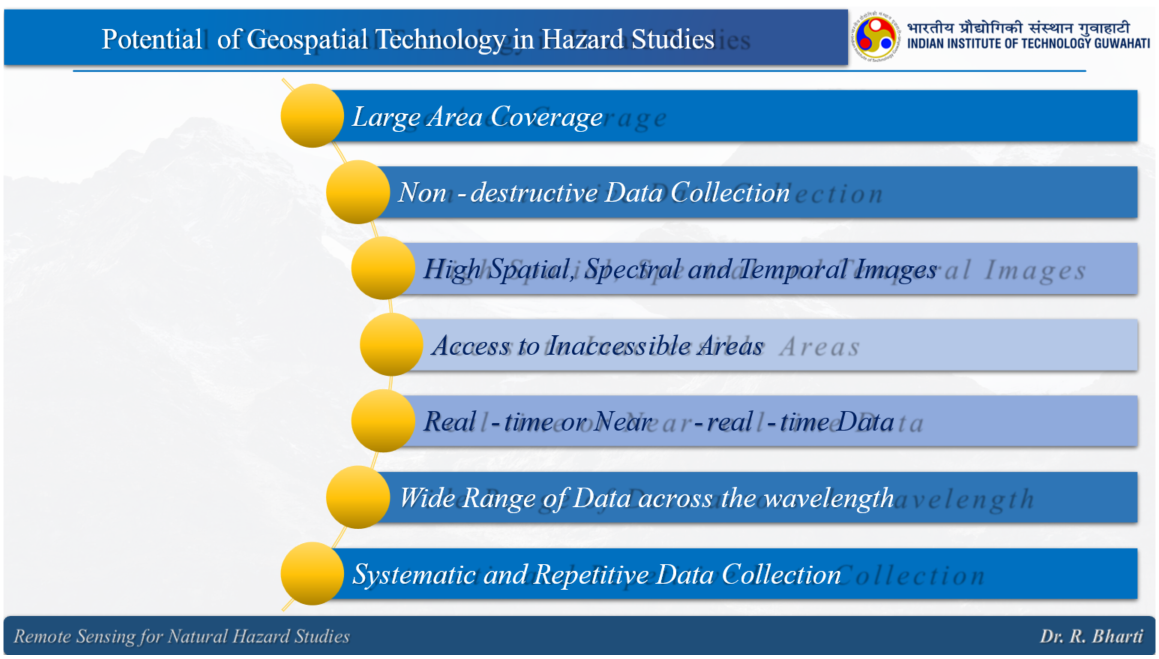
REMOTE SENSING FOR NATURAL HAZARD STUDIES

Course Instructor: Dr. Rishikesh Bharti
Associate Professor
Department of Civil Engineering
Indian Institute of Technology Guwahati
North Guwahati, Guwahati, Assam 781 039, India
e-mail: rbharti@iitg.ac.in
Website: https://fac.iitg.ac.in/rbharti/

