REMOTE SENSING FOR NATURAL HAZARD STUDIES

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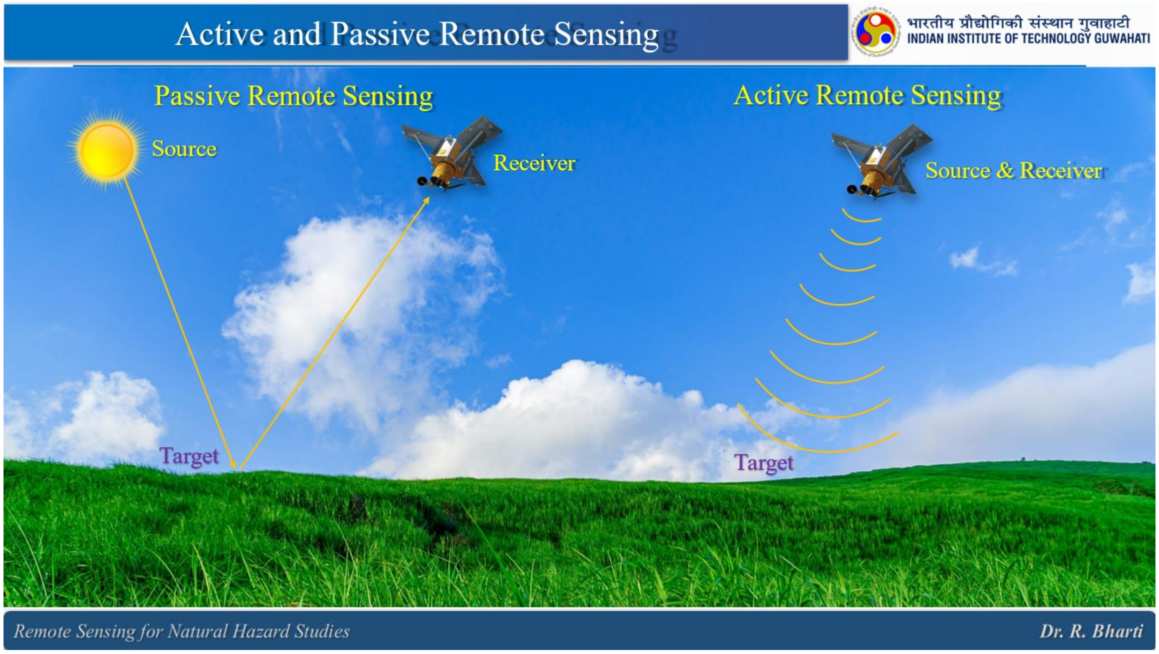
Lec 12a: Potential of Remote Sensing and GIS in Hazard Studies: Overview -Part A

Hello everyone, welcome to Lecture 12. Today, we will talk about the application potential of remote sensing in different natural hazard studies. So, this is from Module 4, and to start, let us begin with the basics of remote sensing.

So that you will be able to understand what exactly I mean to convey, and how remote sensing has proven to be a very important source of information in natural hazard studies. So, let's start with the basics of digital images. So, you can see that these and this are both different from each other. Though both of them are showing the time, these wall clocks are sketched, and this has been captured using a camera. So, such images are captured by the electro-optical sensors, and once you have these images with you, you can import them into your system, and then you can try zooming in. Once you zoom in, you will find that there are small check boxes in that particular image. These check boxes are nothing but the size of a pixel, which represents a certain area on the ground. So, these are called pixels, and these pixels have associated values that are reflected from the target or from that particular area, and that is being stored. So, we call them digital numbers. So, if you import any given image into your system in some programming language, you will find this kind of matrix. So, all these values are nothing but your digital number. So, these digital number can be further interpreted and to extract the information required in your study. So, here you can see the kind of setup we have to measure the images or acquire the images from space or from the airborne platform and this is one of the examples where continuous monitoring or the continuously acquired images can be used together to see how a particular glacier is moving. So, the digital images captured by satellites are widely used in various applications. So, another example is land use land cover (LULC). So, these are popular and required in many of the applications across the discipline. So, when we talk about remote sensing, we have two major types: one is active, and the other is passive.

