**Conservation Geography**
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**Module - 12**
**Special topics in Geography and conservation**
**Lecture – 35**
**Disasters**

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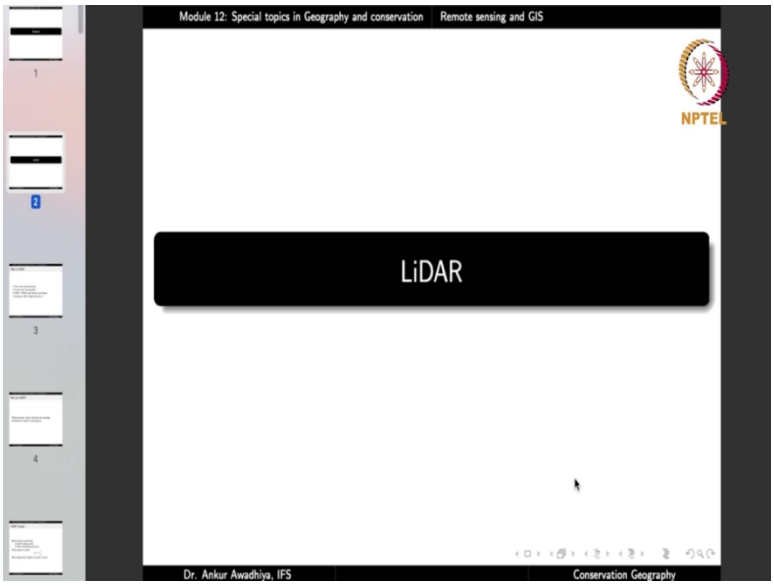

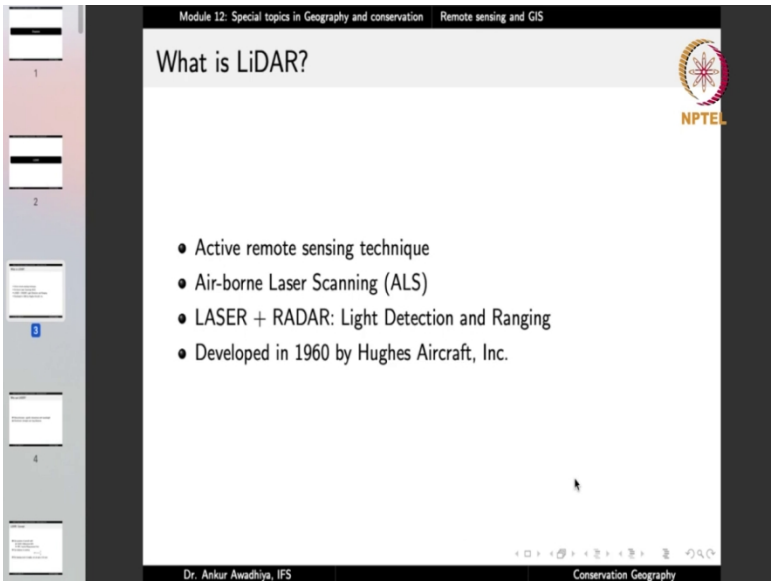
Module 12: Special topics in Geography and conservation
Remote sensing and GIS
What is LiDAR?
NPTEL
Active remote sensing technique
Air-borne Laser Scanning (ALS)
LASER + RADAR: Light Detection and Ranging
Developed in 1960 by Hughes Aircraft, Inc.
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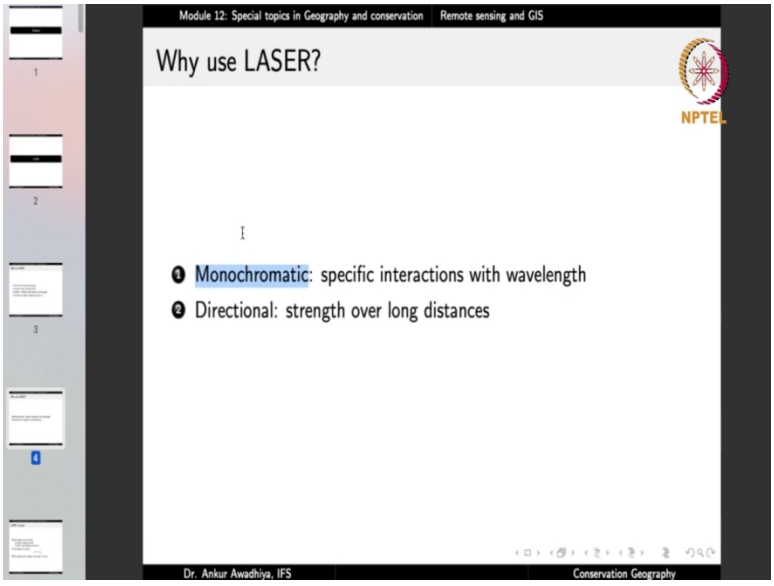
Module 12: Special topics in Geography and conservation
Remote sensing and GIS
Why use LASER?
NPTEL
1. Monochromatic: specific interactions with wavelength
2. Directional: strength over long distances
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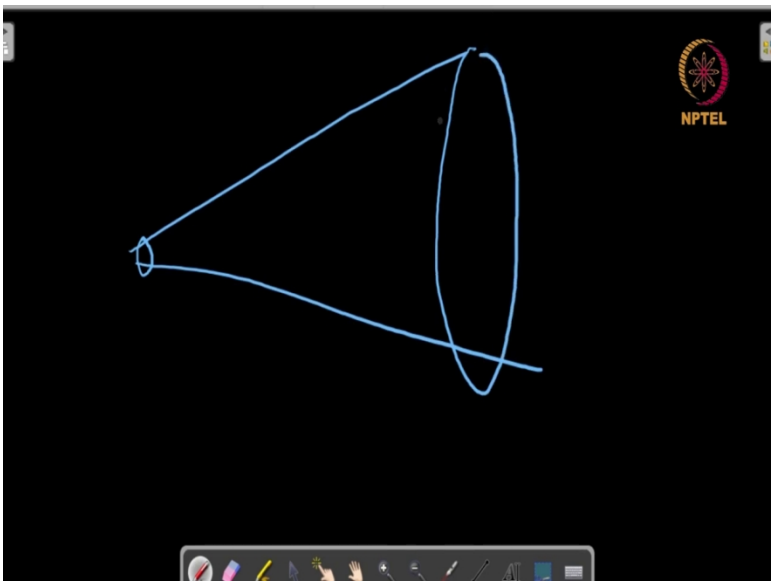


