Geographic Information Systems
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Lecture-42
Integration of DEMs with Satellite Data

Hello everyone! and welcome to a new discussion which we are going to do today on Integration of DEM's with satellite data. Because as you know that though DEM and satellite data, both are raster and as DEM is a you know, storehouse of information or several derivatives which we can drive which we would be saying in subsequent lectures. And satellites data are also a storehouse of lot of information and depending on what area you are going to cover; how much area you are going to cover and spatial resolution you are going to cover?

All kind of choices are available. And nowadays you know 10's or 100's of products based on satellite data are also available. One of the most popular satellite data products is DEM itself. So therefore, we need to integrate many times satellite data with DEM to see things in 3D perspective or you know make a representation of the Terrain in more realistic manner rather than a bear digital elevation model. So, from that point of view the exaggeration is very much required.

Both are raster except you know one major difference and that is the value of this cell value or pixel value which is a differently otherwise both are raster. And therefore, many times or most of the time I would say, the Integration of DEM with satellite data is rather easy. But it is very important because satellite data through this Remote Sensing technology is really providing lot of products or which we can ourselves also generate and can use in our GIS platform.

In the demonstration which will follow after this discussion. I am going to also demonstrate how you can handle satellite data quite easily on a GIS platform. And the platform which I am using for demonstration you know, is ArcGIS. That never means that I am promoting that one but that is the platform which I am using. You can try the same thing or same steps which I had been

demonstrating on this software like on QGIS and GIS other products. So, only you what you have to understand here is I am only discussing the generic form of GIS and for demonstration, I am using one of the platforms of GIS.

At your end if you do not have ArcGIS that does not mean that you cannot work. You can equally work or sometimes even better than what this software provides. So, there is no issue about this and only thing that tools are there. You have to find many times your own way to maneuver within that, select an appropriate tool and do the processing.

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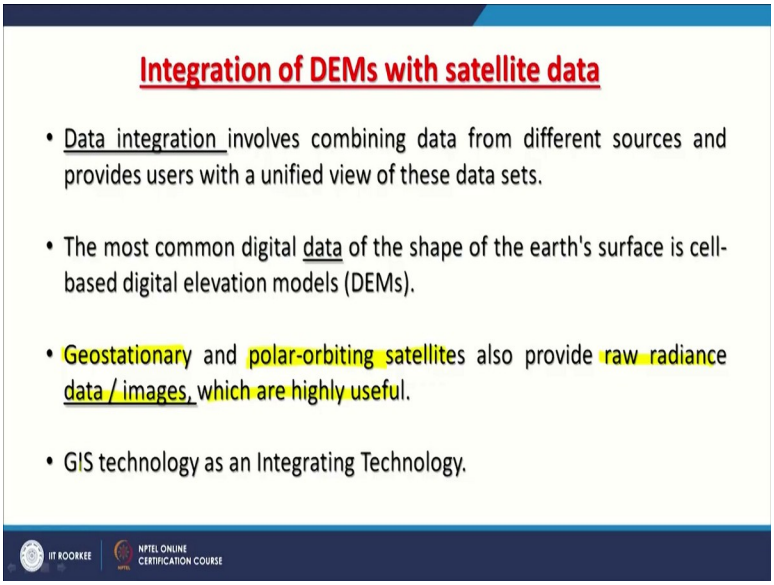

Now why this satellite data integration? Basically, as you know that data integration involves basically combining various data coming from variety of sources. As per our definition of GIS also that here the data comes from variety of sources. And then we would like to integrate them so that a combined product which we can generate using this DEM and satellite data, can be very-2 useful and people are doing on a regular basis by combining these datasets.

The most common as you know the digital data form that is the shapes of the Earth is cell-based elevation model which is there. One of the examples of data integration specially particularly with DEM's satellite data is the Google Earth which is in the background having digital elevation model and for you know draping, they are using the satellite data of various resolutions, depending how zooming you are doing.

So, when you zoom in then that means you are going for higher and higher spatial resolution data. When you zoom out then you may be seeing a relatively lower spatial resolution data. Further as you know that in case of Remote sensing, various satellites are there. Most common one is this polar orbiting or this sun synchronous satellite like that series started with LANDSAT, our own IRS or SPOT or even NOAA AVHRR; NOAA series of satellites and MODIS satellite and there are many such satellite which are polar orbiting satellite.

So typical Remote Sensing is done with polar orbiting satellite but as you know that this technology has improved vary significantly in last two decades and therefore now like a geostationary satellite also can provide very good images or data source, though they are snapshots. For example, if I give example of INSAT series of Indian geostationary satellite. So earlier, they only meant for communication. Now, they are also having very high-resolution digital camera which can cover the entire India and subcontinent in just 1 snapshot.

And also, these geostationary platforms are being used for various purposes. Even these geostationary satellites are now being employed for navigation purpose. So, this IRNSS which is Indian satellite system or in short, we say NAVIC; that Indian regional satellite navigation system NAVIC which we are using these geostationary satellites for navigation purpose also. These are basically multipurpose satellite, mainly geostationary satellites

Whereas polar orbiting satellites are mainly having only one agenda and that is acquiring images relatively at higher resolution. So, these satellites basically provide the raw data or raw radiance images and which we make use of them and nowadays you know 10's of satellites of different countries are in orbit. Many data especially, relatively, comparatively coarse resolution data or medium resolution data say up to even 15-meter or 12.5-meter, it is available free of cost and upward definitely.