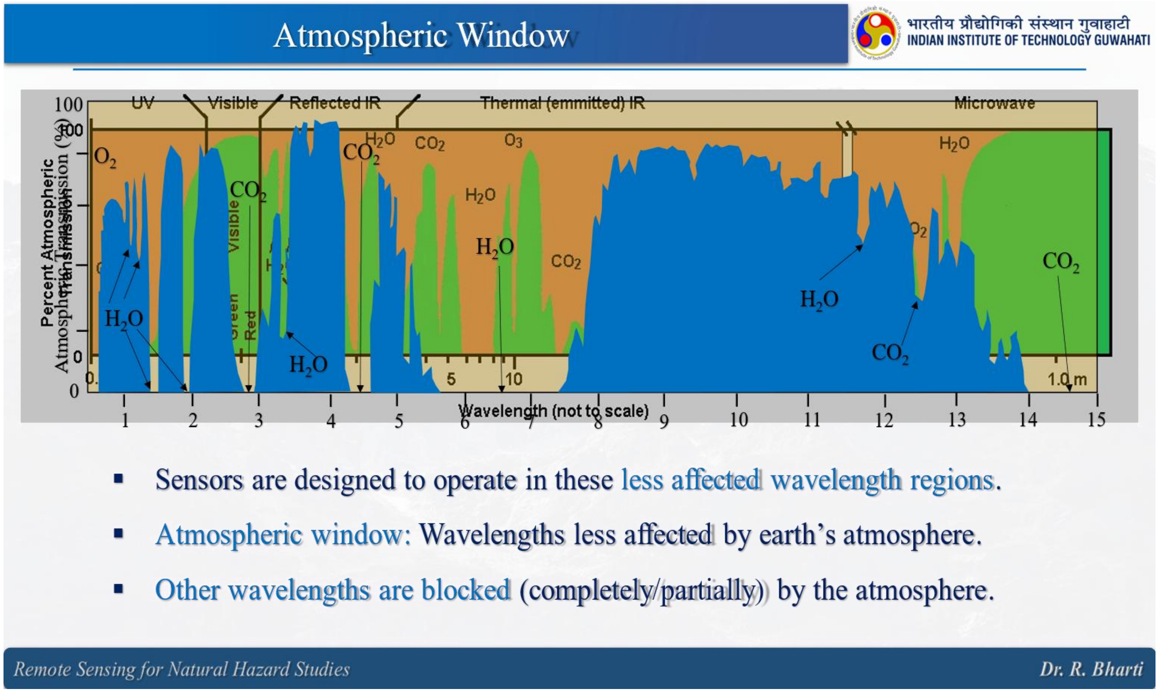


So here you see this is an example of passive remote sensing, and here you have the sun as the source, and you have a receiver. So, we are dependent on the solar radiation. In such cases, we call it passive remote sensing. However, when we say active remote sensing, the sensor itself has a source of energy, and it can illuminate the target, and in the same way, the signal will reach the sensor, and it will also measure it. So, both the source and the receiver are available here.