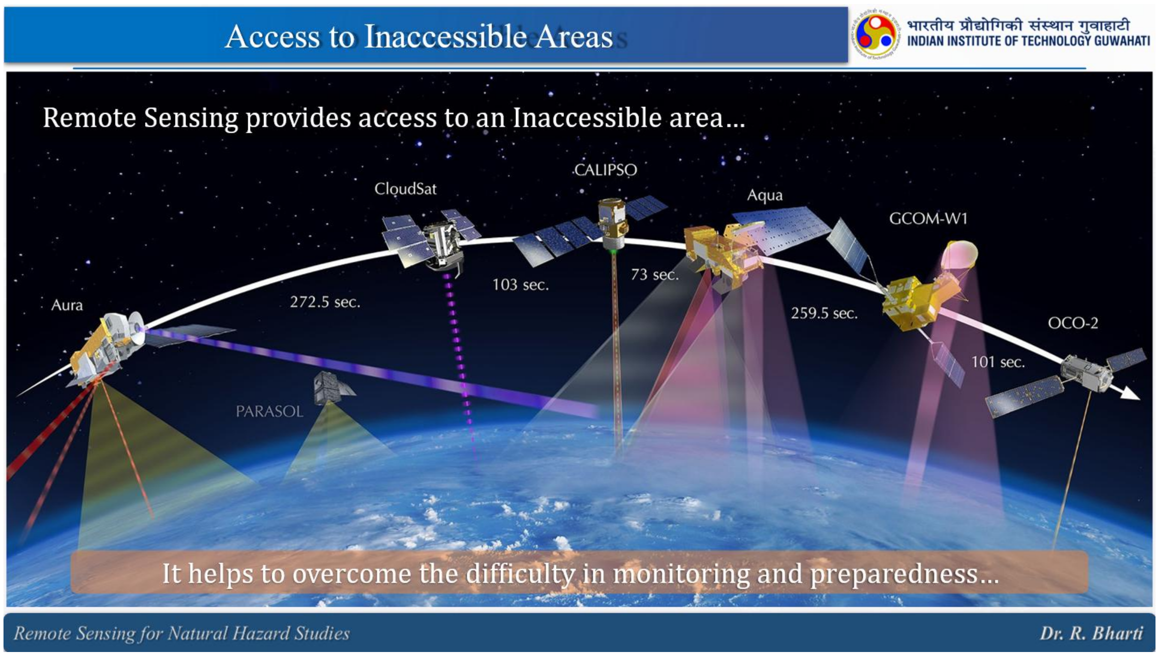
Lec 36: Present and Future Scopes

Hello, everyone. Welcome to Lecture 36. So, today we will talk about the present and future scope of remote sensing in natural hazard studies. So, to understand the present and future scopes, we need to understand the capabilities or advantages of remote sensing as well as the limitations of remote sensing in natural hazard studies. To start with, these are the advantages of remote sensing in natural hazard studies. So, here the first one is the large area of coverage.



So, when we talk about this space-based measurement, our area is comparatively large because the distance between the target and the sensor is great. The second one is the non-destructive data collection. Here, when we try to collect the information using electromagnetic energy, the samples are not disturbed, and they remain in their natural settings. Then come the high spatial, spectral, and temporal images.

So, here we mean the spatial resolution, spectral resolution, and temporal resolution; with the advancement in technology, these are increasing day by day, which has led to more precise information extraction from remote sensing images in terms of the parameters that are required for any natural hazard studies. Then comes access to inaccessible areas, particularly during the hazard or post-hazard; it is very difficult to reach the area. Why? Because the area will have non-accessibility, and some areas are also inaccessible by nature. So, in such a situation, remote sensing plays a very crucial role here in providing the information. And as I said, the real-time or near real-time datasets will be available, which is not possible by any other means, A wide range of data across the wavelength is also available, as depending on the target, the nature of the hazard, the area, and the weather conditions, you can choose whether optical remote sensing datasets or microwave remote sensing datasets are more useful.



So, you need to select wisely which particular wavelength region is more useful in your systematic and repetitive data collection; that is another advantage. So if you refer to any of the satellites, let us say we have the Landsat data series. So, these Landsat series, all the data sets acquired to date, are available in the archive. So, if you want to study the condition of a particular glacial lake in 1980, and what the status is now? You can use the same sensor data provided by different series, and you can analyze the changes for the same wavelength and the same area acquired by the same sensor, but with how the particular area has evolved, which you will be able to analyze because the data format remains the same. So, the hazard-prone areas are difficult to access, particularly during or after a disaster.

This is what we discussed in the last slide. So, it will provide a physical barrier because of the natural hazard. So, rough terrain, dense vegetation, and collapsed infrastructure like roads and bridges, or the hazard itself, will restrict you from reaching the area. Then the safety concern is that it might be too dangerous for rescue teams, aid workers, or even residents to enter or remain in these areas due to ongoing threats. Then comes the infrastructure; remote areas might not have an existing road or transportation network, making them naturally inaccessible. So, in such a situation, what happens is that the area itself becomes inaccessible, and we need to have some information so that we can start the disaster relief. So, the implications of inaccessibility can be understood here: the challenges of disaster response, the increased vulnerability of the population, difficulties in monitoring and preparedness, and then prolonged recovery. So, if there is an area where we do not have any information, it will take more time to respond, and the recovery itself will take more time. Remote sensing provides access to inaccessible areas in terms of information. The remote sensing datasets provide vital information during or after a disaster event, and this information can be interpreted, and then subsequently support can be provided.

When we talk about data collection, particularly in remote sensing, you can see that in any other analysis, you are disturbing the natural setting of the sample. So here we are collecting the samples in gunny bags for this eye score that will be extracted. So we are trying to change the natural settings. But if we want to have the in situ information, that is only possible when we have the remote sensing sensors. So, the data collection through conventional techniques or through any other instruments required disturbing the natural form of the samples.

