Digital Elevation Models and Applications

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Lecture - 19
Applications of DEMs in Viewshed and Flood Hazard Mapping

Hello everyone, and welcome to a second last topic of digital elevation models and application course. And in this topic, we are going to discuss the view shed analysis, and also we will in the last we will be covering about the how flood hazard mapping can be done using digital elevation models. If you if you recall the previous discussion when we were we have been discussing about how to use digital elevation models in solar energy estimations, there also we have discussed about the view shed, but that view shed is a hemi spherically upward looking view shed. Here it would be looking this view shed analysis is based on horizon that means, parallel to the surface of the earth, so that is the major difference.

Of course, there will be some other and differences and options which will which are going to be available when we go for view shed analysis. And also we will be discussing where view shed analysis can be applied in our engineering applications. Also sometimes in the literature you may find a different term which is also called visibility analysis. So, instead of view shed one can also call visibility analysis. So, what we are going to discuss here that what is view shed basically, view shed is the identification of areas of terrain using a digital elevation model that can be seen from a particular point on the surface of the earth.

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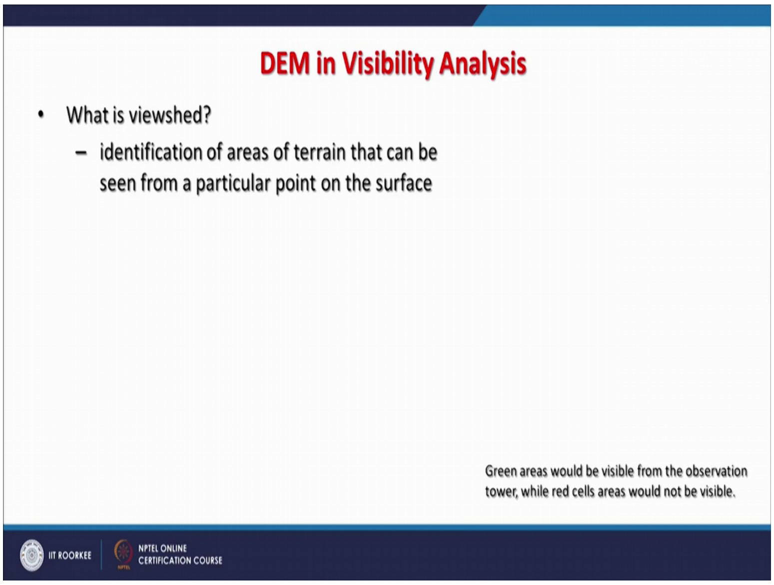

So, this is what view shed is we may we may determine if view shed in a particular direction or maybe a 360 degree we may add some offsets to the target may be offset of the person who is going to look from a point or a height of a tower. These all these things we will be looking.

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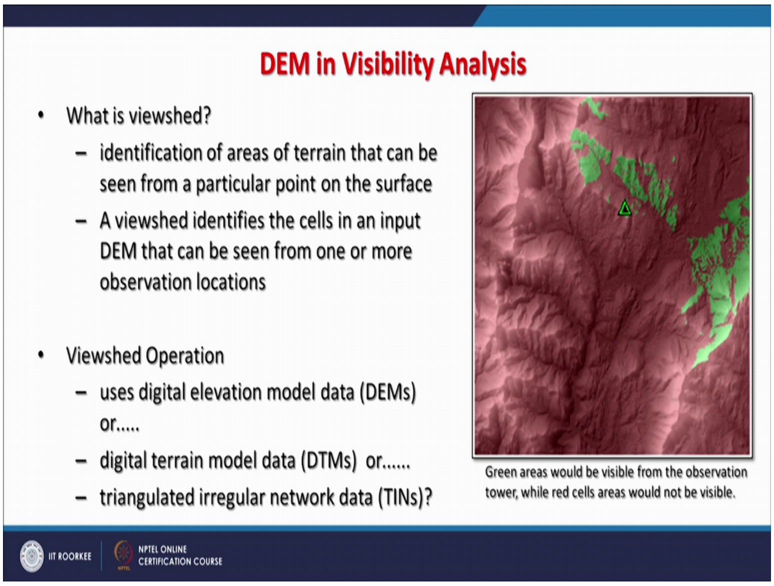

So, in this like in this example on the right side what we are seeing this is the location of a point from where the view shed analysis was done in the terrain. And on if we restrict that only on one side, I want to analyze then these green areas are showing that from this point these green areas would be visible and the remaining areas will not be visible from that point. Because if you see very carefully you would find that this point is located on the slope which is roughly north facing and therefore, southern facing slopes and all those sides will not be visible at all. So, this is what the identification of areas of terrain that can be seen from a particular point on the surface and this is what the example is.

And we also see that in view shed identifies the cells because it is what we are implying is a digital elevation model which is a raster base. So, it identifies the cells in an input DM that can be seen from one or more observation locations. In view shed analysis, you can also involve not only one observation location, but multiple observation locations as well. So, through a point five that information can be provided along with offsets another thing and then a combined view shed analysis can also be performed.

And the this operation the view shed operation and both say of course, a digital elevation model which is the main input here or a digital terrain model or maybe a TIN. So, on TIN also which is another terrain surface representation can also be employed for view shed of operations or analysis. And they say view shed when we use a DEM to calculate new set of a particular point what we basically require that the location of that point. So, x y location and then of course, what is the height and that you know so we can add that one. So, in this like a point x can be seen from surface y may be target location is there and what part of surface y can be seen from point x.

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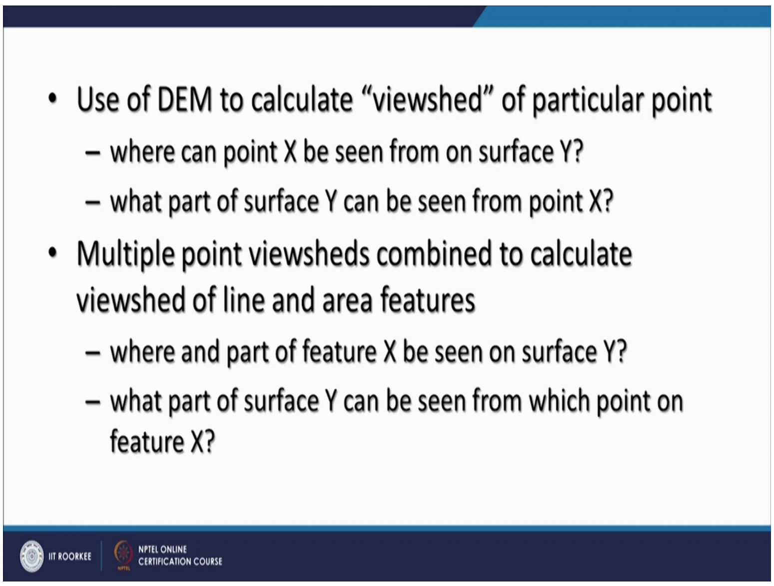

So, if I can see a point y from location x then I should be able to see the same x from y location. And the multiple point view shed can also be combined to calculate the view shed of line and areas. And where they say the when the part of feature x can be seen from on surface y, and what part of surface y can be seen from which point on the feature x. So, when we involve multiple points then analysis becomes little complicated, but does not matter. And this can be achieved quite easily only the interpretation part may be little confusing, when we involve the multiple observation points.