But if you go for 5-meter resolution data then probably you have to pay money. So, I always say to my students in IIT Roorkee that start using whatever available free of cost and try to exploit that one. There is other hidden advantage with using this raw data is that if you to claim anything

and later on somebody would like to check how you have used that thing and which data you have used so they too can perform the similar or identical analysis at their platforms.

But if data is not free then people cannot compare or check on your products. So, that is the advantage of also using satellite data. You provide sort of a challenge that I have done like this. If you want to do it, follow these steps. Data is available free of cost, do it yourself. So that is another very good part of free dataset. Now as you know that GIS is a platform basically which provides the tools technology to integrate various types of data which is coming from variety of sources.

Not only the vector data but raster data like satellite image. So, it is a wonderful platform from Data integration point of view and of course analysis and finally at the end of the day, one always tries to go for modelling or prediction.

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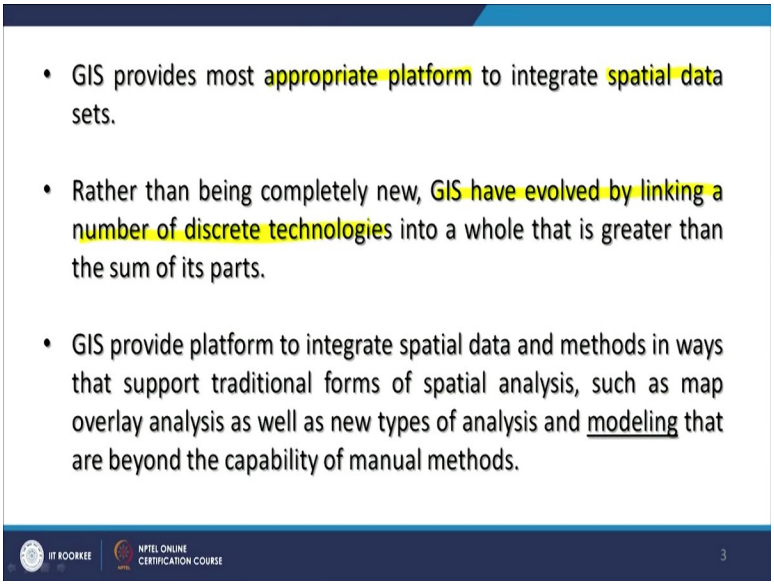

So, this is the most appropriate platform for integrating especially this is spatial data. And GIS has as you know has evolved by linking number of discrete technologies which we are relying in isolation. And I can give name of the technologies like digital image processing, like CADCAM Technologies or many-2 mathematical concept which were there. But GIS has started incorporating it and this is how it is progressing or this is how it is evolving.

So, when we employ all these technologies; whatever is available best in other domains and if it is useful in GIS purposes then people are integrating this technology. So, this technology in every day, it is becoming enrich with other technologies or discrete technology, we are not integrated earlier. As you know, we have just discussed that GIS provides platform to integrate spatial data and methods.

Because this is what I was just mentioning about methods, algorithms, concepts which are in the domains especially like mathematical or computer science domain, are being incorporated integrated into the GIS and which will provide ultimately the batter spatial analysis and you can generate maps, different kind of overlays and new types of analysis also becomes possible and ultimately than you go for modelling, that is beyond the capabilities of other methods, other manual methods or any other Platform.

GIS is the only platform which can provide modelling for spatial data, that is the unique thing about this thing. I have already mentioned that like Google Earth is one of the best free satellite models of the earth breaches which is the unique platform. Not only it is integrating digital elevation model and satellite images but various other datasets. But the major one are these two digital elevation model and Satellite data.

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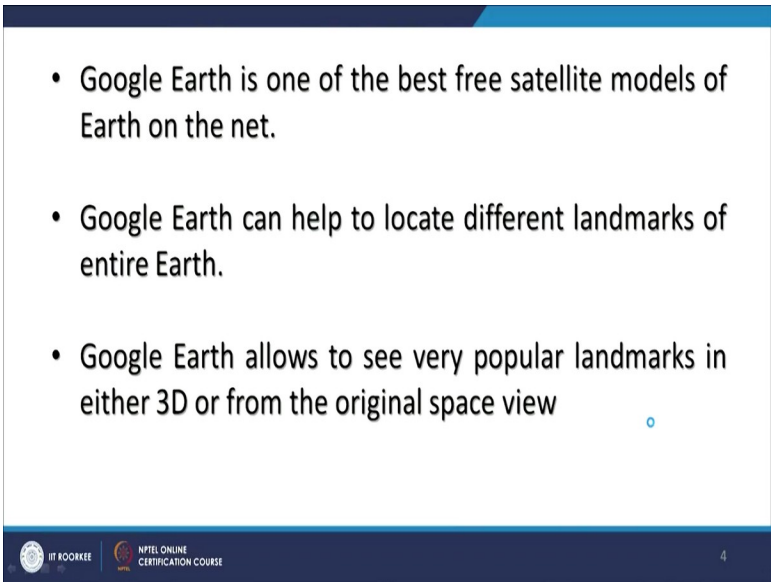

Using Google Earth, people always look for different landmarks which are present on the surface of earth. And for entire Earth, you can study sitting in front of your system. So, Google Earth also allows to see very popular landmarks in either 3D. And this 3D is nothing but it is coming through the integration of digital elevation model with satellite data. So, this 3D perspective view or fly through view which you get on Google Earth, is a beautiful example on data integration and that is DEM and satellite data integration.