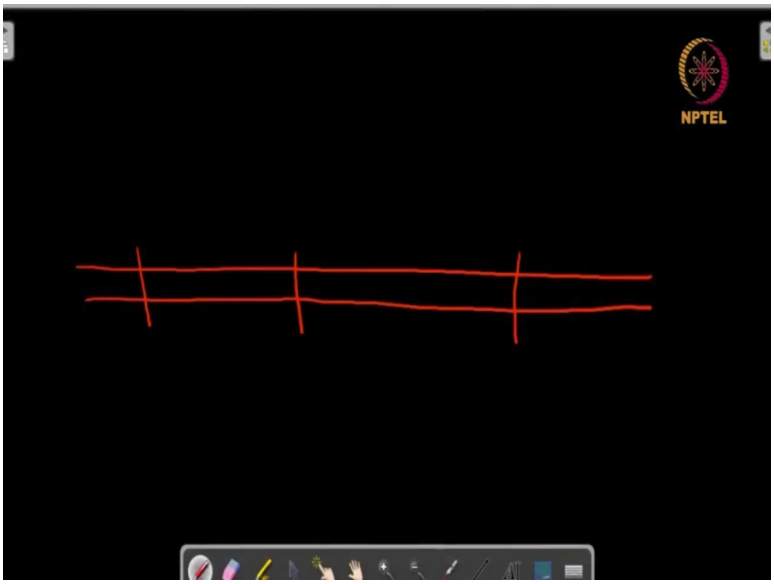


Namaste! We move forward our discussion on the special topics in Geography and Conservation. And in this lecture, we shall have a look at disasters. But before that will carry on with our bit that was left out of remote sensing and GIS specifically LiDAR. Now, what is LiDAR? LiDAR is an active remote sensing technique.

Active means that it requires energy. So, unlike passive remote sensing, which makes use of suns energy sunlight, that gets reflected from objects to bring data to the sensor, in the case of active remote sensing, we generate the energy that is sent to the object that has to be investigated, that energy then interacts with the surface of the object.