So, while calculating this view shed a line of sight from the observer point to the terrain surface is calculated, and which search the inter visibility matrix through which it calculates the inter visibility matrix. And visible parts of the terrain surface is an example I have shown earlier that some parts of the terrain where visible from that particular location and in none way visible areas or dead areas can be assigned a different colour.

And this we can as mentioned earlier that we can add a offset of the terrain offset from the observation point, because if a person is standing then his height can be added as offset or a person is standing on a table or building top of a building or roof of a building, then the height of the building can become offset. So, that that offset is also added. And if it is related with some turbine or some other thing that height can also be added.

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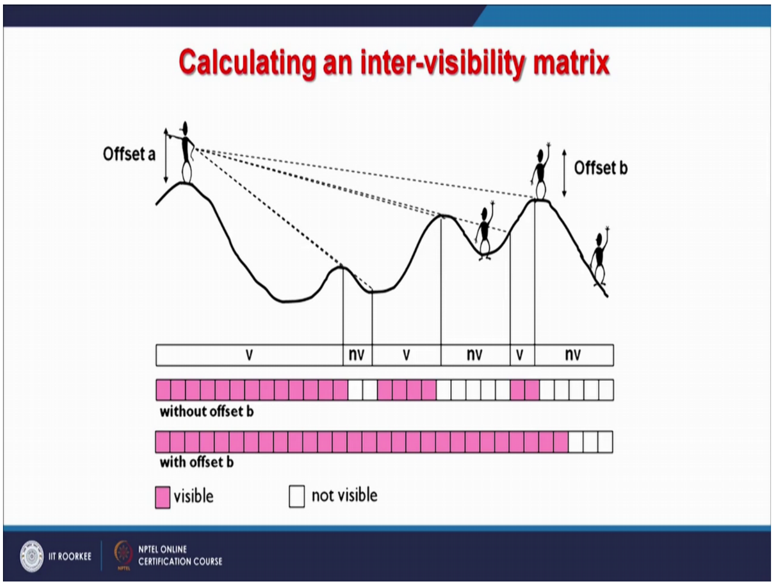

If we see the example here that what we see here and that a person is having offset A is located here there are persons which are having offsets B. So, we can analyze along a this is a of course, a profile section, but we see here that the person A can see partly the person standing in this nv area or on the top of the hill that person can fully see. But the person who is behind this hill cannot be seen by this even offset or a person standing at this hillock.

So, this is without offset B if we do not add the offset v, then this is how the analysis nv not visible, here not visible and this part is not visible. And whereas, with the with the offset B then we are having that upset then entire they up from this location; that means, from this location up to this location and the entire area is visible. But except this part that is the other side of the slope which is not visible.

And this is of course, an example here with the offsets in a two d or just along a profile, but in when we imply digital elevation model we can see all around and it is not only along a profile but all around. Maybe as per requirements we can go do this analysis for 365 degree as well.

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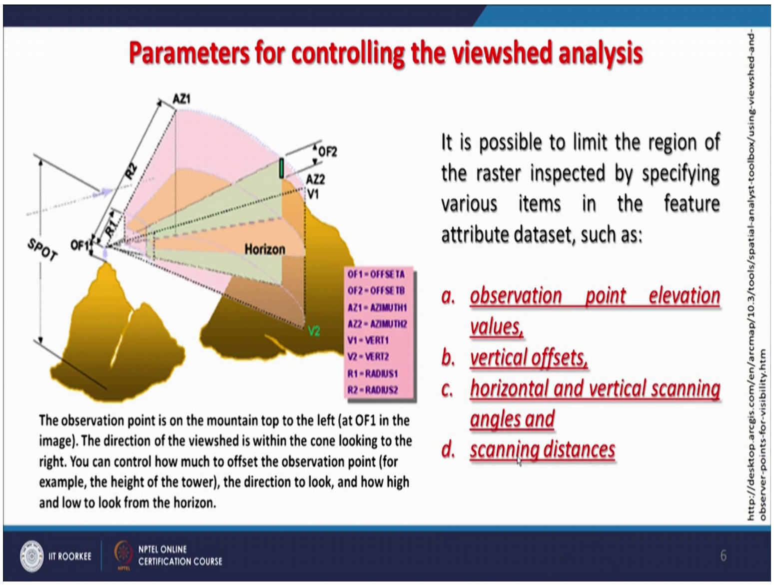

So, what are the parameters which control or in the input which are required while doing the said analysis as mentioned these offset A and B that means, observer. And target offsets can be there and then we can restrict the azimuth that in only in between this azimuth and like in this example azimuth 1 and azimuth 2, I want to analyze this view shed or creative view shed. And then I can also restrict the vertical angle that how up above from horizon it will look, so that horizon is here. So, this vertical one and vertical two can also be incorporated. And then radius that what is going to be the radius of that area whichever one would like to analyze.

So, involving in this these kind of inputs one can determine a view shed as per desired or as per requirement. So, it is possible to limit the reason of the raster or DEM which is inspected by specifying various items as or various options as given or can be provided through attribute table. And there for example, observation point elevation values, vertical offsets, and horizontal and vertical scanning angles, and scanning distances how far the analysis is required. May be end of the boundary of digital elevation model or if you are covering a very large or if you are analyzing a very large digital elevation model then you can restrict the distance that the scanning distance is only that much required.

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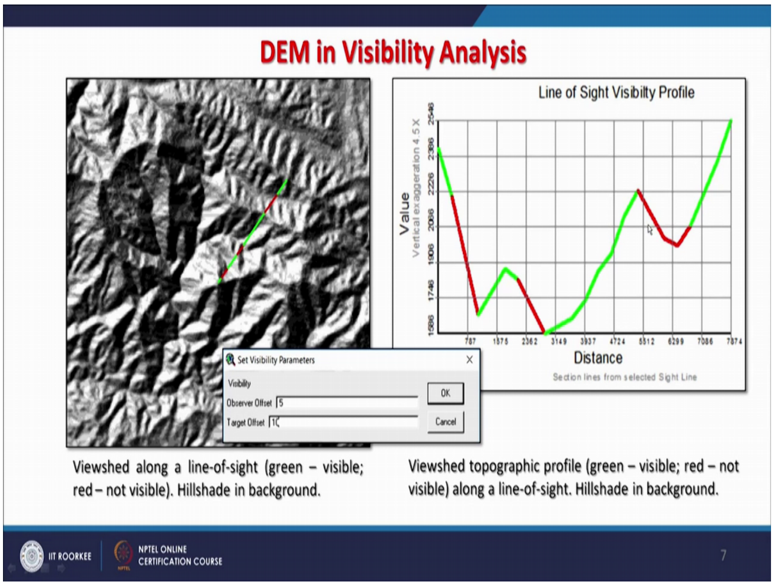

And this is the example of view shed analysis along a line as line of sight you can say. And on the same DEM which we have been using in this course the example DEM. And if a person is standing here the line of sight has been drawn like this then these are the areas which would be in the green areas which would be visible or part of the terrain. However, in this line of sight there are areas marked red will which not be visible. And of course, this is a hill shade just to bring the terrain in relief and relations, so that this view shed has been overlaid or rather in background the hillside has been kept. And so here we like in simple analysis we can provide the observer of shed and that would be in the units which your elevation model is having four vertical scale.