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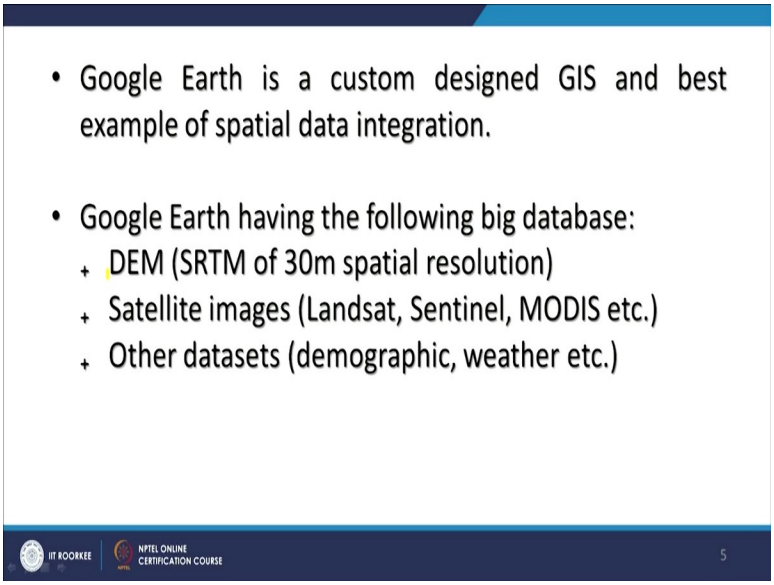

Now Google Earth is no issue, a custom designed GIS product and it is mainly meant for spatial data integration. Google Earth is in the background, it is having SRTM 30-meter spatial resolution data. And top of this, you see the satellite images of various satellites, Landsat. All images are free. Sentinel images, these are also free. Modis images are also free. So, it's a platform basically which has integrated DEM with satellite data for entire globe in order to study landmarks or many-2 studies are now coming there.

Even school children have started using Google Earth in there in Civics or Geography classes. And many other datasets have been integrated or you yourself can integrate by converting them to KML or KMZ file, through even any GIS standard software. So, you can see the demographic. You can see the weather, even earthquake data. Latest Earthquake data are also plotted automatically if you would like to see. Road network, Rail Network; all this information. Whatever the information which you see on Google Map, can also be seen on Google Earth.

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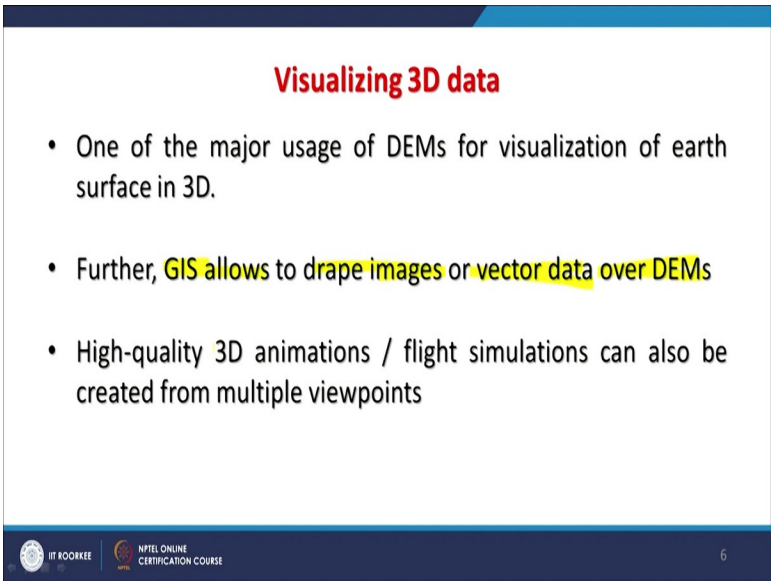

Now main purpose of integrating digital elevation model with satellite data is to have 3D perspective view because a bare DEM without features of the ground cannot give you the full feeling of the terrain. So, for that purpose, we always go for integration with satellite data; this DEM. And our GIS platform allows to drape these images like in Google Earth, Landsat and Sentinel images or even you can drape the vector data like locations or earthquake locations or city locations or demographic data or any other such dataset and over the DEM.

DEM is always in the background of Google Earth. And this high-quality 3D animations which are being created may be on Google or may on GIS platform or some other platform but in the background, they are having a digital elevation model. And for draping, you may have a satellite image. You may have if it is 3D animation of an animal then you can have a skin as an image and you know beautiful 3D perspective view can be created here.