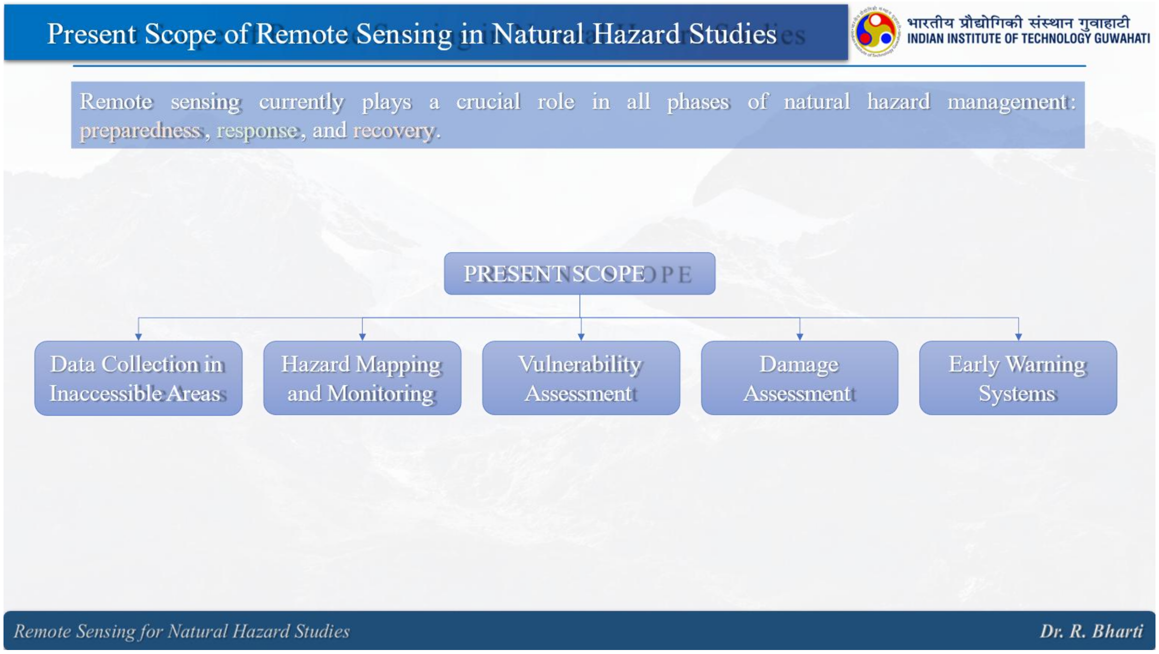
However, remote sensing-based measurements, like spaceborne or airborne, are non-destructive in nature; we are not changing the sample settings. So when we talk about the advantages of advancements in technology, we have high spatial, spectral, and temporal resolution. This is an example where we have used 1988 as our reference image and, with respect to 1988, how the river boundaries changed in 1992, which you can see here with respect to 2002. Then, in 2014, how the river is changing its course can be understood. Similarly, when we have frequent measurements or acquisitions of images for any glacial body, we can use them to measure the velocity, and we can also model this to see how beautifully we can.

Observe the changes, how it is flowing, in which direction it is flowing, and which of the tributaries are providing more input to this. So, those are things we can analyze. So, the consecutive measurements or observations at a specific time interval help to study a phenomenon; it can be any natural hazard. So, when we talk about high spatial resolution, I hope you remember that spatial resolution is the size of the pixel that represents the ground. So, one pixel might represent 10 by 10 meters on the ground, or 30 by 30 meters, or 20 by 20 centimeters.

So, this is called spatial resolution. So, here you can see one example where you have a coarse resolution; you can see a larger object, but subsequently, when you have the improved spatial resolution, you can see how the information is increasing for a particular target. And ultimately, you can also identify a particular object or a particular phenomenon and how it looks on the ground. Similarly, high spectral resolution will provide you with more information to derive or to identify or characterize the material when you have high spectral resolution. So, here you can see that this is basically low spectral resolution all these points are connected, but here, when we talk about hyperspectral remote sensing, we have too many data points across the wavelength that help us identify which particular absorption feature is more evident and which we can use as a characteristic of a particular material, and subsequently we identify the material's characteristics. So, this is known as low spectral resolution; this is high spectral resolution. A wide range of datasets is available through remote sensing sensors, particularly at higher altitudes; the major problem we face is cloud coverage due to bad weather. So, in such situations, we use the microwave remote sensing data because the optical remote sensing data sets will be basically hindered by cloud coverage, as well as other weather parameters. So, optical remote sensing data sets are often difficult to use during disasters due to frequent cloud cover, particularly in high-altitude regions.