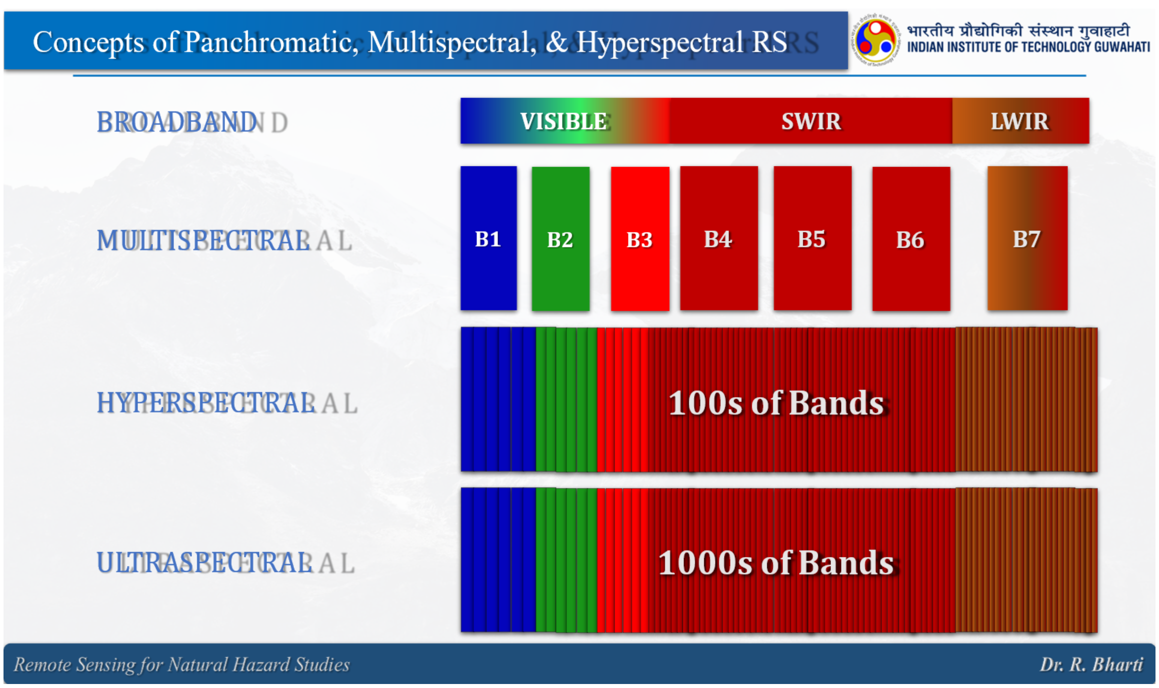
So, in such cases, we are calling it active remote sensing. These are the different examples of images that are acquired from the remote sensing datasets. These are the different images captured by various methods. So, some of them are DSLRs, some of them are satellite images, but both of them have digital images. But you see the different modes of acquisition. Here, you have a normal camera, a DSLR, or any other camera, but when we talk about satellite images, they look like this. So, here the spacecraft has a sensor that captures images of the given target. So, the space-bound satellites are the carriers of the payload, such as instruments, equipment, or systems designed to perform specific functions or tasks while in orbit, such as communication, observation, or navigation and these are the payloads or the sensors that are attached to these, So, the scientific or technological instrument carried on board a satellite for a specific purpose is termed a payload. So, the payloads are nothing but a bundle of detectors. So, the satellite sensors are instrument-mounted on satellites orbiting Earth or other planets, capturing data across various electromagnetic spectra about the surface and atmosphere, including images, temperature, and other parameters. So, in our study, we are utilizing much of this sensor data to extract information about the target or the environment. So, in particular, when we have this kind of setup, when we have a satellite that is looking at a particular ground, the energy that is going up after the interaction will be captured. So, this satellite has the payloads, and that payload is basically a bundle of detectors.

So, you can see this will look like that and then further, you can see these detectors are arranged in a manner so that they are looking at the ground, and these individual detectors are responsible for generating one pixel of your image. So, the reflected, emitted, or backscattered values will be captured and then arranged in a manner that they will look like or appear as an image, so that you can perceive. So, this is basically this area and then further, if you import them into any programming language, you will see the associated values, and these values are of our interest. These are reflected, emitted, or backscattered energies; further, we will interpret this and then derive the meaningful information for our study. So, with the help of remote sensing instruments, we can generate several images at different wavelengths for the same area. So, that is the major difference between a normal camera and a sensor. So, here we are acquiring several images captured by the same sensor at the same time, utilizing different wavelength regions, and for one particular pixel, we can have all these five values. So, those five values can be plotted here. These can be used to see what the behavior of that particular material is across the wavelength. So, when we say remote sensing from space, we cannot use the entire wavelength range because some of them are partially or fully blocked by the atmospheric constituents.