And then the energy gets reflected back bringing with it the information about the object. Now, LiDAR is an active remote sensing technique means that it is remote sensing, sensing from a distance, but utilizing energy to generate those light or those beams that are going to go to the object interact with the object and bring back data from the object.

It is a method of Air-borne laser scanning or ALS. So, it is airborne. We typically use it attached to an aircraft and it is a method of laser scanning. So, it uses light amplification by stimulated emission of radiation to scan the different objects. The word comes from a combination of laser plus radar and we can say that it is light detection and ranging LiDAR. It was developed in the in 1960, by Hughes Aircraft  Incorporated.

Now the thing is, why do we make use of lasers, lasers have some very specific properties that make them very useful for LiDAR, one, laser is monochromatic. mono means one chromo is color. So, the laser light has only one color meaning that it has only a single wavelength, it is not a combination of lights of different wavelengths, it has one specific precise wavelength.

And so, if we want to study the interaction of that particular wavelength with the object, we can very well make use of a laser. So, there are specific interactions with that particular wavelength. Two, it is highly directional, this means that the beam of light does not spread, it moves just as a beam for a very long distance.

Now, what happens is that if you have a beam of light that is spreading, the beam of light is going like this. In that case, the energy density here would be very high, whereas the energy density at this location would be reduced because the area has increased. Whereas in the case of laser, it just moves as a continuous beam without any spread.

So, the energy density at this location is equal to the energy density at this location is equal to the energy density at this location and so on. So, laser is highly directional beam, so it maintains its strength over long distances. Meaning that we can use laser to have a small amount of energy that is transmitted to a very long distance, that energy interacts with the object that has to be investigated.

And then the reflected beam is able to bring energy about the object back to the sensor. If on the other hand, we used a beam that was a spreading beam. In that case, we would have required a

very large amount of energy so that some amount of information is able to come back to the sensor. But lasers being highly directional, they maintain their energy density. And so even a small amount of energy is sufficient, which allows for the generation of laser using smaller devices.

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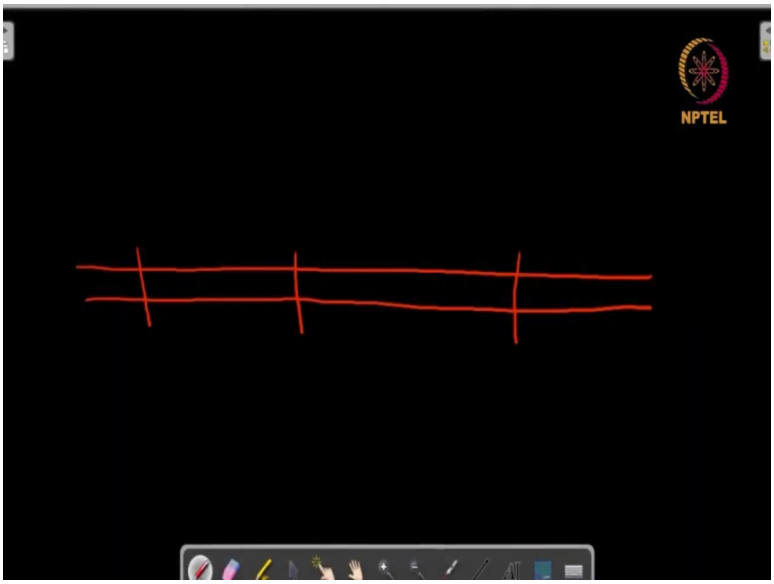