So, this is 5 meter, and the target offset is given 10 meter and then analysis is performed. And of course, in the profile also you can see the same analysis that this is the line of sight visibility profile. So, these red parts cannot be seen whereas, then green part this is that corresponding green part is seen. Then again you do not see a small patch of the terrain is here mark red and then a large part the green part is shown here, then again a red patch and then finally, a green patch.

So, likewise plan view can also be seen in a line of sight as well as a profile, but when you are going for a 360 degree then only in one particular direction or along a line of one particular direction, you can have this profile. Otherwise, you say in only in case of a line of sight this profile can be determined.

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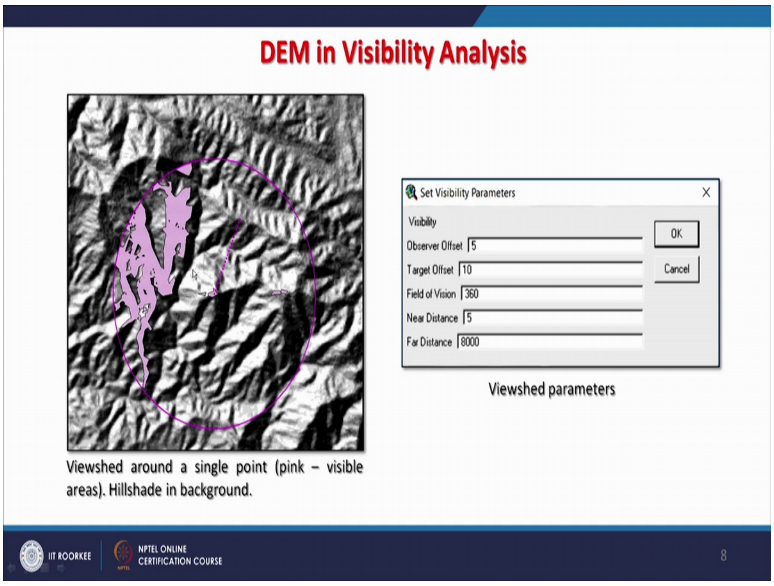

If we go for a view shed analysis along a single point in a circular fashion and by giving this radius, what we have restricted that the distance it has scanning distance it has to cover is as per the radius given here. The point here and the areas which would be visible are all shown in the pink colour, and rest of the areas are will not be visible from that point. So, likewise such a analysis can be done only along in line or in a radius or depending on.

Now, here the input parameters the offset was again kept a 5 meter, a target offset was 10, field of vision that means, in it has to look all around that means; that means, the 360 degree, one can also restrict to say 100 degree or 90 degree or 180 degree depending on the requirements. And less the degree we will keep quickly the analysis will be done by the system. And near distance how close you want and how far distances it should cover. So, all that can be given as options. And once the analysis is done such outputs can be created.

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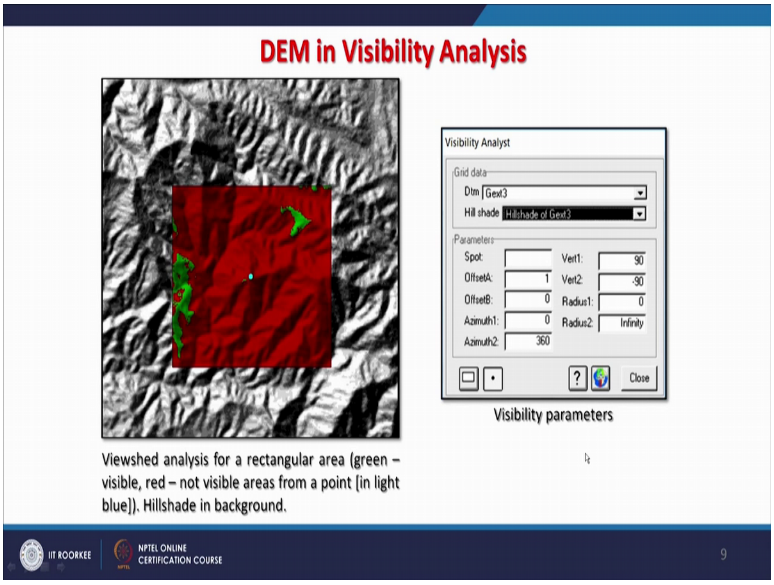

We will see some applications also. So, instead of having a circular approach one can also have a rectangular approach that I want only the visibility analysis in this particular rectangle whose centre is here. So, the observer is here. And then again the red areas from that point which is light blue colour cannot be seen. Whereas, the green areas are only seen. Here also a different tool in rgx and this visibility analysis again brings some options here offset A, offset B, azimuth one, azimuth two, vertical one, vertical two and all these options are available for our analysis.

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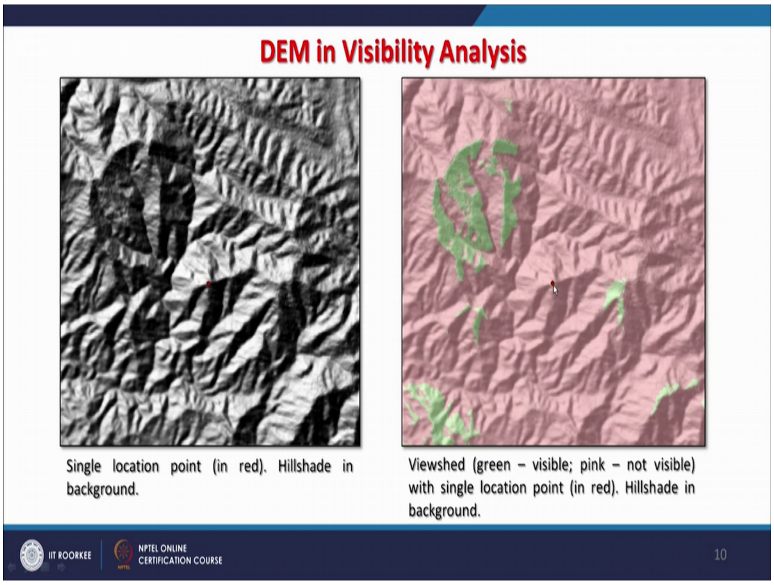

Similarly, view shed analysis can also be done for entire digital elevation model inputted digital elevation model. So, we can do the view shed analysis along a line that is line of sight. We can restrict in a particular direction, we can restrict we can restrict and under a circle whose radius we can decide or a rectangular or even for entire digital elevation model as shown here and that the observer is here and then submitted for entire area. So, red areas are not visible from this location get that particular offset which was given here.