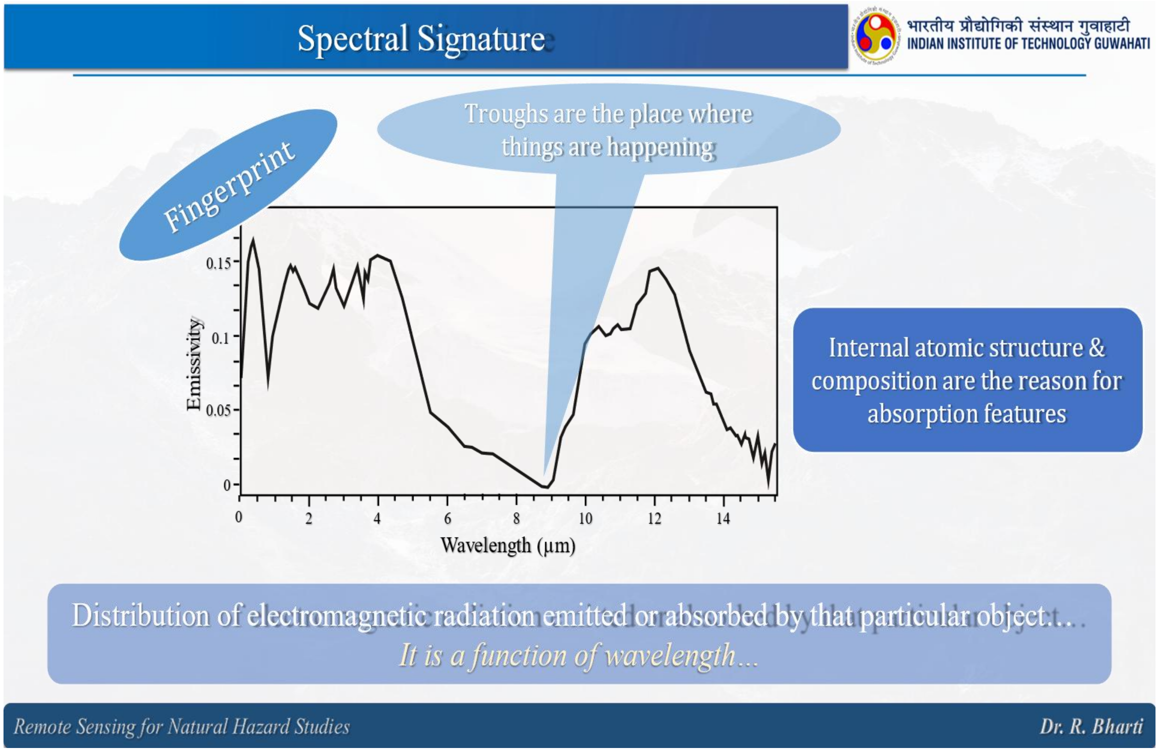
So, here you can see the transmittance of the atmosphere across wavelengths. So, some of the wavelengths are completely blocked only where we have this green color; that is the place where the energy is crossing the atmosphere. So, that is the transmission. So, once we have that, we can easily find out what wavelengths are available for remote sensing from space. So, sensors are designed to operate in these less affected wavelength regions, not in the complete range. So, we will identify this, and we will design our instrument so that it can measure the intensity in this particular wavelength range. So, these are called atmospheric windows, which are less affected by the Earth's atmosphere. Other wavelengths are blocked completely or partially by the atmosphere. So, we cannot have remote sensing. In this particular wavelength.



