the fragments that we make can be of different shapes and sizes. We can go with circular plots, rectangular plots, strip plots, or topographical units such as in the case of hills.

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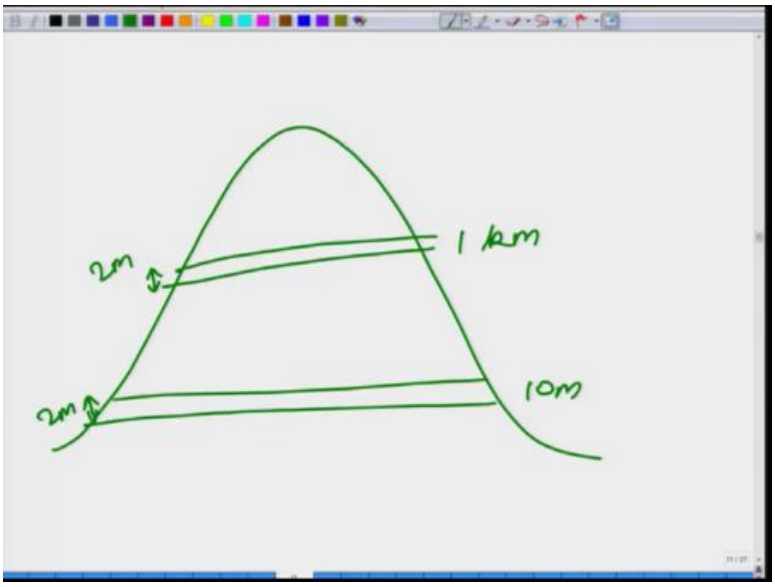

We could say that this is strip at say 10 meters is 1 unit; this is strip, at 1 kilometer is another unit, and in both these cases, the strip has a width of 2 meters. So, we can make use of these topographical plots as well.

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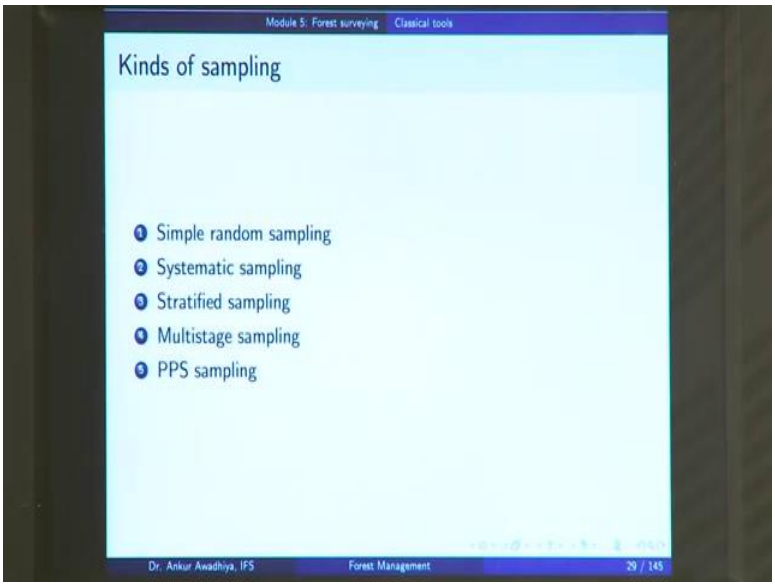

Now, when we are selecting the sample from the frame, we can we do it with a certain procedure. And looking at the procedures, we can have different kinds of sampling. We can have simple random sampling, systematic sampling, stratified sampling, multistage sampling or a probability proportional to size sampling.

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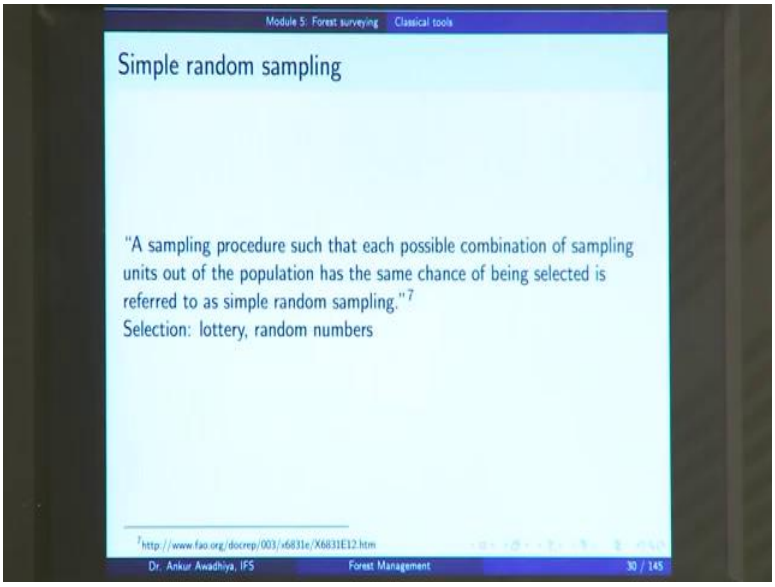

So, what are these?