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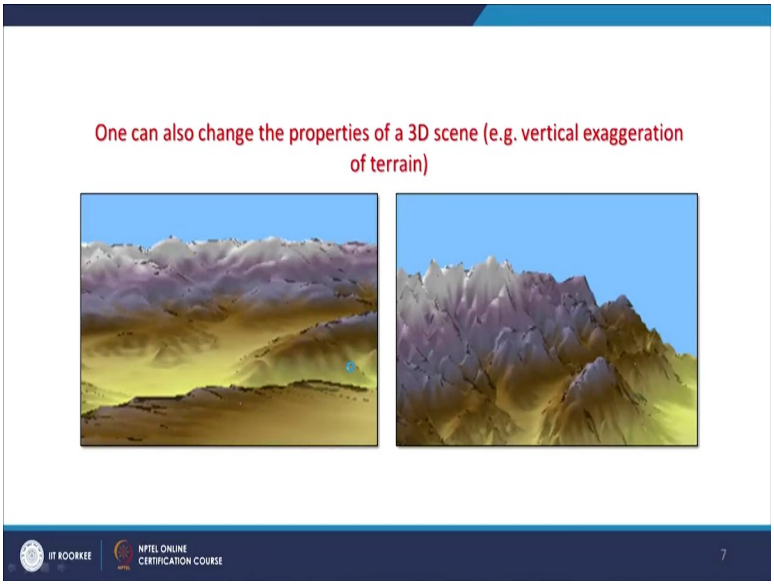

We see one example of 3D scenes and how this can be used. Another advantage of involving computers is that we can increase the vertical integration of the Terrain, that means that we can increase the skill for vertical compare to horizontal because if we keep the same scale for horizontal and vertical, we may see something terrain like this. But when we increase the vertical integration that means I want to exaggerate the z scale compared to my x, y scale then you may see terrain like this.

It depends for what you are going to use it. One has to be very careful while increasing this vertical exaggeration because it is not giving the real picture. It is exaggerating things as name also says, exaggerating. In Google Earth also, you can exaggerate that means vertical exaggerating, you can introduce and can see. So, this is very-2 useful. If you are going in a flat terrain like in a desert area or in an Indo Gangetic Plains and still you are looking for the undulations or ruggedness in the topography or whatever the ridges or valleys or depression then vertical integration can really work very well for flat areas, plain areas or desert areas, snow covered areas.

But doing a vertical integration for already highly rugged terrain like Himalaya may not give you a great help, though it may bring some confusion. So, one has to be very choosy judicious while going for vertical integration.

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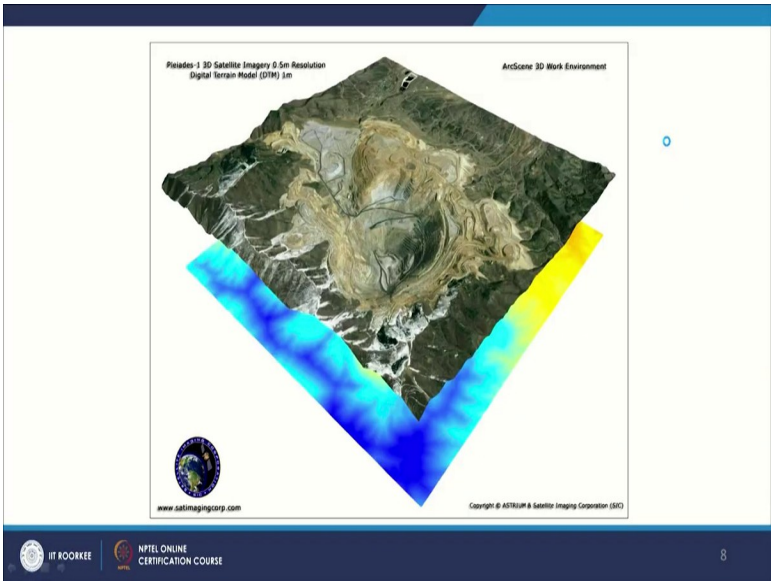

This is one of the examples of you know like in the background, what you are seeing a digital elevation model and top of this, you are saying a satellite image and a 3D perspective view of a terrain is being presented here. This is very high-resolution data provided by the satellite that is Pleiades. And this is being used for urban mapping and other things, especially for creating 3D. So, this is especially in launch for that purpose where you can have a very-2 high resolution digital elevation model of 0.5-meter. Earlier, it was never thought but now it is possible to do it with satellite images.

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Now, this example is from Google Earth as you can also see here and this is 3D perspective view. When you tilt that one image or the symbol which is on the top right corner generally in

Google Earth, you can see a 3D perspective view. You can rotate or you can tilt or whatever you want. And this is what the Haridwar looks in 3D perspective view and the surrounding area in Uttarakhand. So, if I want to see, like this view is basically looking from South towards north.