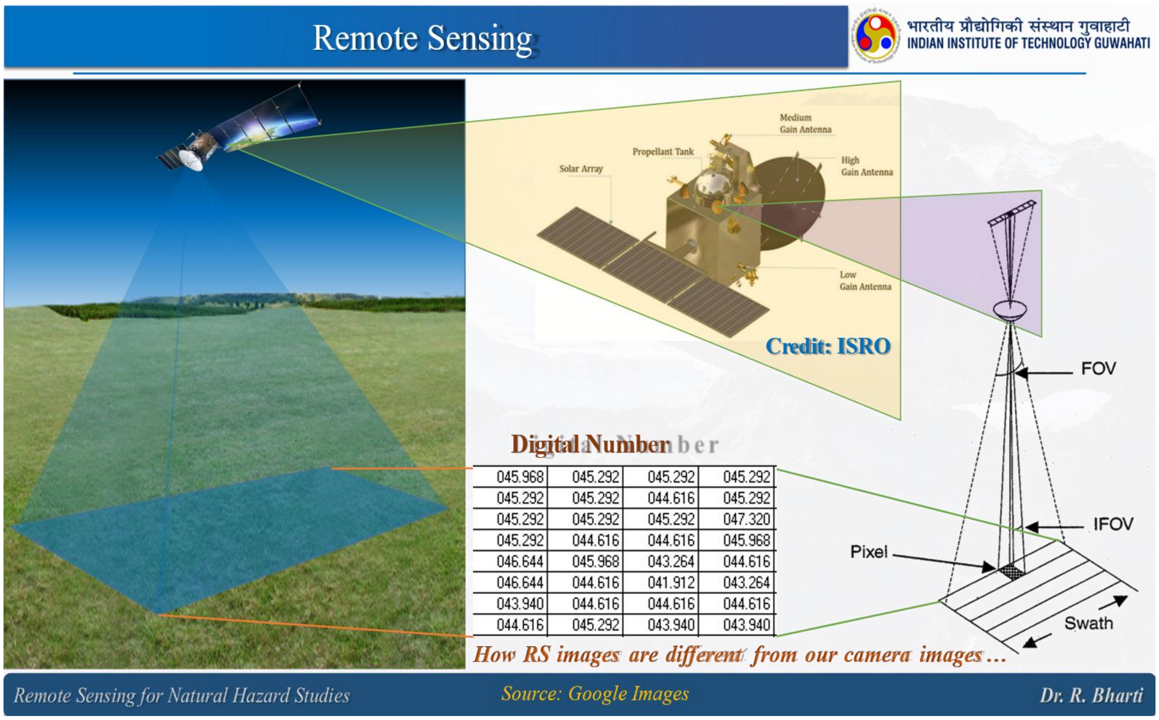
The concepts of panchromatic, multispectral, and hyperspectral are also very important before we see the potential of remote sensing in hazard studies, because based on your basic understanding, you will be able to choose which type of data and what type of data is useful in your study.



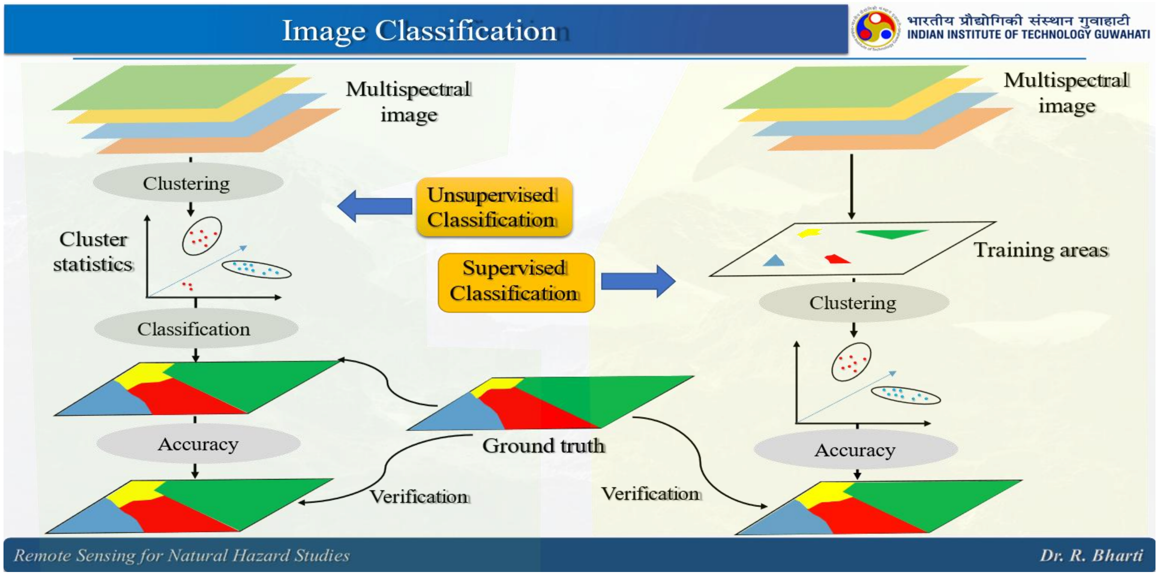
So, when we talk about broadband, we are utilizing this wavelength region where it has high energy.



