REMOTE SENSING FOR NATURAL HAZARD STUDIES

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Lec 12b: Potential of Remote Sensing and GIS in Hazard Studies: Overview -Part B

Hello everyone, welcome back to Lecture 12. This is the second part of this lecture, where we will try to understand the application potential of remote sensing in natural hazard studies. So, first let us see the different advantages of geospatial technology in particular.


So, we have large aerial coverage when we discuss satellite images. Especially, the remote sensing datasets are a non-destructive data collection method. Remote sensing can provide high spatial, spectral, and temporal images. It can also provide access to inaccessible areas. Real-time or near-real-time datasets that are needed for the hazard studies can be obtained from remote sensing. A wide range of data across the wavelengths is also available because some of the areas located at higher altitudes have cloud coverage. In such situations, the optical remote sensing datasets cannot be used because of cloud availability, but in such conditions, we have the microwave remote sensing dataset that can be used and further analyzed for our parameters.

Systematic and repetitive data collection has been conducted since 1972; I explained in the previous part that we have had Landsat data since then, and all of them have a similar nature. So, as we have seen, the Landsat has had continuous measurements since 1972, which can be analyzed together to see how things are changing in a particular area. So, that is the advantage associated with remote sensing data, particularly when we talk about hazardous studies. So, the hazard-prone areas are very difficult to access, particularly during or after a disaster. So, that makes the hazard-prone areas inaccessible. So, because of that, we have these physical barriers: rough terrain, dense vegetation, collapsed infrastructure, or the hazard itself can create the physical barrier.

The safety concern is that it might be too dangerous for rescue teams. Aid workers or even residents are unable to enter or remain in these areas due to ongoing threats. Then, the infrastructure damage in remote areas might mean that there are no existing roads or transportation networks, making them naturally inaccessible. So, these factors indicate the importance of remote sensing, because of remote sensing, we have access to an inaccessible area. So, the implications of inaccessibility will lead to challenges for natural disaster responses. Increased vulnerability of the population, difficulty in monitoring and preparedness, and prolonged recovery. So, at least with the remote sensing datasets, we can have the monitoring and preparedness beforehand. So, remote sensing provides access to an inaccessible area; it helps to overcome the difficulty in monitoring and preparedness, and with the help of all these satellite images, we have different parameters for the inaccessible area that can be used to model a particular natural phenomenon. So, the data collection through conventional techniques or through any other instruments requires disturbing the natural form of the sample. However, with remote sensing-based measurements, we have the advantage that we are not even touching the sample. or disturbing the natural setting of that particular location.

Here, this is one case where we are collecting the sample, so we are naturally disturbing the sample with the high temporal resolution. We can easily monitor how a particular river is changing its form or geometry over time, and even how a glacier is moving with time and what the velocity that can be estimated is consecutive measurement observations at a specific time interval help to study a phenomenon. So, that will give you information about the behavior or the process of a particular problem. So, the high spatial resolution that has further advantage to this. So, here you can see the entire Earth's surface. From outside, it will look like this, but slowly, if you have a sensor that is capable of capturing the very specific area with high spatial resolution, that will help you gather information about the target in detail, So, this can have the further advantage in your study. So, the role of spatial resolution is critical in any application. So, high spectral resolution is required to characterize a particular material. We have seen the example in the case of hyperspectral remote sensing that helps you gather more data