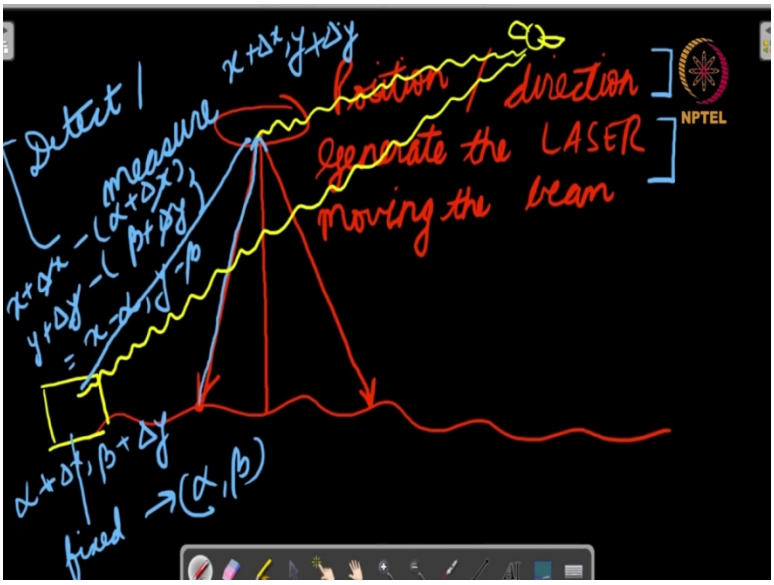


Now what is the concept of LiDAR? The concept of LiDAR has got to do with three things. You have an aircraft and if you want to have information about the ground surface, you need a mechanism to find out the position of the aircraft. So, once you know the position and say the direction or the tilt, et cetera of the aircraft.

Then you can figure out what is the position and direction in which the laser beam will be generated. So, once you know the position you will have to generate the laser. So, you need a mechanism of generating the laser beam and if you have to scan the surface with this laser, then you also need a mechanism of moving the laser beam.

So, this laser beam can be moved so, it can be say moved like this or it can be moved like this. Now, if you have a laser beam that is moving like this, then it will come it will interact with this surface at this point and we will get a return laser. Now, the return laser will move back to the aircraft and now you require a mechanism to detect this laser or probably also to measure the laser.

So, we require three things, one mechanism to know the exact position and direction. Two, a mechanism to generate the laser and move the beam. And three, a mechanism to detect and measure the laser. So, we get the position of the aircraft with DGPS and IMU, DGPS stands for differential GPS. Now differential because if you have the aircraft here, we will typically also have another station here on the ground and the GPS is based on the data that are coming from the satellite.

Now, the aircraft gets its position from the signals that are coming from the satellite and at the same time the ground station also gets its position from the signals that are coming from the satellite. Now, it is possible that this the signals that the satellite is sending, they get certain amounts of errors, errors in generation or errors that occur during transmission especially the errors that are kept in because these signals are moving through the atmosphere.

Now, once that happens, we will have certain errors in measurement. Now differential GPS tries to eliminate that error by doing a subtraction. So, essentially at this location at the location of the aircraft, suppose the actual position is x and y and you get an error so you get an error of delta x and you get an error of delta y.

Now, similarly, at this location, you have the coordinates that are given by alpha and beta. But here again because the signal is getting an error, so you have an error of alpha plus delta x and beta plus delta y. Now, this is because the error is the same because it is coming from the same satellite.

And in that case, you can now compute the location of the aircraft with respect to the ground station. Because once if you subtract both of these locations, you get x plus delta x minus alpha plus delta x and y plus delta y minus beta plus delta y. Now in this case, delta x and delta x get cancelled, delta y and delta y get cancelled and so now the exact location of the aircraft is given by x minus alpha and y minus beta.

Now in this case, because we know alpha and beta very well because this is a fixed station, so we very well know what is alpha and beta. So in this case, the position of the aircraft can be very easily computed and very accurately computed by knowing the x and y so we take the measurements at two locations.

One is the location of the aircraft and the second is the location of a ground point or a fixed station. Do a subtraction of both of these and because the errors are the same in the measurement in the aircraft and in the measurement on the ground, these errors will get cancelled away and we can figure out the exact location of the aircraft.