But if I want to change my perspective view say from east from west direction still, I can see very well. Now why to prepare the 3D perspective view by using our own data sets on GIS platform or use these Google Earth platforms for 3D perspective. The purpose here main is to study the terrain; landforms of the Terrain, characteristics of the terrain and get a feeling of the terrain if I am going to visit that area.

For example, here geologists will see completely different way. A civil engineer will see this 3D perspective view in a completely different way. A new person who is interested for climbing and Mountaineering or other things, they will look at differently. So, the same perspective view, same 3D view can be used differently by different people. Geologist will try to interpret from structural point of view or from stratigraphic point of view that how rocks are oriented and is there any fault? Like I know that there is a Ganga tear fault which goes roughly north south.

And it has broken the Shivalik Hills which you are seeing here and has allowed Ganga to flow in between. So, depending on what somebody is looking. If civil engineer has to find a place where new bridge can be constructed. So, without basically or before going on the ground, a study can be done initially for feasibility purposes or feasibility study can be done using whatever available like a Google Earth.

And once you have broad identified location then a detailed view can be generated with high spatial resolution and high digital elevation models for that particular area where further study can be done. So, for detailed project report of DPR ground survey may be required or this new satellite data like Pleiades can be used because it provides a 0.5-meter resolution. So, in that way, data can be used but initial or feasibility study can very well do based on 3D perspective views available on Google Earth and this is what people do.

A pilot will look Google Earth completely differently because he has to take off or land. So, if he is going in a territory where he has never flown, he will try to see the things and 3D perspective or fly through these things, like how he will move and in which direction, at what time, all those things can also be simulated using Google.

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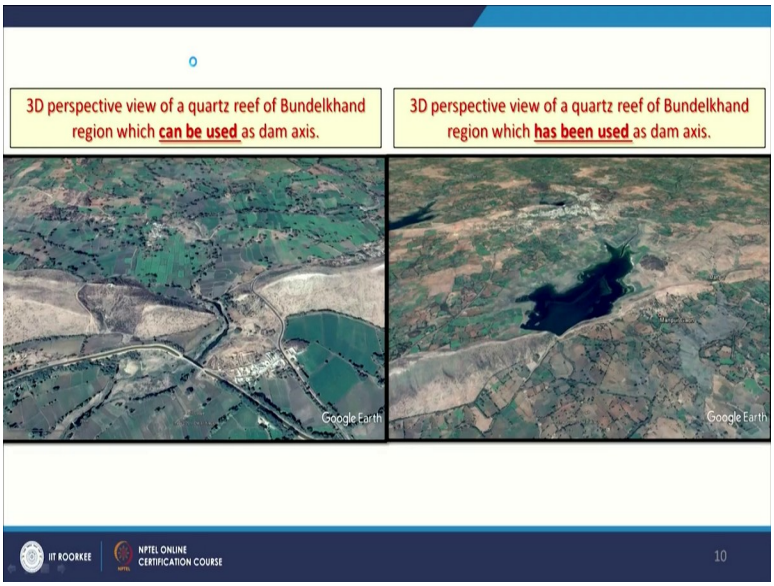

Another like if I am interested from groundwater recharge point of view then I would use this data little differently. Because let me give you some interpretation about these images, though it is 3D perspective view but still. This is what you are seeing is the quartz reef. These are made of basically mineral which is known as quartz. Now from here, one river stream is going like this.

So, if I am looking a suitable site to construct a Reservoir for groundwater recharged or surface storage then this side, I would say definitely very good because I am already having abutment on the both sides; natural abutment created by the nature. So only thing I have to block this path and then I can definitely use that one. So here let me try again with a different colour like here, what I am saying. This is the ridge and this ridge is continuing.

So, if I block here on the ground then I can store this water in upstream side like here which is shown here. So earlier people must either used the toposheets or other things but now we can employ satellite images to exploit these quartz reefs which are in hundreds which are running in this larger central India part Bundelkhand region in Northeast, Southwest direction. And if any

drainage line or stream, river which is going across then those can be blocked and can be used for groundwater recharge.

So, my purpose of showing all these is that these 3D perspective view which is coming through the data integration of DEM in satellite images can be used by different people for different purposes. So, one or two purposes, I have shown in the previous image of Haridwar. Here the purpose is completely different. Because once you have integrated one thing or another, you can integrate with other datasets also.

It is not necessary that only you would be integrating DEM with satellite images. You can integrate one DEM with several satellite images even for change detection, this is the example here.