So, it will definitely become the shorter wavelength. In such cases, you will have very high spatial resolution, but your spectral information will be limited. So, that is why we have multispectral images where we have multiple bands of three or more. So, that will be known as multispectral data. Here, you can have gaps between the first and second bands. Band and these can be utilized to identify the material based on its spectral behavior. Then comes the hyperspectral, where we have the contiguous measurement of the spectral bands, and the bandwidth of each band will be very, very small, on the order of 10 to 20 nm. So that gives you more information about the target across the wavelengths. So, you will have very beautiful spectra, and that will capture the behavior of that material interacting with the electromagnetic wave across the wavelength, Then comes the ultra-spectral, where we expect some sensors to be launched in the future, and we will have finer details about the material properties, So, this kind of spectral signature can be generated using the high spectral resolution data set, where it can be considered a fingerprint. So, the absorption position of a particular material does not change with time and position. So, if the same material you captured in the United States or in India, you will have no difference, So, that is the basis of remote sensing: how remote sensing images are further interpreted to identify material properties. So, the internal atomic structure and composition are the reasons for absorption features, and the troughs are the places where things are happening, and these are unique to a particular material. The distribution of electromagnetic radiation emitted or absorbed by a particular target is a function of wavelengths. So, this is the function of the wavelength. So, from panchromatic to hyperspectral, how is the information changing? How we are utilizing them is explained here. So, when we talk about remote sensing measurement, there is no doubt it is quick and non-destructive in nature; we are not changing the form of the target to measure or collect the information.



So, when we have the panchromatic data, we have high spatial resolution. When we have multispectral data, the spectral resolution is increasing while the spatial resolution is decreasing. When we talk about the hyperspectral data here, the spectral resolution is very high, and the spatial resolution is also managed. So, when we want to conduct qualitative and quantitative studies, we have to use hyperspectral. When we want to conduct a qualitative study, the multispectral method is preferred. When we want to detect the object, activity, or event, and when we want finer detail, such as 20-centimeter or 50-centimeter spatial resolution data, we have to have the panchromatic images. So, what is the purpose of this image acquisition? So, what is the purpose of these remote sensing images? Ultimately, we need to extract the information; for that, we need to have some sort of algorithm that can identify the image classes available within that particular image. So, different classes or maybe different properties can be marked easily; for that, we refer to this image classification method.



So, it helps you assign the pixels of the image to different classes or categories, So, when we have this image classification, we have two different types. The first one is pixel-based, and the other one is object-based.