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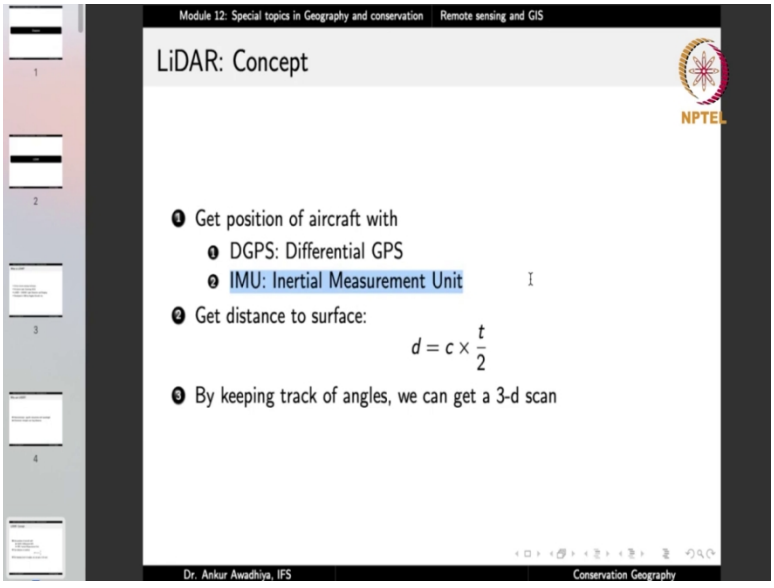

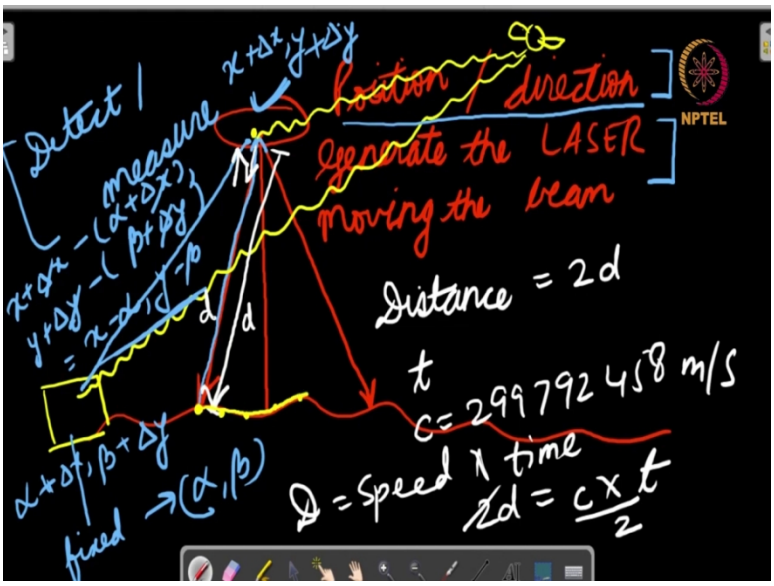


So, that is the utility of differential GPS. The second thing is IMU which is the inertial measurement unit. Now, IMU is a device that can tell you the speed of the aircraft, the acceleration of the aircraft and the direction of the aircraft. So, if the aircraft is say tilting towards the front or it is tilting towards the side.

The IMU can help you find out what is the amount of tilt, it can tell you what is the speed at which the aircraft is moving, and it can tell you the acceleration of the aircraft. Now, with that information combined with the information from the differential GPS, we exactly know the location, speed, acceleration and tilt of the aircraft at the point or at the time when the laser beam was generated.

And so, we exactly know the location of the aircraft. So, this is done. So, the first thing that we needed was the position and direction of the aircraft that we now very will know. Next, when we generate the laser and we move the beam and the beam interacts and it comes back. Now in this case, the distance of this point from the aircraft is d.

Now, when you have a situation when the laser has been sent and the laser is received back in that time the laser covers a distance which is twice of d because it is traveling d from here to here in this direction and it is traveling the same distance back. So, you have a total distance which is given by twice of d.

Now, we can measure the time it takes for the laser beam to come back after it has been shot. Now suppose the time is t now we know the speed of light which is given by c is equal to 299792458 meter per second in vacuum and in the case of air there is a slight reduction. Now, if we know that then because distance is equal to speed into time.

So, we get 2d is equal to c into t or dividing both the sides by 2 we get d is equal to c into t by 2. So, we know very well the distance d from the object. Now if you know the position of the aircraft and this distance d and you exactly know the direction in which the laser was shot, you can compute the coordinates of this particular point.

Now similarly, when you scan the area, you can compute the coordinates of this point of this point of this point of this point and so on. And by joining these points together, we can generate a digital terrain model of this area. So, we need to keep track of angles and then we can get a 3-d scan of the area.