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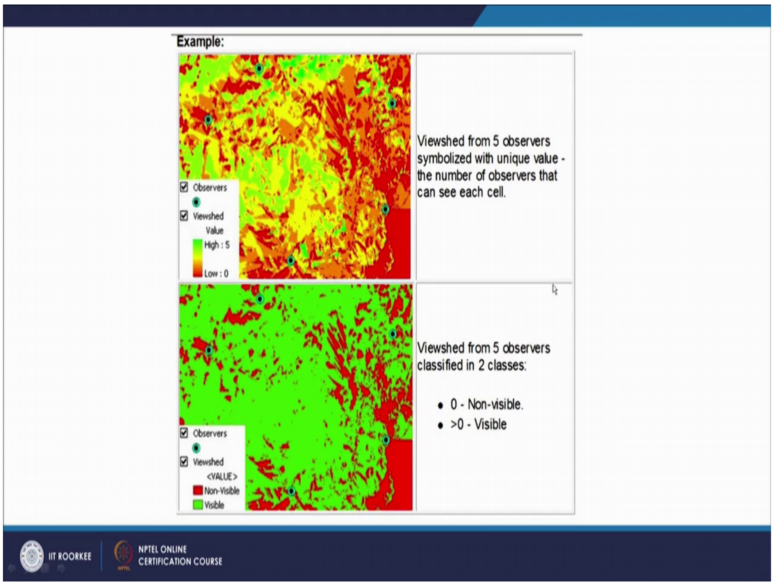

Whereas, the green areas are visible in this one. So, multiple examples can also be added and multiple observer observers can also be added as one can see here that a view shed has been done for five observers here. So, again as a convention is that that view shed analysis has been done, so the low visibility or rather no visibility for the red areas green will build the visible from these points. And the range is there between 0 to 5. And this means that if a yellow colour is coming that means, from and roughly from two or three locations that and that area can be seen or two observation points. So, that is why there is a range between 0 to 5.

5 means from all five observation points and that area that is shown here is green colour can be seen. Whereas, complete red means from and no other remaining points means four points or and no points that area can be seen. So, there are five observation points. And suppose this is the area which cannot be seen by any of these observation points. So, five means the terrain part of the terrain can be seen from all observation points. And zero means and from none of the observation points.

And if we want to just classify and between visibility and non-visibility instead of a range like here in this region and is telling us between 0 to 5, you want just a sort of binary that visible and not visible then this analysis can also be performed like this. So, only if visible from any point then it will be considered as green; if it is not visible from all points then it will we considered and none points, then it will be considered not visible. So, not visible part is little less compared to whereas, green area that is visible part is maximum because five observation points and the classification has been done based on just visible or not visible. So, once the output has been created or review shed has been created then we can classify in that case when we are involving more than one observation points.

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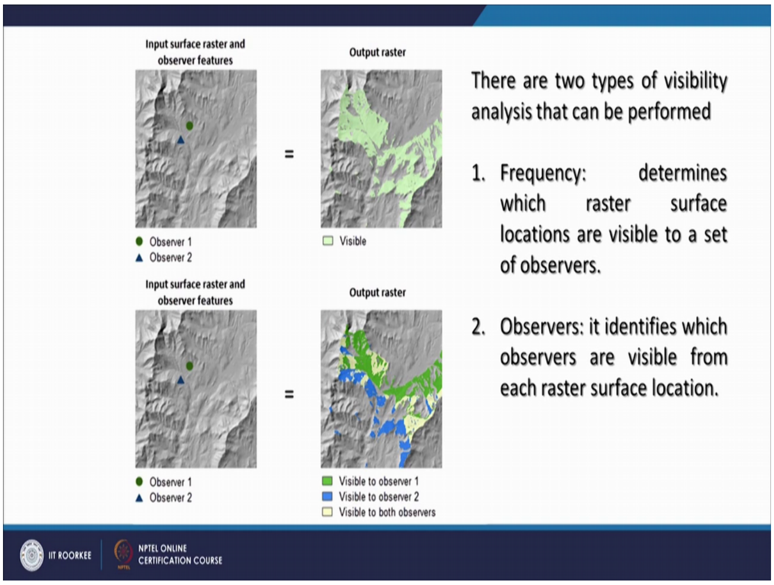

And there are some other examples also there, there are there that there are two types of visibility analysis that can be performed here also that the two observers are here in this example. We see only the visible part whereas with the same observer locations, but we want to see which one are visible which part of the terrain is visible from observer one, which part or of the terrain are visible from observer two and which part are visible from both the observers. So, all three possibilities are also there. So, this can be also analyzed like this.

So, this frequency means this determines that from how many locations a part of terrain is visible. So, frequency determines which raster surface locations are visible to a set of observers. If we are having five observers, whether it is visible from five locations or three, or two or one whatever. And observers it identifies which observers are visible from each raster surface. So, the analysis has to be done from both ways as is given in the beginning that a location x should be visible from y and vice versa is also true because it cannot be one way the visibility will always have the direct connection.

Now, when we are doing this analysis for terrain or the when large distances are involved, and therefore when visibility analysis being done o over a large area, then two other parameters will play very important role. And one is the curvature of the earth, and another one is the refraction. And these corrections then have to be performed if our line of sight is very long, or if our search area or a scanning area is very large because if it is there then these two parameters will play very important role. And if the corrections are not incorporated, then the analysis will not be very reliable. So, the view shed will generate may not be very reliable.

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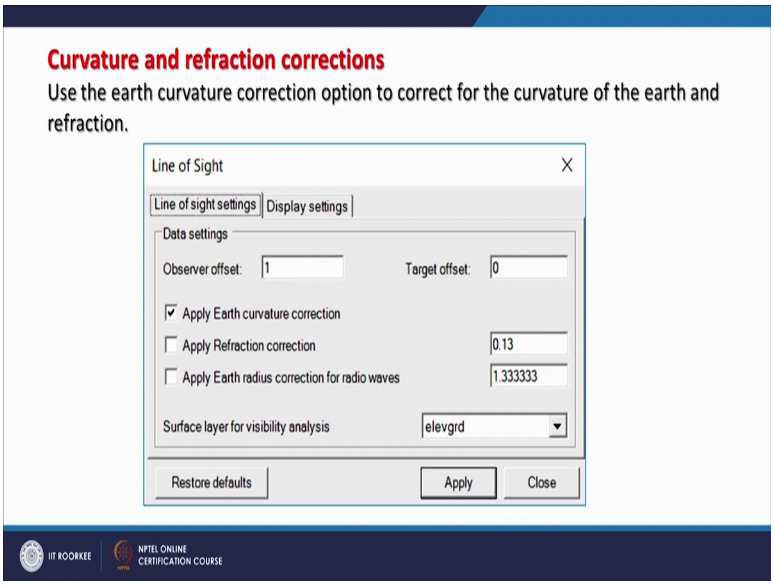

So, use of earth curvature correction of sun to correct the curvature of the earth and refraction, and now with the modern GIS softwares these options are becoming now available. So, we do not we do not have to basically program the things, but now only thing we have to understand that how much correction will be required in so on and so forth. So, if I take the example of line of sight then observer of set is 1, consider is say in meters and the target offset do not have any and so it is a 0 just surface. And when we apply for earth curvature then these are the values which when we opt for that then these are the values we will come in the default for refraction and earth radius correction for radio waves and others.