points across the wavelength, and that will help you identify a particular material like this one, which can be considered a fingerprint of that material.
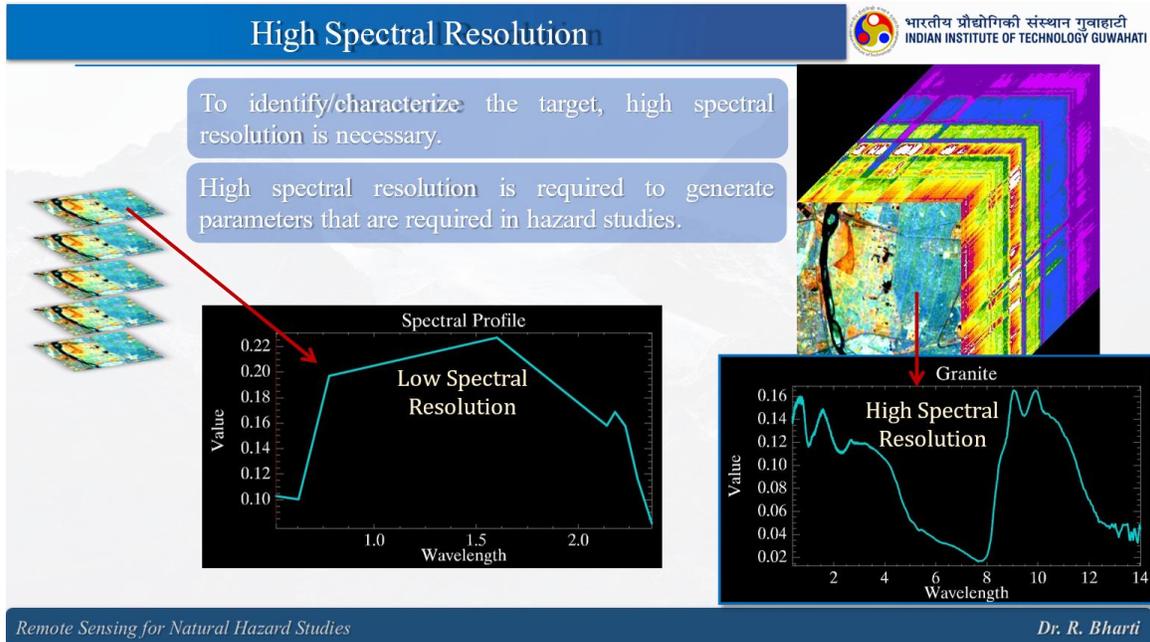

So, we always have an advantage when we have high spectral resolution, So, a wide range of data across the wavelength is available. So, here let us see this particular image where you have very high cloud coverage. So, if I have the intention to see the changes in this particular area, but it is blocked, we cannot have the information. So, in such cases, remote sensing provides you with another option where you can have the microwave data set to identify or study a particular area, especially when it is under cloud coverage. So, the optical remote sensing data is often difficult to use during a disaster due to frequent cloud cover, particularly in high-altitude regions. In such a situation, microwave remote sensing becomes a very important source of information. It has cloud penetration capabilities as well as being less vulnerable to atmospheric scattering than shorter wavelengths. So, at higher altitudes, it is recommended to use microwave remote sensing when the weather is not good. So, during a hazard, you cannot access that particular area, but your sensors are continuously working with the near-time or near-real-time dataset especially in the higher altitudes, where you are expecting a lake that may breach. So, you can have continuous monitoring, and then you can monitor the process. How it has happened and when it has happened, So, this is one example of how we are monitoring a particular area with the help of remote sensing datasets, especially here we have the example of glacial lake formation and its expansion. This is another example from South Lhonak. So, here you can see how the area is changing over time, and it has also improved in recent years. Here we have identified and monitored the glacial lake over time; you can see how it has changed starting from 2008, 2014, and then 2019.
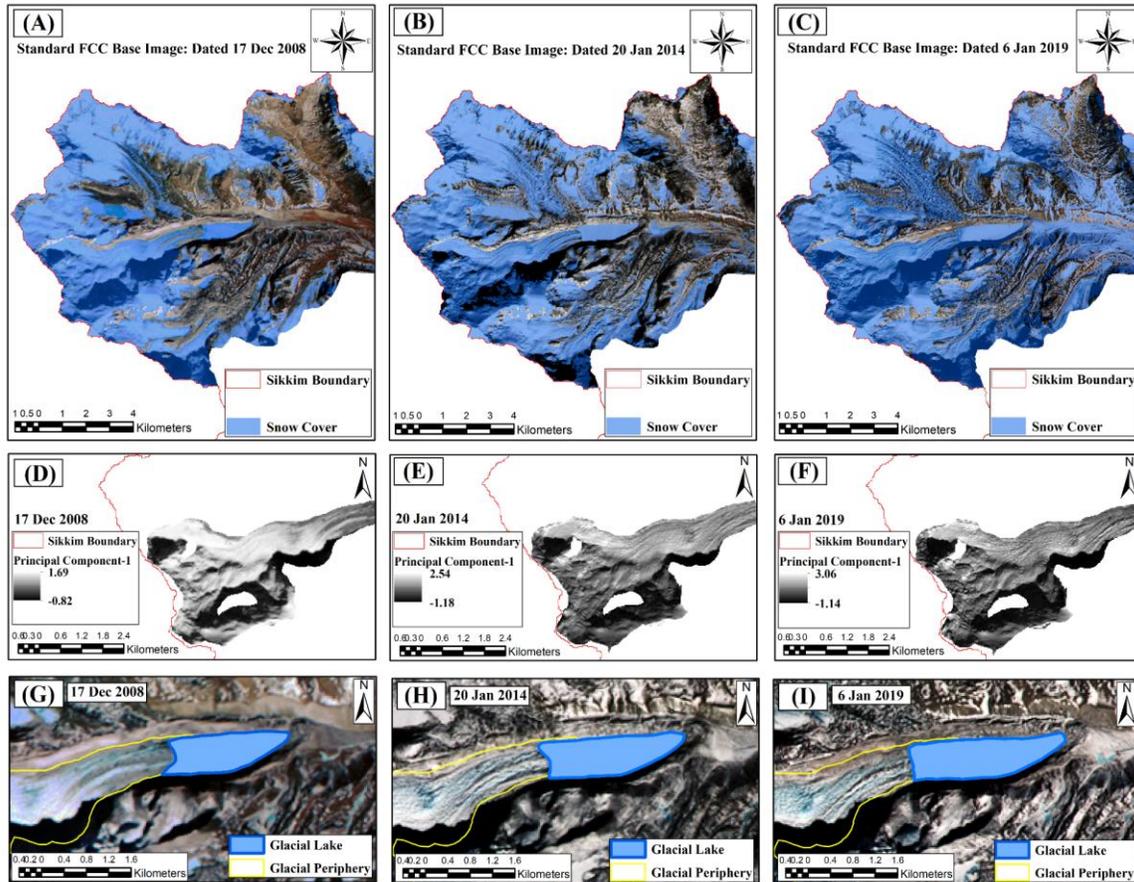
So, how the lake area is changing can further be analyzed to see at what rate it is increasing. Then, what is the impact of climate on the surrounding glaciers, at what rate they are melting, how much time it will take to fill this particular depression, and when can we expect this particular lake to breach if the scenario remains the same in the future? So, here you have the example of a change in the glacial lake area over time. So, we started in 1989 and continued until 2022, and we have seen that some of the lakes have changed their shape and size over time, and it is because of the change in the weather conditions, particularly in this region. Based on that, we have used all the parameters derived from remote sensing and the field investigation.