But in such a situation, we have the option of using microwave remote sensing data, which becomes a very important source of information, particularly during bad weather conditions. So, real-time or near-real-time data sets available with remote sensing help us identify what has happened during a particular catastrophic event. Natural hazard. So, this is one example from South Lonak Lake. This is another example from the Quick Bird satellite image of tsunami damage.

It was from Sri Lanka, and here you can see this is before the tsunami, how the area looks. Then we have a few minutes before the tsunami; how the waves are generated, you can see here. Then this is during the tsunami; you can see how things are changing. So this is from a quick bird satellite image. This is another example in which we are utilizing the remote sensing datasets for flood studies.



So, how is a particular area susceptible to flooding? That we can study. So, this is the no-flood image; this is another image of the flood, and then we can identify which areas are flooded during a particular flood event. So, this is one of the examples of how satellite images or remote sensing images are used in natural disasters. So, remote sensing currently plays a crucial role in all phases of natural hazard management, including preparedness, response, and recovery. So, the present scope includes data collection in inaccessible areas that we have discussed in detail, hazard mapping, and monitoring.

Then we have vulnerability assessment, then we have damage assessment, and we can also go for early warning system development using remote sensing data input, which will help us save lives and property. So when we talk about data collection in inaccessible areas. So, here we have satellite images, and UAVs are very popular nowadays. So, these are two different types of measurements in remote sensing that are being used. Then comes hazard mapping and monitoring, vulnerability assessment, and damage assessment. Here you can see an example of monitoring. So, here is how South Lonak Lake is changing with time. Then we have the example of glacial lake vulnerability analysis, where we can identify which of the lakes are more or highly vulnerable and which are safe. Here is another example of how a glacial lake is changing and how the retreat is behaving in this particular area. So, this kind of information can be extracted using the remote sensing dataset.

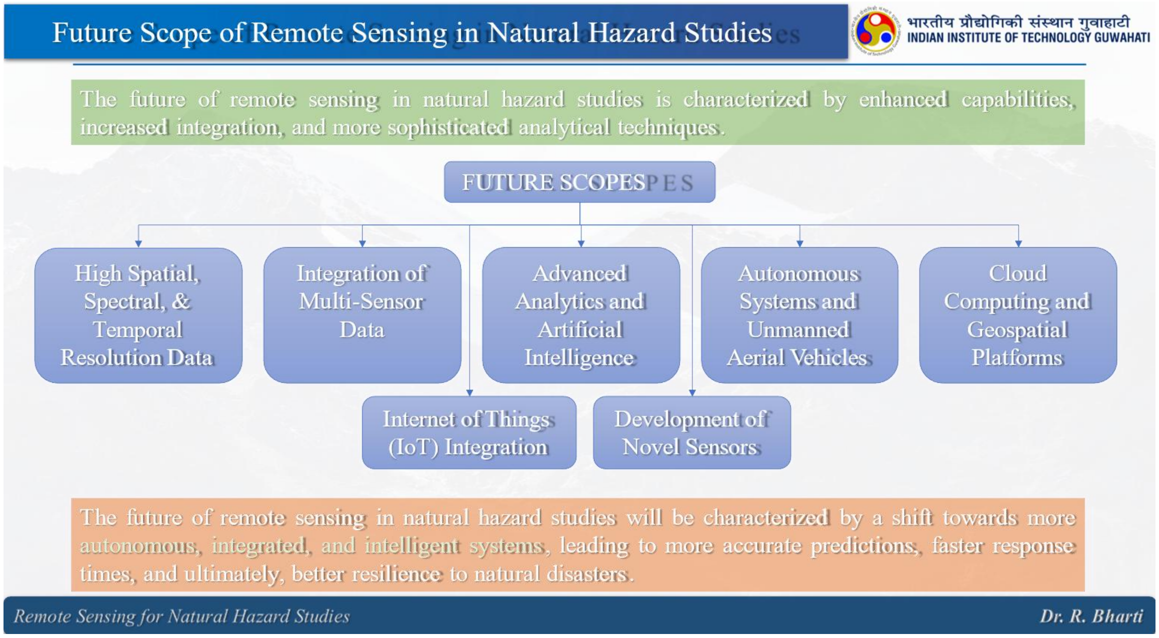
Then, this is another example of a vulnerability assessment. So, which of the areas are highly susceptible to flooding or have low susceptibility? So, this is very low, low, medium, high, and very high. These can be studied; this is another example of damage assessment, where we have an example. This is the damage density; here, you can see the scale and the color. The yellow boundary is for the landslide, the blue is for the water, and the green is for the vegetation.