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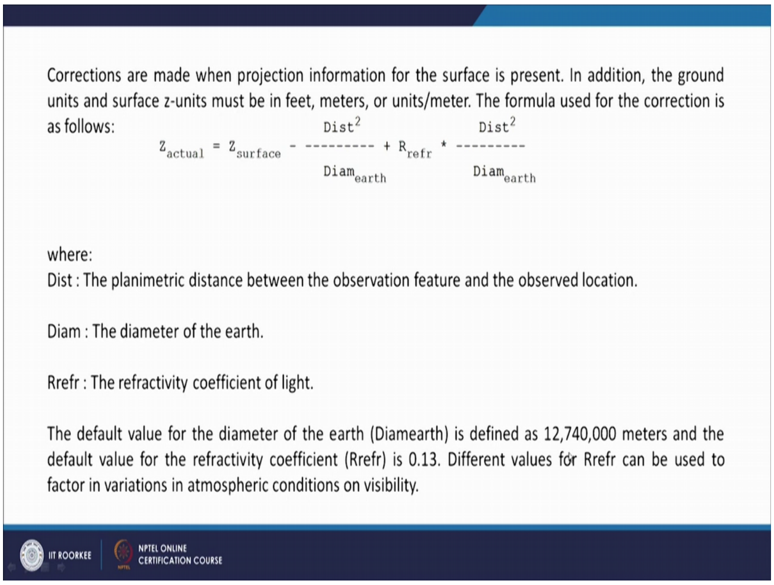

And when we go for applying this thing we get the correction performance. So, corrections are made when projection information for surface is present, and that means, that that in the digital elevation model has to be projected in some map projection. If it is just in degree decimal non projected situation, then such corrections of earth curvature and refraction cannot be incorporated. So, one has to remember this thing that the corrections are made only when the projection information for surface is present or the digital elevation model has been projected in some projection system may be say UTM or poly conic or whatever.

And in addition the ground units and surface z unit must be in feet meters or unit meters that means, both units horizontal unit and vertical units should be the same, and the formula used for this correction is something like this that z actual that is the height z actual equal to z surface which will come from digital elevation model minus distance two and the diameter of the earth. And then plus refraction factor multiplying by distance two divided by diameter earth.

So, with this with this correction, we can perform more reliable view shed analysis for when a large area or longer very long line of sight is involved. And these the refraction or curvature of the earth are very important in case of targeting some missiles and other things, because and these missiles travel for very long distances and therefore, refraction and earth curvature plays very important role.

So, these that when these are that the distances two mean distances are mentioned here. So, distance the planimetric distance between the observation feature in observed point diameter of the earth, refraction, this refraction is the refractive coefficient of the light. And the default value for diameter of the earth is defined this much meters, but when it is projected then accordingly it will be taken. So, and this coefficient is 0.13 is taken and that is why in this here 0.13 has already been taken in this to apply for refraction correction as a default value.

So, by when involving this thing our visibility analysis may be little different, but if area is large then only we see much difference is while involving earth curvature correction and the refractivity refraction correction. But in for a small area probably, we may not see much differences if we even been incorporate these corrections.

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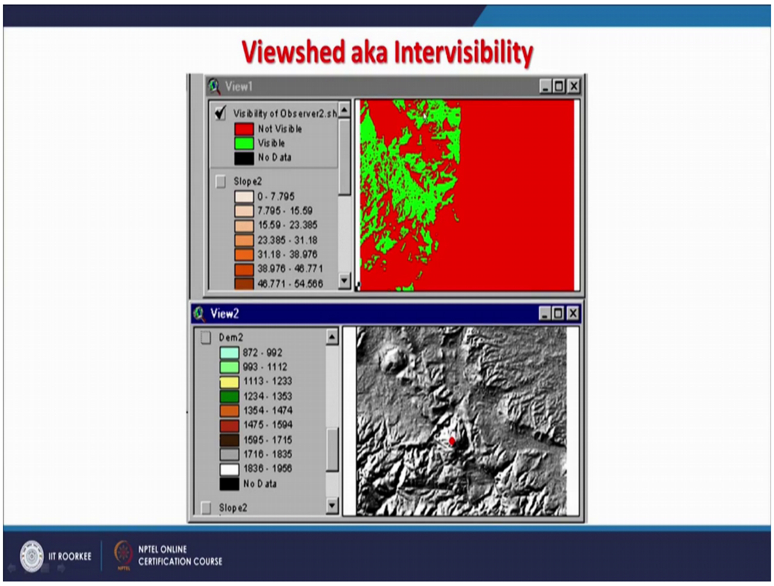

So, this is visibility or view shed analysis for a terrain area.

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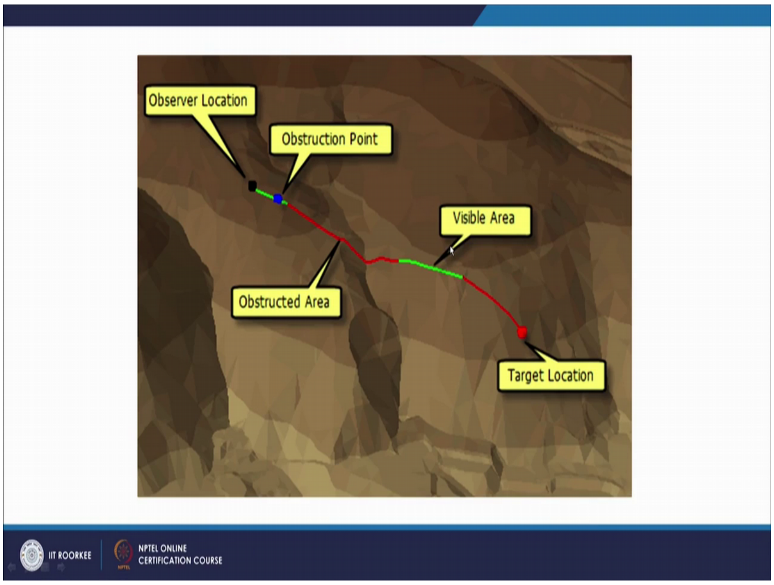

Again along in line this is example from digital elevation or tin triangulated irregular non-network on which also we can perform the same view shed analysis. This is the example here that this is the observer location this is the target location which part would be visible. And which are given in green colour which part will not be visible are given in the red colour. So, the input can be either your digital elevation model that is raster or can tin also

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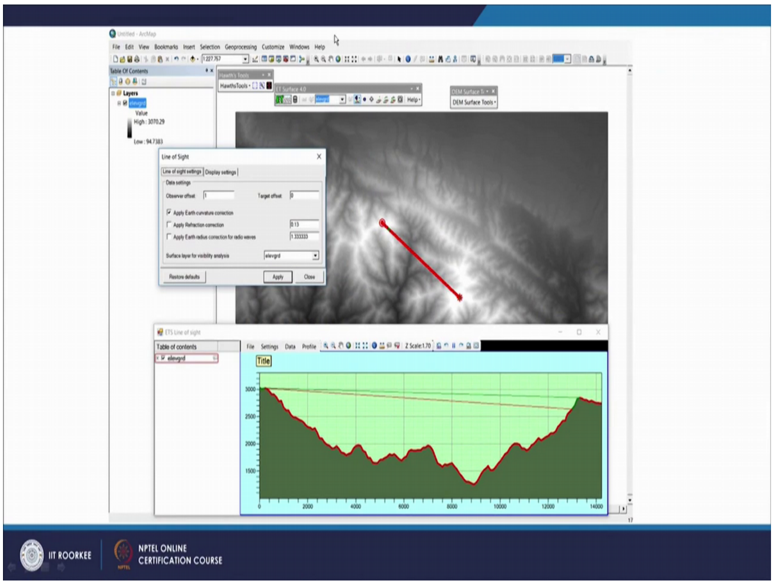