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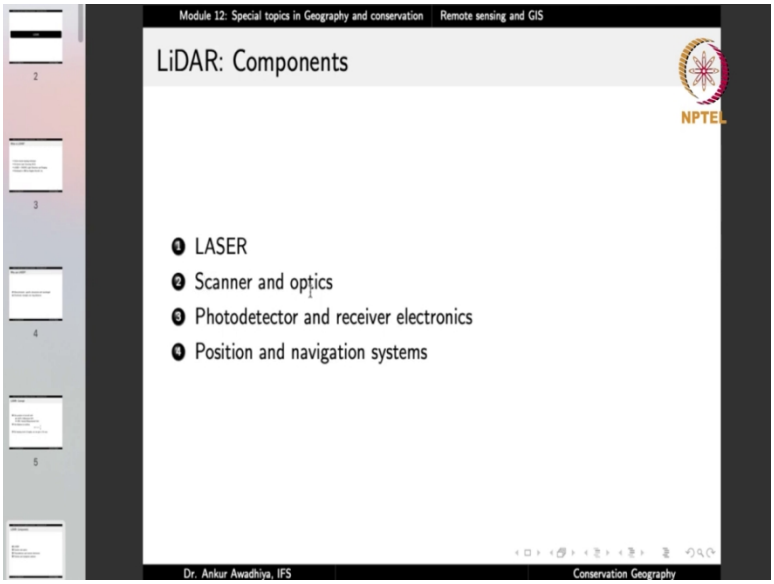

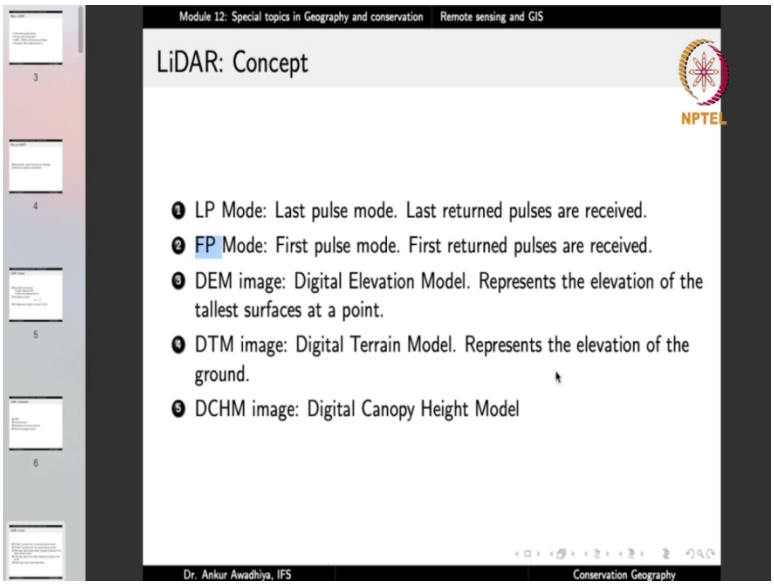
Module 12: Special topics in Geography and conservation
Remote sensing and GIS
LiDAR: Concept
NPTEL
1 LP Mode: Last pulse mode. Last returned pulses are received.
2 FP Mode: First pulse mode. First returned pulses are received.
3 DEM image: Digital Elevation Model. Represents the elevation of the tallest surfaces at a point.
4 DTM image: Digital Terrain Model. Represents the elevation of the ground.
5 DCHM image: Digital Canopy Height Model
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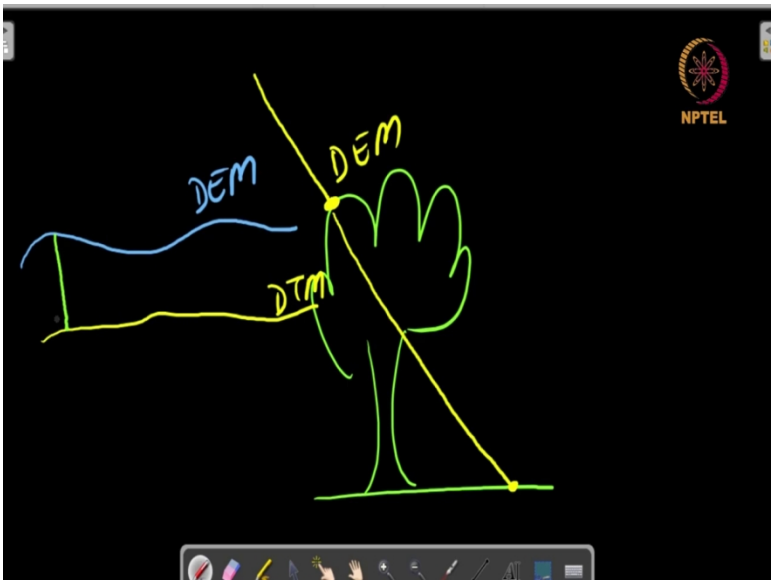
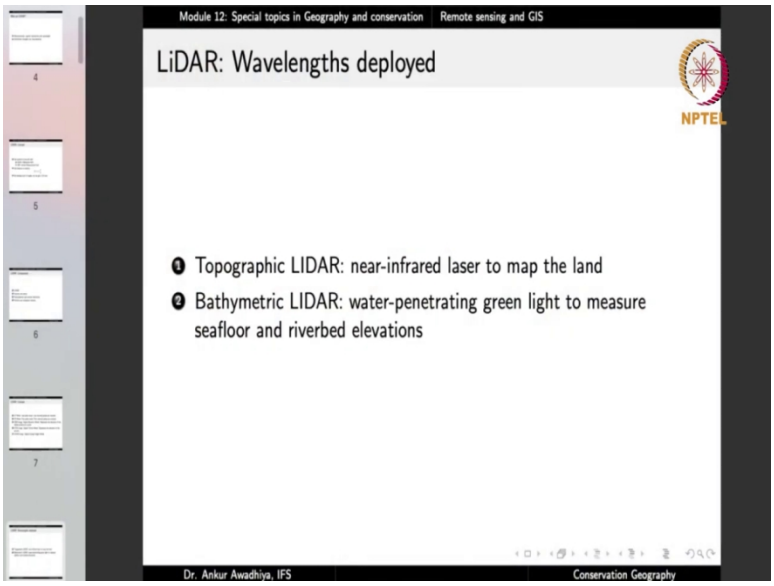