In the case of a simple random sampling, the sampling procedure is such that each possible combination of sampling units out of the population has the same chance of

being selected, and then it is referred to as the simple random sampling, such as lottery or random numbers.

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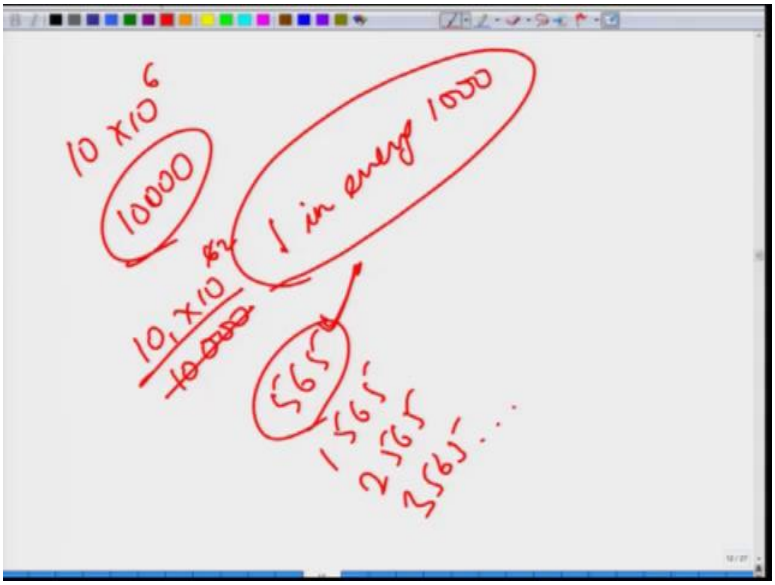

So, what we are saying here is that we had chosen 10 million units in our frame, and out of these 10 million units, you have to select 10000 units. How do you select these 10000 units? You go for a lottery. So, you on different chits of paper, you write your numbers from 1 to 10 million, put them into a bag, and select randomly 10000 chits from this bag.

Now, if you are using such a procedure, then this is known as a simple random sampling, Now, of course it is difficult to write 10 million numbers on chits, and then put them into a bag, and so, we make use of random numbers these days. So, the case of random numbers, you can ask your computer to generate a sequence of random numbers between 1 and 10 million, and you choose the first 10000 of these numbers; so, these are your sample.

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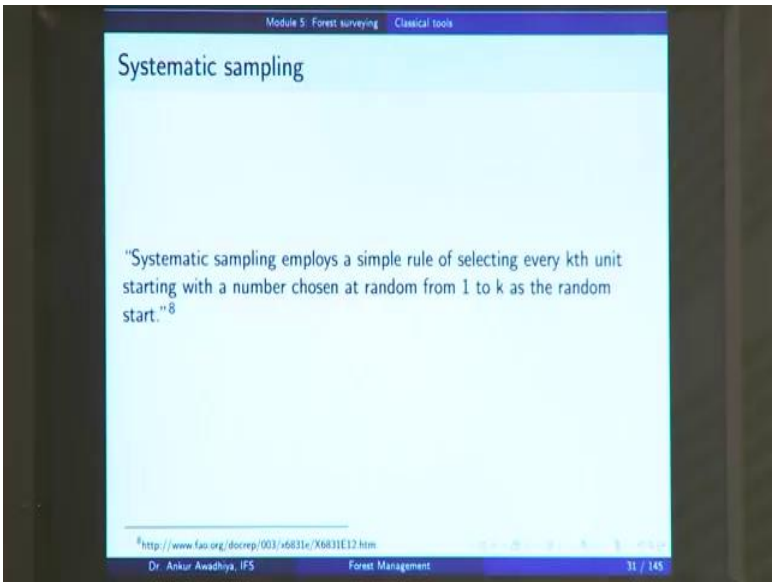

Secondly, you can make use of a systematic sampling. In which case, you select every kth unit starting chosen at random from 1 to k as the random start. So, what you are saying here is that you have a 10 into 10 to the power 6 units, and you have 10000 here.