Now, this is the example how one can perform in arc GIS. And when I choose all these things I have to give this is in line of sight so I am giving a direction and a target location and offset another values. And once you do it, then you get this kind of analysis. For example, here only a small part of the terrain here which is visible, rest are not visible. Because if offset has not been added, much offset has not been added, then there are chances that the through visibility analysis, you would find that only a very small path along the line of sight is visible and same would be in case of if I go for a rectangular or circular area. So, offset has to be added generally some offset at least human height has to be added if one is targeting from the top of a building or a tower observation tower then and that offset has to be added.

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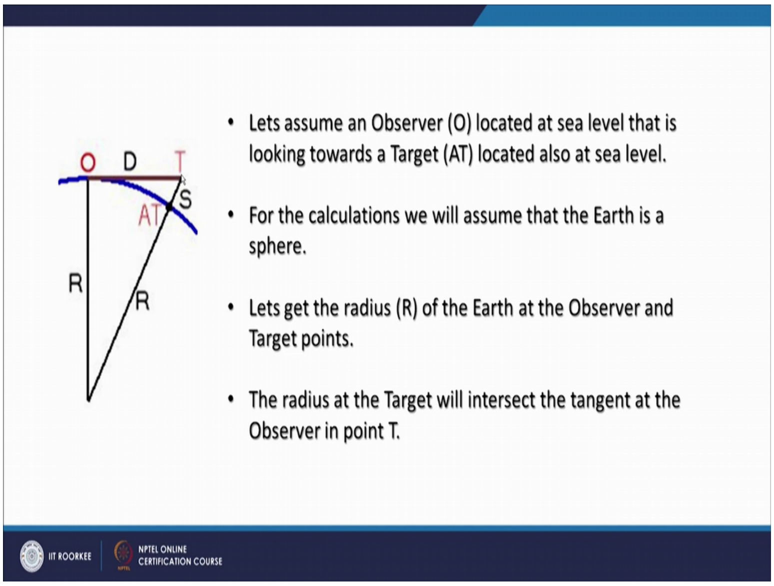

Now, how other these corrections play very important role as we can see that here. And let us assume that an observer O is located at sea level that is looking towards the target here that AT located again at the sea level. And now the earth curvature how it is playing important role. So, for the calculation, we will assume the earth is a sphere, but you know that for perfect calculations few more parameters have to be incorporated because earth is not a perfect is sphere, nonetheless less for here we are assuming that earth is a perfect sphere. Then lets let us get the radius R that is the earth of the earth at the observer O and at the target location here also at AT.

Now, the radius of the at the target will intersect the tangent at observer at point T here. So, this lesson this indicates the sync of the target and instead of here it is coming here due to curvature of the earth as S. So, this S factor has to be incorporated.

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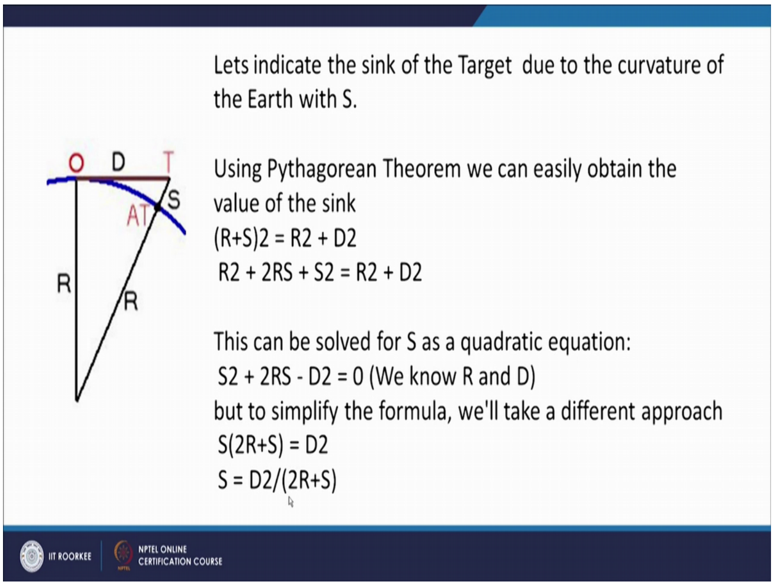

So, using Pythagorean theorem, we can easily obtain the value of the sync how much drop is there and that is R plus S square equal to R square and D square. And likewise we can calculate so this can be solved for s as a quadratic equation. And then we get the perfect the value of the S which is D 2 D square by 2 R plus S.

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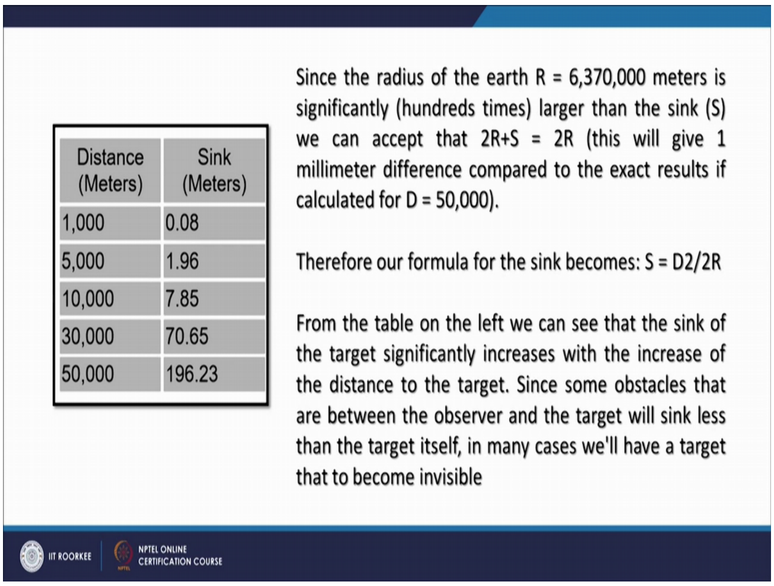

So, for different distances and this has this think how much sync effects will come or drop effects will come has been calculated for 1 kilometre, 5 kilometre, 10 kilometre, 30,000 kilometre, 50,000 kilometre, these number of meters and the sync would be there. So, it plays very important role for the sync. And only this correction or such corrections are required when large distances are involved our calculations in view shed analysis.