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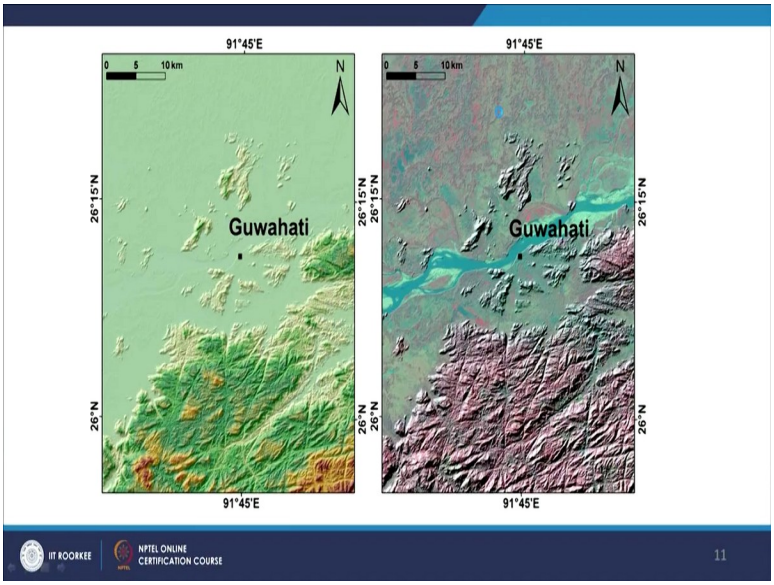

That in time how these things have changed, see here you do not see the river. As I have been saying it's a bare digital elevation model and product is shaded relief model which we would be discussing in subsequent lectures, how to generate. So here, you do not see even the presence of river but if I bring a satellite images, not even creating 3D perspective view; the shadow part I have already brought from digital elevation model.

And if I bring a satellite image with 50% transparency like this, I get both the things without much distortion. See I can do integration. I can create 3D perspective view but if it is not really representing the true ground condition then it may be misleading. So always one should try to remain as close to as the natural conditions. And still perform integration and still exploit those outputs. So, that should be the purpose. Here you are seeing very clearly that this Brahmaputra river is now clearly seen along with whatever the undulation in the southern side of that river is there.

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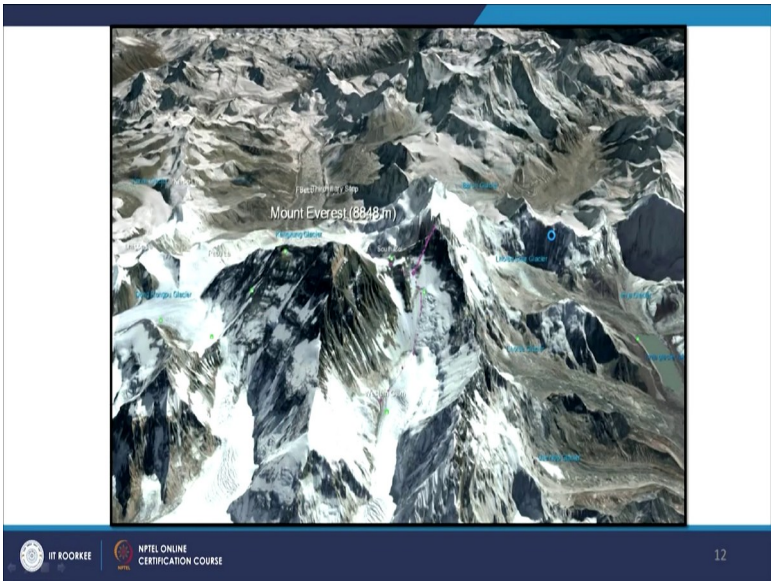

This is glaciated terrain which is highly inaccessible areas of the Himalayan terrain. This example is of course from Mount Everest and climbers; when they go, they always try to see what is the best way to climb and because 3D perspective view is available, they can exaggerate, they can rotate and change the scale and change the view and then plan the things. Of course, for Mount Everest, only two ways are known and established and hundreds of people are climbing.

But somebody is interested may be for lower peaks elsewhere than those things can also be plan by this.

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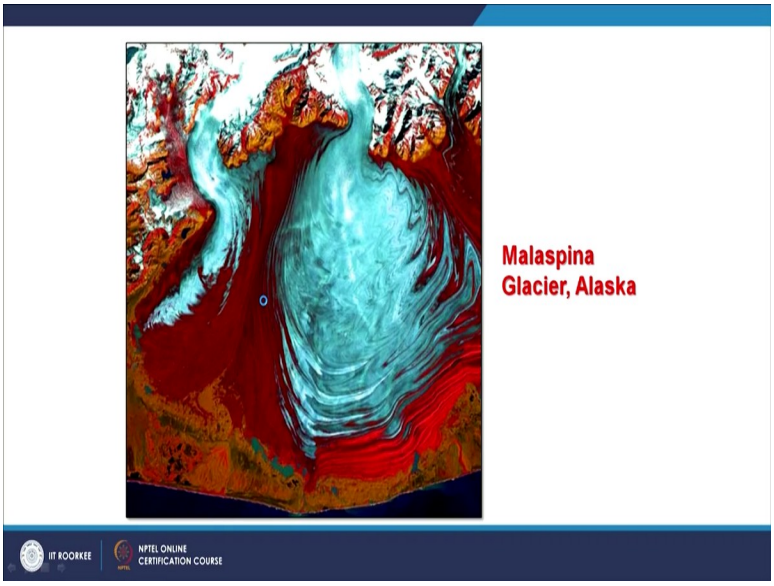

This is a study about the glaciers. How in Glacier study? Very famous glacier of Malaspina, Alaska which is in completely fan shaped as you can see like this, it is fan shaped Glacier. Similar kind of features are not seen in Himalaya. Our Glaciers are more or less either in finger shaped or linear in fashion.