So, 1 in every 1000 value has to be chosen. So, you say that I will start with say a random value, and between 1 and 1000. So, you get a random value with; which is say 565, and now you say that in your systematic sampling because you have to select 1 in every 1000; so, you take you choose your numbers like 565, 1565, 2565, 3565, and so on. So, the first member is chosen at random, and then one out of every kth member which is determined by your sampling intensity will comprise your sample.

So, this sort of a sampling is known as a systematic sampling. The first unit is a random and then you take every kth unit. So, for instance, you can say I will take every second member; every third member; so, suppose you have to select 10 members. The first member came out to be 2, and you say every third member I will be selecting so, 2 next is 2 plus 3 is 5, next is 5 plus 3 is 8, next is 8 plus 3 is 11, and so on. So, if you take such a procedure, then you reach a systematic sampling.

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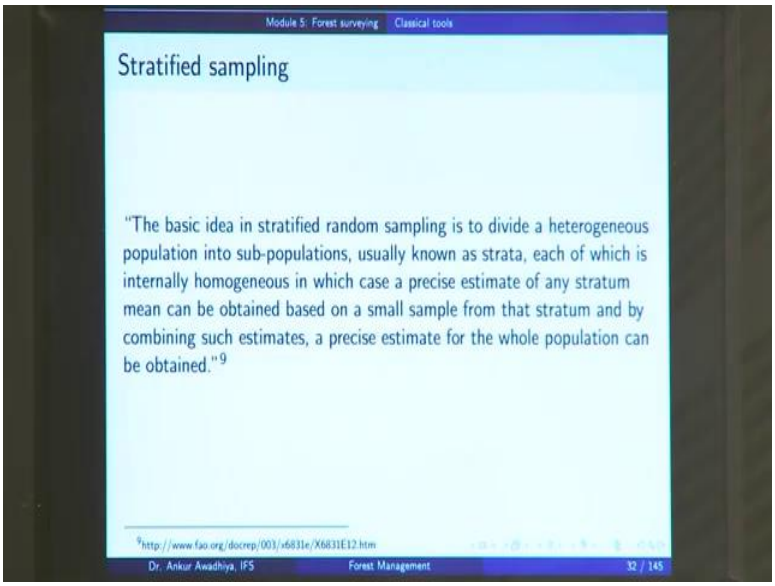

Next, you can make use of stratified sampling. So, the basic idea in stratified sample random sampling is to divide a heterogeneous population into sub populations, known as strata, each of which is internally homogeneous, in which case a precise estimate of any stratum mean can be obtained based on a small sample from that stratum, and by combining such estimates a precise estimate for the whole population can be obtained.

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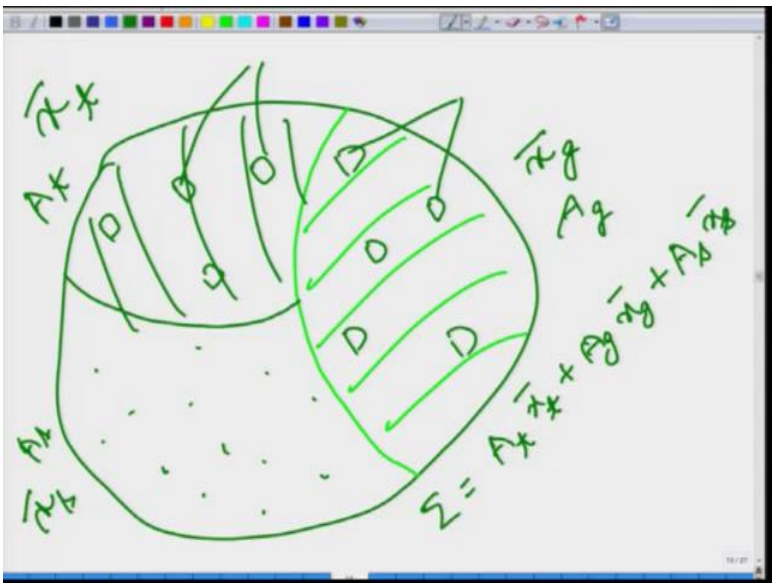

So, what we are saying here is that you have this large size forest and you could go with a simple random sampling of the whole area. But, a much better procedure could be that

suppose in your forest these areas are grasslands; this area is a teak stand; and this area is say a solid stand.