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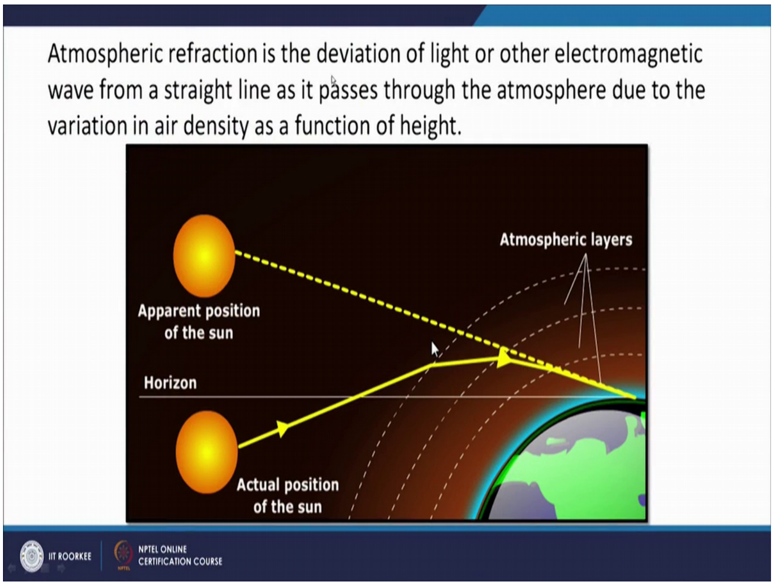

Also a little bit about how atmospheric refraction will play important role as we can see here that these atmospheric different atmospheric layers which surrounds the earth. We are having the position of the sun actual position of the sun, but because of refraction effect we get the apparent position of the sun somewhere here. Same way our observations or in view shed analysis, instead of getting the actual position, we get the target position apparent position something like this. So, atmospheric refraction is the deviation of light or other electromagnetic wave from a straight line as it passes through the atmosphere due to variation in air density as a function of a height. So, when it passes through different layers, it bends and the position is somewhere else.

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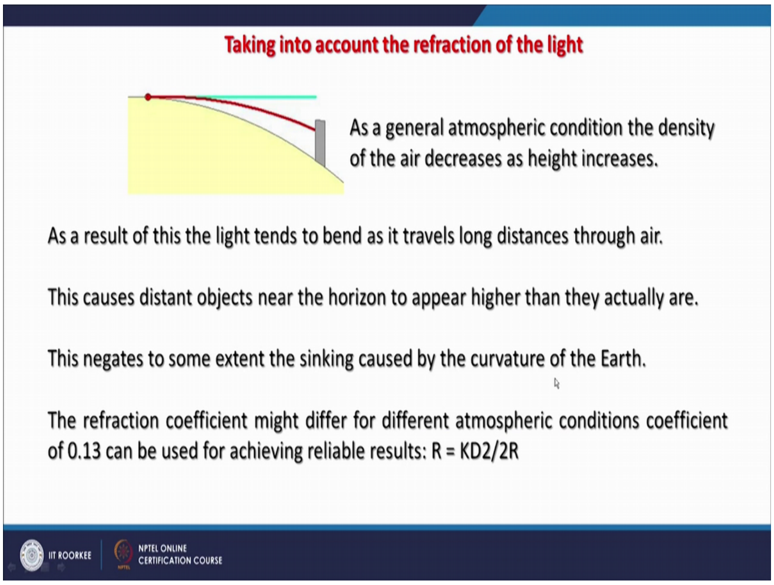

So, taking into account the refraction of the light as a general atmospheric condition, the density of air decreases at height increases; and as a result of this the lights tend to bend as it travels long distances through air. And this causes distance objects near the horizon to appear higher than they are actually are. And instead of feeling here and you make it you may have a feeling that that the target or and the height of that location or point is much above. And this negates to some extent the sinking caused by the curvature of the earth, but not fully, so that the refraction coefficient might differ for different atmospheric conditions, but since we do not have regular availability of such values. So, 0.13 can be taken in most of the cases. So, this refraction coefficient this is how it is derived.

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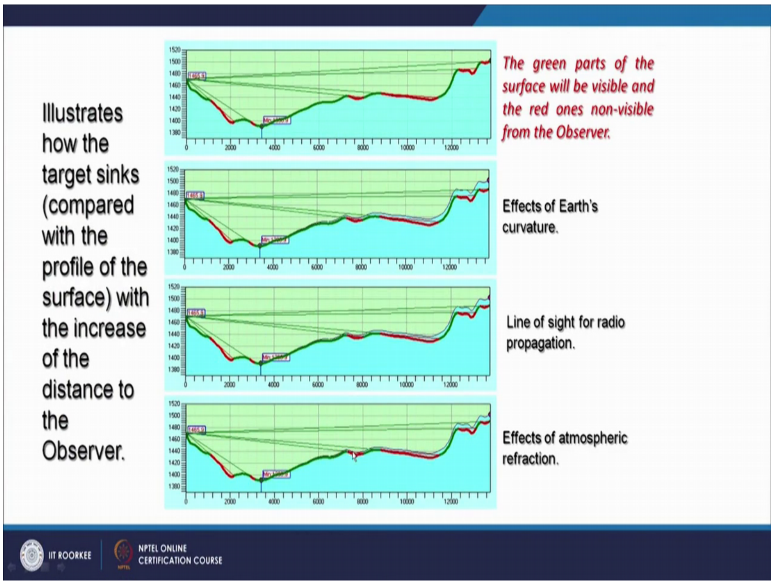

Now, there are examples of view shed analysis or line of sight analysis with the different sinks are there. And that compared with the profile of the surface with increase of the distance to the observer. So, how things are changing here as you can see very well here that observer is here. And then what we see the changes in the visibility part of that as one can see very easily here. So, if we change this the distances and the sinks will affect, and therefore, we will have a different view shed analysis.

Here in the first example, and there is no difference and whereas, when we add a few more things then the differences becomes large as you can see. So, the green part here of the surface will be visible along this line of sight profile and the red parts are not visible. And the effects of earths curvature can be seen here. And this is the line of sight of radio propagation, and this is the effect of atmospheric refraction. So, these factors curvature and refraction probe and changing atmospheric conditions may bring some changes as depicted here; otherwise we may get analysis something like this. So, actually that analysis should not have been like this for view shed this should have been like this in this one.

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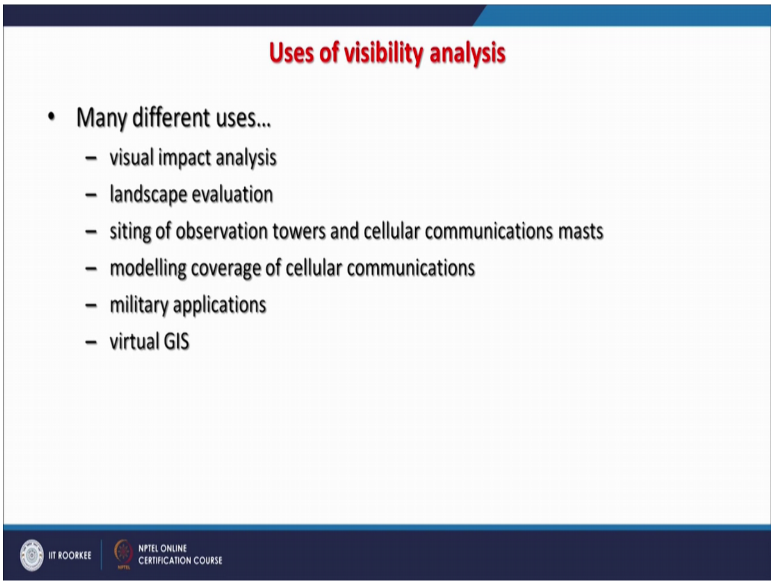

Now what are the applications of visibility analysis. There are various applications when mainly for observations or locations one can use that for visual impact analysis. Somebody is going to construct a tower or building or something and before that they would like to see that how much part of a valley or hill would be visible from top of that building or from the window of different floors, they can analyze. Also when somebody is constructing these observation towers maybe in a forest area or maybe in a mining area or for security purposes or for telecommunication then this view shed analysis can play very important role. These mobile operators nowadays are using view shed analysis to see the level of signals which would be available in the target locations.