NPTEL
DEM
DEM
DTM


Module 12: Special topics in Geography and conservation
Remote sensing and GIS
LiDAR: Wavelengths deployed
NPTEL
1 Topographic LIDAR: near-infrared laser to map the land
2 Bathymetric LIDAR: water-penetrating green light to measure seafloor and riverbed elevations
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Remote sensing and GIS
NPTEL
Uses in forestry
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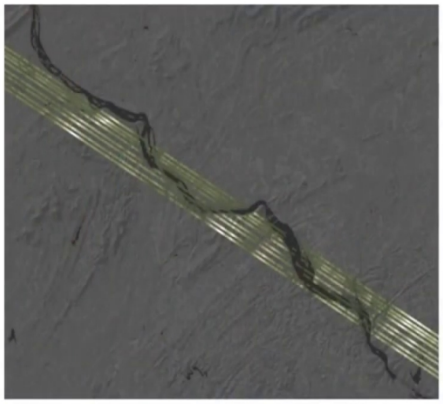
## Scanning the forest at various scales

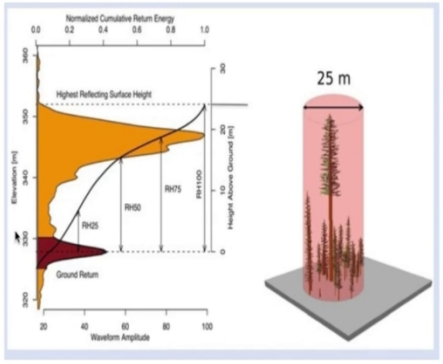


Source: NASA https://earthobservatory.nasa.gov/images/144818/return-of-the-gedis-first-data.