Application Potential of Geospatial Technology in Cryosphere Hazard

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Results from Sikkim Himalaya

Lake	Areal change rate b/w 1989 & 2022
TL37	2.7
L51	3.76
TL29	1.47
L107	1.15
TL10	0.74
TL11	Vanished

Remote Sensing for Natural Hazard Studies

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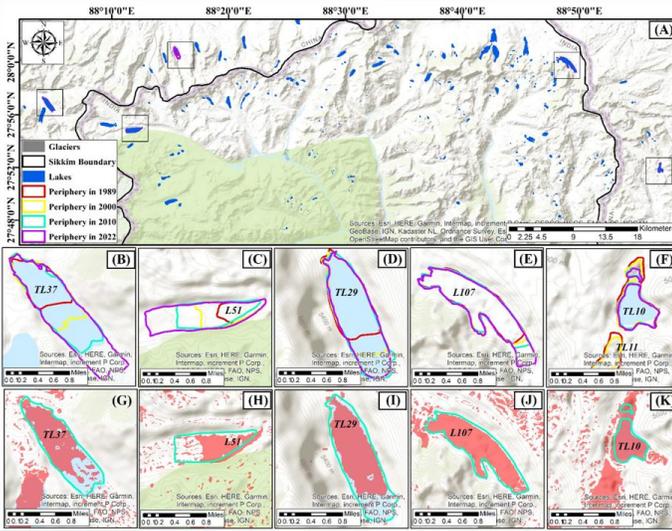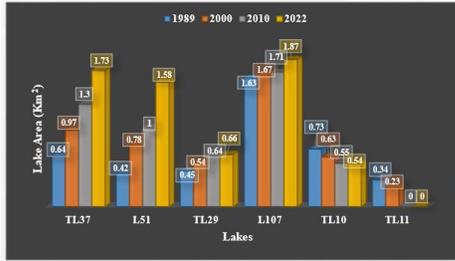
Based on the AHP analysis, we have found that some of the lakes fall under the category of highly vulnerable lakes. Some of them are moderately vulnerable, some of them are safe, so here you can see an example from this location we have also visited, and we found this is classified as moderately vulnerable. So, we have to be very careful because this particular lake has been showing an increase in size in the last few years. So, it has been observed that 8 glacial lakes are highly vulnerable to future GLOF events. This is based on the AHP analysis.

Vulnerability Assessment

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It has been observed that 8 glacial lakes are highly vulnerable to future GLOF events.

These lakes are moraine-dammed lakes, and their areal coverage as well as volumetric capacity have been increasing rapidly in the last few decades.

11 lakes are classified as moderately vulnerable and should also be checked for a GLOF event as they might become vulnerable in the near future due to glacial melt.