Now, try to understand what information is available in this particular image. So, the damage density map per unit area of 50 meters is given here. Light color represents a lower probability of damage, while dark color represents a higher probability of damage, as referred to in this particular legend. Green represents vegetation, blue represents water. The black line represents the fault.

So, here you can see this particular black line. So, this kind of analysis can be done, especially for damage assessment. Then, for the early warning system, I have covered this in detail in some of the lectures. When we talk about the early warning system, there should be monitoring and prediction, then communicating alerts and responding. These three are the key components of the early warning system.

So here it includes risk knowledge, monitoring and prediction, dissemination of information, and responses. If any one of them fails, that will disqualify this particular model from being the early warning system. So, this is very, very important. Now, we will try to understand the future scope of remote sensing and natural hazards. The future of remote sensing and natural hazard studies is characterized by enhanced capabilities that include increased integration and more sophisticated analytical techniques.

So, that way we will be able to obtain more precise information. So, we will definitely have higher spatial, spectral, and temporal resolution. Then we are talking about the integration of multi-sensor data, which is very, very important. As we have understood that some of the areas have limitations with the optical remote sensing data set, we also have other sensors like LiDAR that can be used here. Then, advanced analytics and artificial intelligence, autonomous systems, and unmanned aerial vehicles can be used, cloud computing and geospatial platforms, IoT can also be integrated here, and the development of new sensors with new capabilities is also expected in the future.



The future of remote sensing in natural hazard studies will be characterized by a shift towards more autonomous, integrated, and intelligent systems, leading to more accurate predictions, faster responses, and ultimately better resilience to natural disasters. So, what is the purpose of these natural hazard studies to save lives and property? So, as we move towards more advanced technology and more advanced analytical techniques, we will have better predictions and better models for particular disasters, and then we will be able to save more lives and property. Multi-sensor data integration for natural hazard studies; here, we were talking about the comprehensive and complementary information. So, when we have this, then we can have the optical remote sensing data set, microwave remote sensing data set, thermal sensors, and lidar; these can be used together. Then we have improved accuracy and reliability.

So, the validation and cross-referencing will be easy, and the ambiguities will be reduced. Then we have enhanced hazard detection and early warnings. So, the identification of precursory signals, validation, and cross-referencing then reduced ambiguity. So, these will be part of this enhanced hazard detection, and then ultimately comprehensive impact assessment and post-disaster response can be achieved. When we talk about advanced analytics and artificial intelligence, autonomous systems and UAVs, and IoT-based data integration.

So, that will help us to improve the accuracy of the prediction. Then, an autonomous system for early warning, so we do not have to do it again and again, and the system itself will be trained in such a way that it will give you the warning. Real-time and near-real-time data integration in the model will be possible because we are talking about the IoT, and then the cloud computing and geospatial platforms, which are very popular nowadays, are very useful in hazard studies. So, one of the examples is Google Earth Engine. So, real-time data streaming from multiple satellites is possible.

An automated alert system using scripts is easily scalable to any geographic area; it can be local, regional, or global. So, when we talk about this cloud computing facility, we have satellite imagery. You can have your algorithm, and then you can have your own application areas. So, particularly when we talk about the Google Earth Engine, it is a platform for scientific analysis and visualization of geospatial datasets. Earth Engine hosts satellite imagery and stores it in a public data archive, including historical Earth images. Earth Engine also provides APIs and other tools to enable the analysis of large datasets.

It offers tools for geospatial analysis, including interactive and batch processing models, because sometimes the datasets are very, very large. So the batch processing facility is there, and Python and JavaScript development environments are also available. Users can visualize and export results to various formats and platforms, and then they can be further analyzed. Earth Engine incorporates machine learning capabilities for tasks like regression, classification, and image segmentation that are integrated with Vertex. And for advanced modeling. So, remember that this Google Earth Engine is currently only for non-profit organizations and academics. So, these are widely used nowadays. So, this is one of the examples; this is a snapshot of the code editor. So, you can use this and do your studies. I hope you have understood the present and future scope of remote sensing datasets in hazard studies.

I hope you will be able to use this in your research.

Thank you. Thank you very much.