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But this is very unique and this can be also studied through 3D perspective. Real feeling you can get it here about the Glacier and one more which is coming from this direction. So that gives you a real ground feeling even without going on the ground. But if I have to study on the ground then I can plan my field studies initially based on these 3D perspectives. Now another example, I am

having about how one can integrate and can solve a problem which is false topographic perception phenomena.

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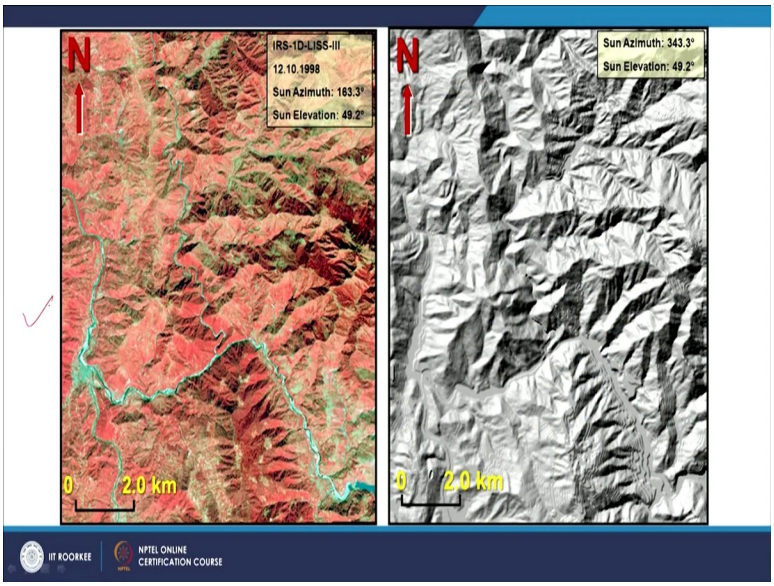

And this is what we have done? Satellite image on the left side is suffering from the false topographic perception phenomena or in short, we say FTPP. And this is a simulated means this is the shaded relief model where the illumination source has been kept in the northwest direction instead of in case of satellite, this illumination sources in the southeast direction. So here, that is why I have used word simulated terrain. So, it is illuminated now from northwest direction rather than southeast direction as happens in case of Polar orbiting or the sun synchronous satellite which we have mentioned earlier.

This is the satellite image of Bhagirathi valley which is a tributary of Ganga and this is from IRS satellite; IRS LISS 1D, sensor name is LISS 3. And you can see that here you may feel that this blue line, River is flowing on the ridge but when you see here without any surface features, you find that this river is flowing in the valley. So, this is basically giving the correct perspective view but this one is not giving perspective view because it is suffering from FTPP.

This problem can also be solved by integrating these things and this is what we have done. So that this product is from digital elevation model so DEM was used here. And of course, the satellite image was also used there.

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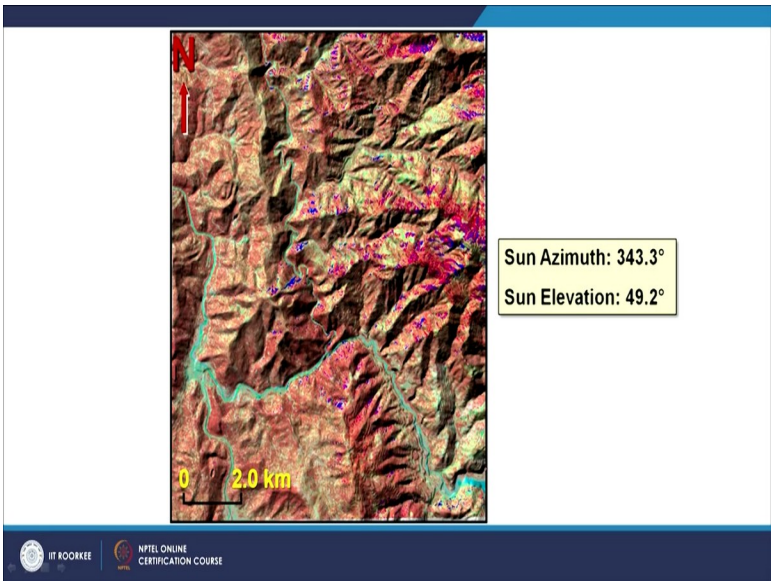

And a new product has been generated which is not suffering from FTPP and the river can be seen as flowing in the valley. So, no false perception, a true perception of Himalayan terrain. So many problems can also be solved by integrating digital elevation model and satellite images. Because using digital elevation models, you can create these shaded relief model or in short, we say SRM or Hillside which can be exploited because here while creating CD relief model, we can choose where my illumination source is going to be.

Like in this case, illumination shows with reference to North is 343.3 degree and sun elevation; that is the height of the sun is 49.2 degree. Because I wanted to get rid of FTPP so I have chosen this which is just180-degree opposite of Sun azimuth here. But if you want to resolve some other or solve some other problems then you may choose any these two angles and can create 3D perspective view like this.