Remote Sensing for Natural Hazard Studies

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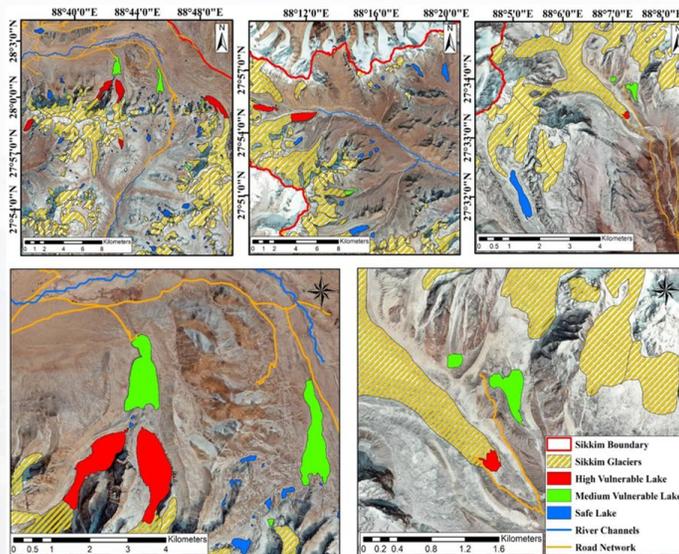
So, this vulnerability assessment can be done using the remote sensing and field investigation datasets, and you can draw a very important conclusion that can save lives and property in that particular region.

Vulnerability: This is an example of the Shisper Lake breach that happened on 7th May 2022. Here, we have also utilized the remote sensing data products as well as the field information to further monitor the lakes. This example is from the Machoi glacier in Kashmir, illustrating how it is changing shape and size over time, which is also given here. This is from the Gangotri glacier, with the moraines representing the retreat of the glacier from 1780 to 2001, and it is very, very important. We all know that the Gangotri glacier is the source of the Ganga, So, here we need to have very close monitoring of this particular glacier retreat. This example is for the snow glacier dynamics of the Sikkim Himalayas, where we again used the remote sensing data products, which were then validated. The classification results were validated using the field information. So, here we have used different indices to identify the snow cover. in this particular region, over the time how it is changing. In another application, such as the physical parameters of snow glaciers, we have also visited the field using the field radiometer, where we are measuring the snow's dielectric properties, and the same has been estimated using the microwave datasets, and together we are deriving different physical properties of the snow glaciers. So, here you can see the snow thickness; now, depth estimation can also be done using the remote sensing dataset, provided you have a very good source of validation. So, this is another example; here we have the example of glacier mobility. We can estimate the velocity of the glaciers using the remote sensing data and the data products, and that can be further analyzed to identify a vulnerable glacier. This is another example where we have mapped the avalanches using the remote sensing data sets that were captured from space and that has been used to identify and classify the avalanches into two different categories.
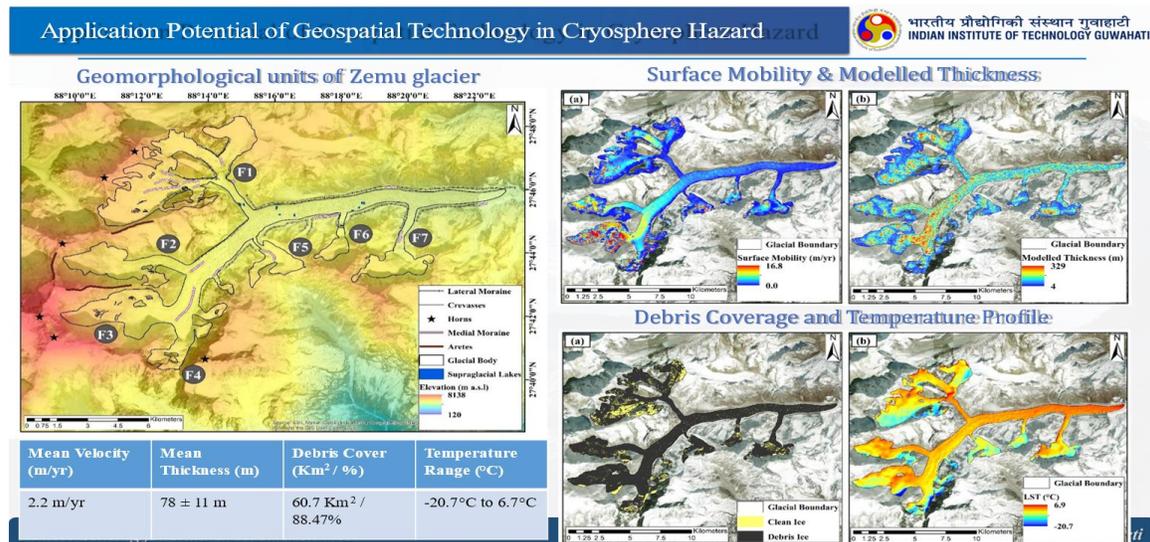
Here, you have the recent avalanches and the old avalanches. Then we have also studied the Zemu glacier for its surface mobility, thickness, debris coverage, and temperature profile. This kind of information can be derived using remote sensing datasets. Then, very recently, we were successful in studying the seismic deformation of Himalayan glaciers using synthetic aperture radar interferometry. So, here you can see that the coherence image has been used. And the vertical displacement has been estimated after the earthquake correctly.