So, in place of taking random samples, what you can do is that you can divide the whole of the forest into these three sections, and in each of these, you will take random samples. Now, the random samples here and the random samples here will be very different. But, if you take the random samples within a strata, they will be close together. So, you will have much precise values in each strata, as compared to when you are taking the whole of the area together as your frame.

So, in this case, you can take the first measurement of the teak stand; so, the number of trees in the average number of trees in the teak stand. The average number of trees in the solid stand, and the average number of trees in the grassland stand. The area of this is suppose 80; here you have A s and here you have A g. So, in this case you will say that the total number of trees is A t into x t bar plus A g into x g bar plus A s into x s bar. So, in this case, your readings will be much more precise.

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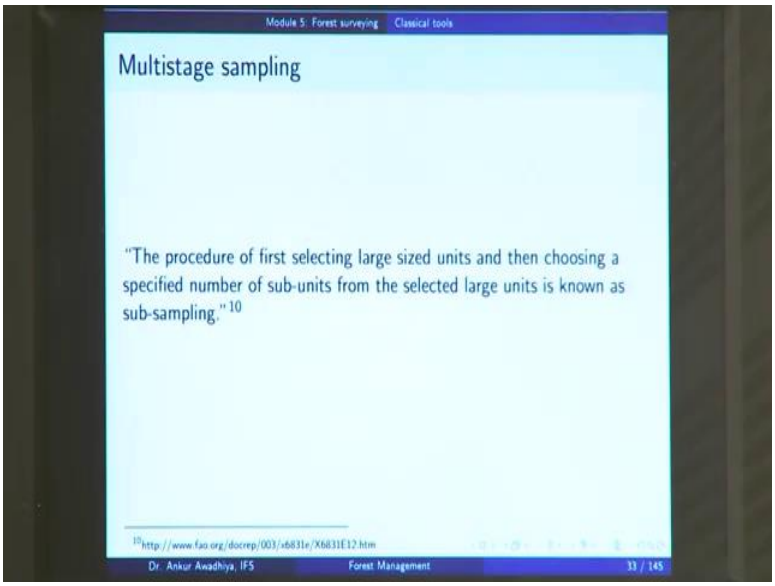

Next, we have a multistage sampling, which is the procedure of first selecting large sized units, and then choosing a specified number of subunits from the selected large units, and this is known as sub sampling.

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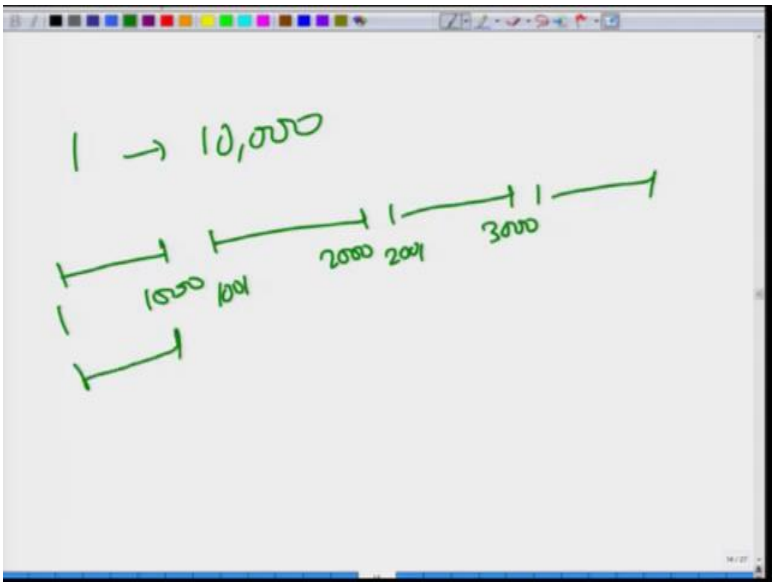

So, in this case, you are saying that suppose you have to choose between 1 to 10000, and what you are saying is that I will divide it in to 10 different stages. So, we I take 1 to 1000, then I have 1001 to 2000, 2001 to 3000, and so on. And in each of these, I will be taking random samples. Now, this is because when you are just taking random samples it is possible that by chance your random numbers come that all your random numbers come between 9000 and 10000. But, if you take this multistage sample, in this case, you will have a much better representation of the whole population.