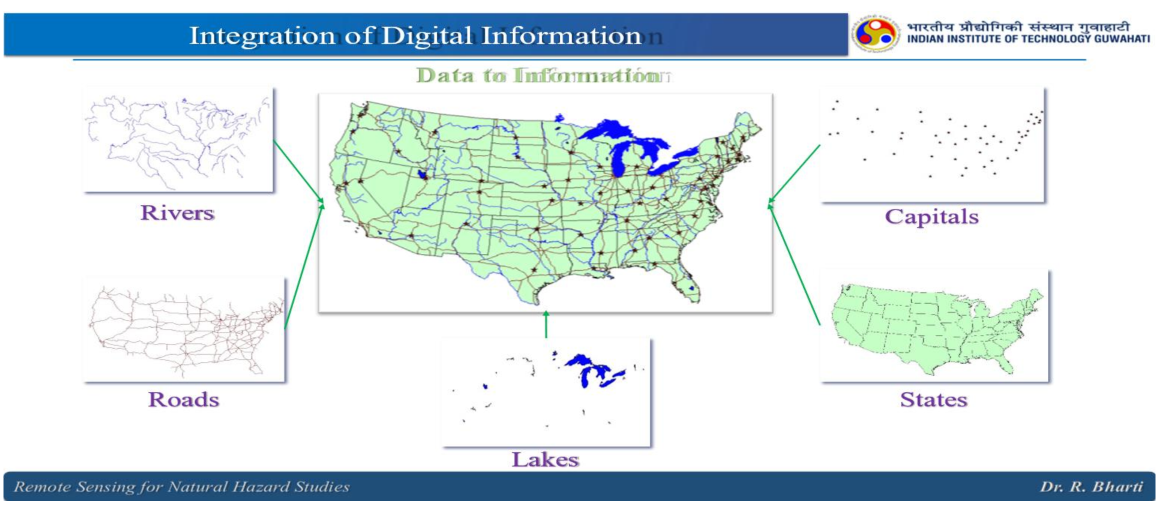
So, the pixel-based methods are preferred when we have medium to coarse resolution data, while the object-based methods are preferred when we have high resolution, especially high spatial resolution datasets. This is the fundamental of how we do image classification. So, we all know that to train the algorithm, we need to provide some sort of information; on that basis, the algorithm will be trained. In another way, the statistical similarities can be estimated at the beginning of the image classification, and further, the machine learning approaches can be used here. To identify different classes or categories.

So, this has been explained to you in a different lecture. So, the remote sensing products are ultimately what we need. So, here are some examples such as slope, aspect, curvature, fault density, drainage density, relative relief, geology of that area, lithology of that area, distance from the road, and TWI. Such information can be estimated or derived from the remote sensing data set and can be used in your study, referring to the data type. What type of data do we require in our analysis? So some of us will have all other data sets in the vector layer or the raster layer that can be used, and the remote sensing products can also be converted into any of these forms.

So, by default, the images are in raster format. But the classified images that can be converted or the information can be converted to vectors where we have the point, line, and polygon and these will be used together to represent the area or the natural surfaces in a better manner. So, here you can see some examples. So, here we have only raster. Here, it is the only vector, but when we want to represent the real world, both should be used together to represent the different boundary conditions of the natural surfaces.

A digital elevation model is one of the very important outputs from the remote sensing data. The digital elevation model provides you with the elevation information of a particular pixel, and this can be estimated using the remote sensing data set. The DEM products, such as slope, aspect, and basin information, are widely used in many applications. These are some of the common digital elevation models that are available in the public domain, and once you have the satellite image and the digital elevation model together, you can proceed with the 3D modeling of a particular area, which will help you understand the impact of a particular disaster located at a higher altitude and what the impact of that disaster downstream can be observed or modeled. So, the space-borne satellite sensors, when we talk about the available data set, include the space-borne satellite data sets that they have captured to date, which are available in the archive, and open up the sky for you to analyze and model a particular event for a given area.

So, the Earth observation technology satellite was launched on 23rd July 1972 and then subsequently, we had a different series of these satellites. So, the Landsat satellite provides the longest continuous global record of the Earth's surface, which is available in the public domain in the archive. So, to date, we have all measurements since 1972. So, these are some examples of space-borne satellite sensors that are available in the public domain. Anyone can register and download the data, and then you can use it in your hazard studies, Now, the geographic information system we have talked about includes the advantages of remote sensing capabilities and how we can interpret them. Now we have to understand bringing the information from different platforms, not only from remote sensing, but also from field investigations; you can bring all the information together in the geographic information system platform, where you can integrate the data and utilize it in different ways. So, these are some of the popular applications of GIS. Now we will try to understand the integration of the data with the help of a GIS platform.



So, here you can see the capital information, state information, lake information, road information, and the river boundary that are available in different files. Unless we combine them together, we will not be able to interpret it. So, here you can see in this particular image we have integrated all the information from different sources to interpret information. So, that can be done in the GIS domain. So, with this, I will end Part 1 of this lecture, and we will continue this in the next part, where we will understand the application potential of remote sensing in natural hazard studies.

Thank you.