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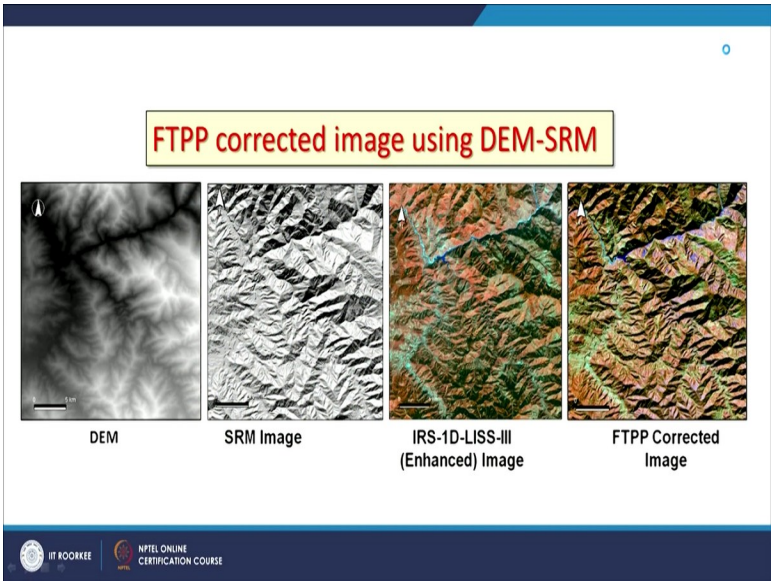

So, this is what you are seeing here. On the first left, you are seeing a digital elevation model which is completely feature less or bare. Then you are seeing is shaded relief model or hill shade so illumination has been added from the northwest Direction. This images of course, suffering from FTPP where illumination sources here. After using this one and this one, a new product has been created where illumination sources here.

Satellite images is here and of course in the background, you are having shaded relief model or digital elevation model. So, a problem can be solved very easily while doing integration in a different way.

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I would also show you an animation where 8 images or 8 simulations have been created and then all had been put in animated form using GIF file creator and what you are seeing this that this white circle is basically showing the illumination direction. And when this white circle is on the northern part or Northern hemisphere, you do not see these false topographic perception phenomena and as soon as it comes in the southern hemisphere, you start seeing that river is flowing on the ridge, that means it is suffering from FTPP.

So not only you can solve the problem but you can convince using search simulated animations. One more I am having where instead of changing the illumination direction, I have change the

illumination source height. That means from Horizon, 5 degree to 90 degree because this is how the sun moves in daytime also. So, it rises in the east and then it goes slowly over the horizon and in the noon generally, it goes overhead.

So, this is what it is simulated here that when sun is overhead, your terrain is having maximum brightness and when sun is close to horizon, you are having big shadow, especially in mountainous Terrain and this is how you see.

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Further from false topographic perception point of view, when you are having large shadow, you are having much more depth perception. When shadows are small especially in the noon time, you are having less depth perceptions.

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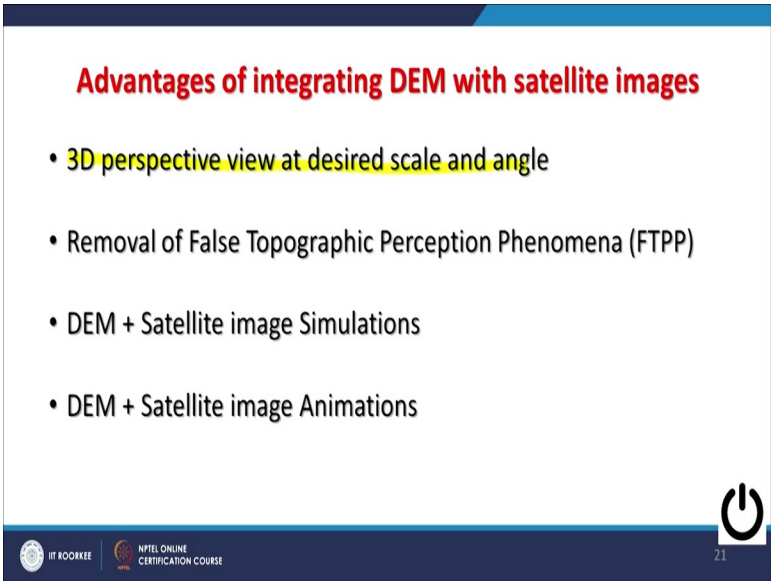

So, what are the advantages? Many of advantages we have seen in between but in nutshell, the advantages that you can create the 3D perspective view at desired scale and angle using GIS platform. Or if you do not want to much processing and other thing, initially you can start for feasibility study, your Google Earth and later on then you can move further. Removal of false topographic perception phenomena, I have already discussed with you.

And DEM and satellite image simulations are possible. DEM and satellite image animation are possible. So, lot of other applications which I have not listed here are there, of using the DEM and satellite images in integrated manner. So new application, new advantages, we would be seeing in future also because lot of digital elevation models of various resolutions are available. Many of them are free of cost, similarly with the satellite images.

And therefore, this integration is happening on various GIS platforms or some custom designed GIS products like Google Earth. So, with this I end this discussion. Thank you very much.