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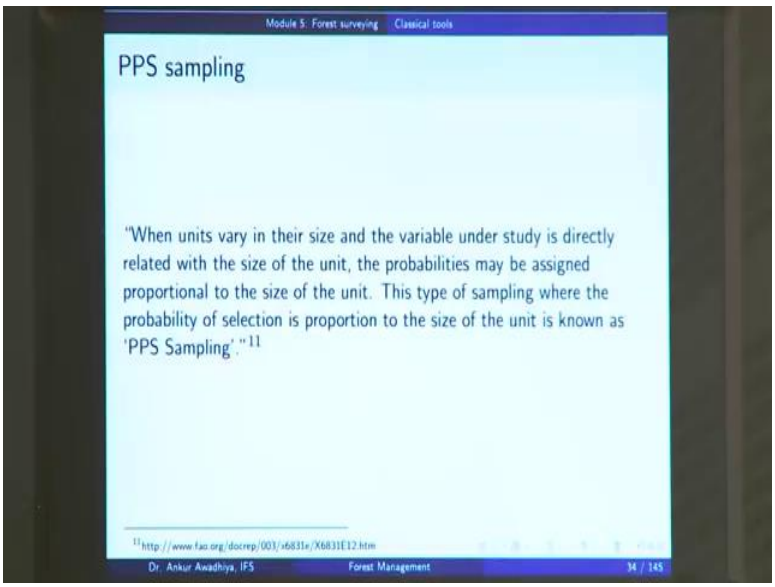

Then, we also have the probability proportional to size sampling or PPS sampling. "When units vary in their size and the variable under study is directly related with the size of the unit, the probabilities may be assigned proportional to the size of the unit. And, this type of sampling where the probability of selection is proportional to the size of the unit, is known as PPS sampling."

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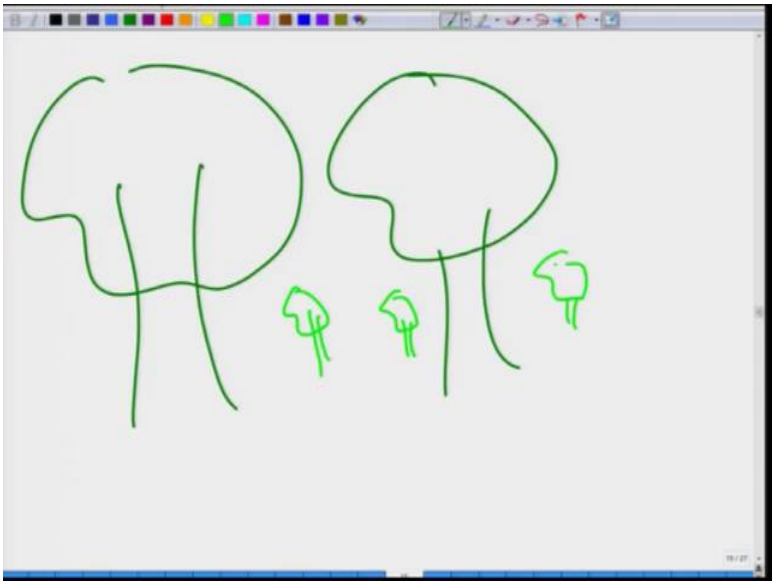

So, for instance, you want to measure the biomass of your forest; and in your forest, you have these large size trees, and you also have certain small trees. Now, if you want to take a measurement of the biomass, then because the large size trees have a much greater representation in the total biomass of the forest, you can say that, I will choose a sample in which these large sized trees are proportionally represented, based on their sizes and the smaller trees are less represented, so that I can have a much better idea of the total biomass in this forest.

So, if you take such a procedure, in which the probability of us of a unit getting into your sample is proportional to the size of that unit, then you refer to it as a probability proportional to size sampling.

So, in this lecture, we started with surveys; what is the survey? what are the different kinds of surveys? what are the different ways, in which we do surveys? and then, we moved into how measurements are taken in, or what sorts of errors are there in the measurements.

Now, our aim is to reduce this these errors. So, we want to have things which have better precision and better accuracy. Now, if you have large sized samples, then a large sized area then a way to economize on your measurements. So, you want to get good measurements without spending too much amount of money or time or other resources; so, in that case we go into sampling in the whole of the surveyed area, and so, we take small samples and we take samples in such a way that we have a good representation of the total population.

So, that is all for today.

Thank you for your attention [FL].