So, this is from Josimath, the Josimath earthquake which occurred in 2021. Then coming to flood susceptibility mapping, we all know that the different parameters required for flood mapping come from remote sensing and field investigations. So, this is one example where susceptibility has been mapped into different classes: very low, low, medium, high, and very high. So, these are the different examples; like in a landslide, we can use different methods to map the area's susceptibility to the landslide. And here you can see it is also classified into different classes derived from various methods, Then, particularly for the liquefaction potential, we have also used different methods and different ways to identify whether a particular location is susceptible to liquefaction or not. So, that can be studied.

So, here you can see this is one example of the spatial-temporal distribution of parameters for the years 2016 to 2017. So, here you can see the SPI (Standard Precipitation Index) and the Normalized Vegetation Water Index that have been used to map the drought potential of this particular area.
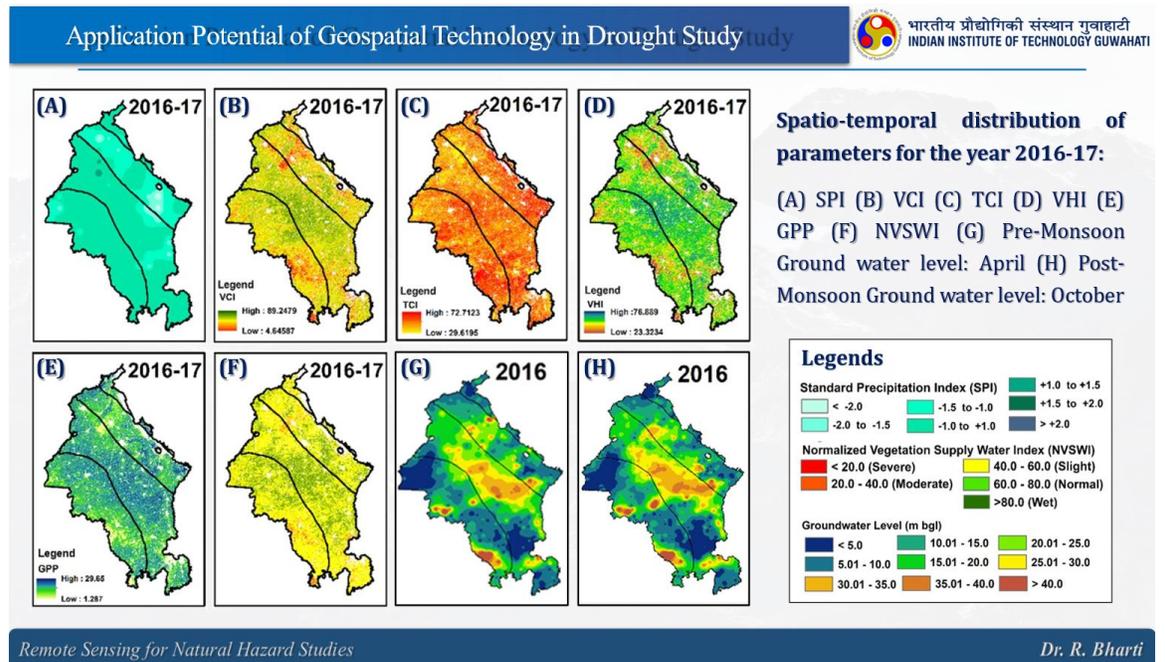
With this, I would like to conclude and emphasize the application potential of remote sensing in hazard studies. So, with the advancement in remote sensing technology and analysis techniques, remote sensing has proved to be an important source of information in natural disasters. So, we will have a detailed discussion of each of the natural hazards listed in the syllabus, and we will have detailed information about each of them.

 So, with this, I will thank all of you.