Also we can involve in landscape evaluation that how things are visible, and they can be organized. And this also as I have just mentioned the sighting of observation towers where the which is going to be the best location for such towers of cellular communication must or towers that can be done. And we can model these coverage of cellular communications or mainly mobile communications. Of course, military applications are there I have given the example and related with missiles and other things, where these corrections or errors have to been taken care especially curvature of the earth and refraction and changing atmospheric conditions if that much data is available.

Then live analysis can also be done. And virtual GIS also where this flight simulators and other things are done where also in those analysis the visibility analysis is going to be very important. This virtual GIS was developed on war footings when we had this Kargil war. And a digital elevation models were employed and top of that then latest satellite images were trapped and then pilot were trained before they were dispatched for the site, so that this virtual gis can help and also in that one this view shed in all these things. And this is not a exhaustive list. So, there can be many more applications of visibility or view shed analysis [noise.

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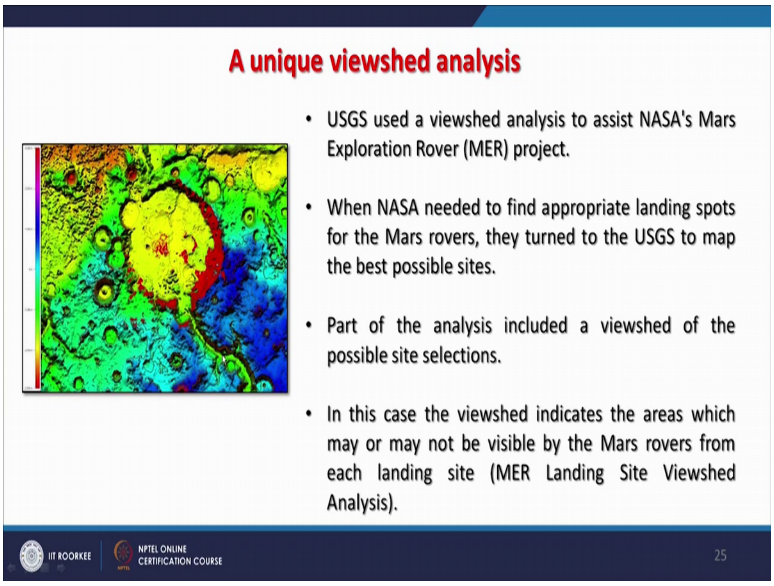

And this is one of the examples of how view shed analysis in on Mars it has been done, because human cannot reach. So, when somebody or some equipment is being sent, so we one would like to assess what would be the view shed or for that equipment. So, this Mars exploration rover MER project and this USGS used a view shed analysis to assist this Mars explorer that when it lands on the surface of the Mars which area would be visible which will not be visible and how it will be doing the exploration part. So, that that was done in advance. Because digital elevation model of mars was available, so view shed analysis could be done.

And when this we want to find out what NASA wanted to find out the appropriate landing spots for mars rovers they turned to the USGS map for the best possible sites basically the USGS maps of Mars. And part of analysis included a view shed of possible site selections and in this case the view shed indicates the areas which may not be visible for Mars rovers from each landing site. So, different sites were evaluated and the most appropriate site was finally, then selected for landing of this Mars explorer rover.

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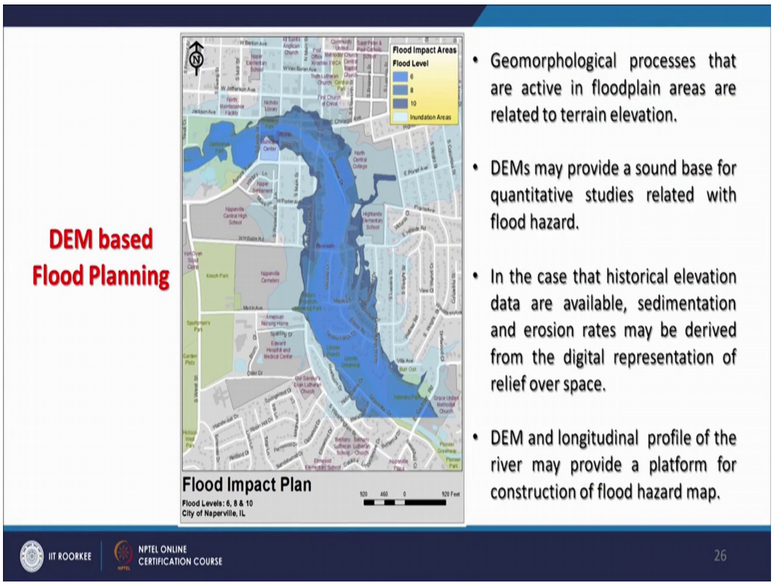

Now, in the last very briefly I will touch how digital elevation model can be used for flood hazard monitoring planning and other things. As you know that digital elevation model is representing the undulations of a terrain. So, along a floodplain of river that they can also be utilized it can be simulated and that if water level in a river goes to this level then how much area would be inundated, this kind of simulation I have we have discussed when I was discussing dam simulation. So, almost the same tools can be used along river valley or across a flood plain. And we can instead of assuming dam, we can assume a water level and then we can simulate or model that how flooding would occur if water level in a river goes like this.

So, this is the one of that example here and given that this is purely DEM based flood monitoring or flood planning rather that this geomorphological processes that are directive in floodplain areas are as you know that related with the terrain especially fluvial geomorphology I am talking. And the DEMs are the most suitable data for such kind of analysis. And we can perform not only the qualitative, but quantitative analysis that where exactly the area which areas would be inundated how much water would be there and so on and so forth.

And historical elevation data if are available then sedimentation and erosion rates may also be derived from digital representation of relief over a space. So, if a if a flood has happened in past, we want to estimate that how much you know sediments fluvial sediments it has created, how much erosion was there what was the rate probably these things can also be calculated. But for which probably we may be requiring several successive digital elevation models maybe in time series.

So, this longitudinal profiles can also be drawn and cross profiles can also be drawn any plan views of a through a digital elevation model of an underrated area can also be drawn. So, this DEMs can really help not only for the view shed analysis of different types as we have discussed, but also related with the flood hazard monitoring planning and you know similar kind of studies where terrain data is involved. So, this brings to the end of this discussion.

Thank you very much.