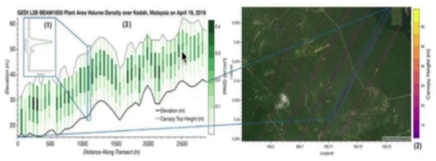


## Returning wave profile




Source: NASA https://earthdata.nasa.gov/learn/articles/first-gedi-data-available

## Elevation and canopy top height

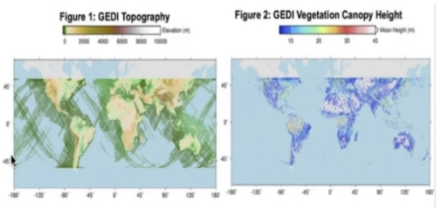


Source: NASA https://landsat.gsfc.nasa.gov/meet-dr-eric-bullock/

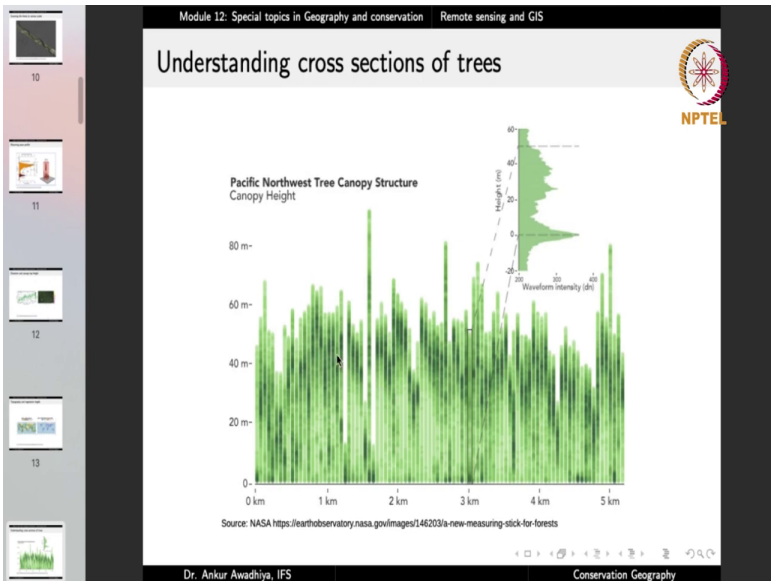


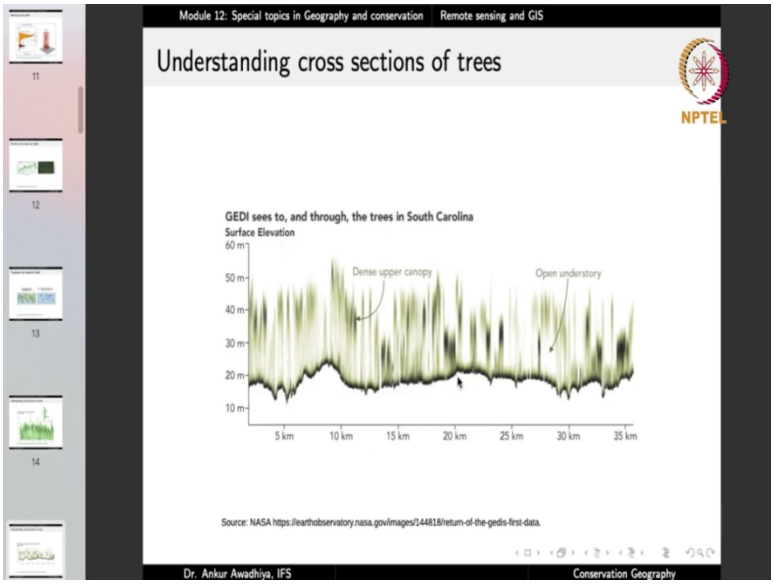


## Topography and vegetation height




Source: NASA https://earth.gsfc.nasa.gov/geo/highlights/gedi-mission-early-success




So, the components of LiDAR are the laser, the scanner and the optics for photodetector and receiver electronics and position and navigational systems that is we require exact position and direction of the aircraft, we require a mechanism of generating laser and sending it in the form of a scan beam and we require a receiver and it is electronics.

Now, the beams that come back can be received in multiple modes, we can have the LP mode, which is the last pulse mode in which case the last returned pulses are received, we can have the

FP mode or the first pulse mode where the first returned pulses are received. Now suppose we have a situation where there is a tree on this piece of ground and we are sending the laser beams.

Now the first return will be from this point where the pulse is interacting with the canopy. Whereas there will be some amount of light that will be traversing and then it will hit this spot and then it will come back. So, you have these two different returns of the pulses that you have shot.

And with both of these we can compute the DEM the DTM and the DCHM. Now DEM refers to the digital elevation model which represents the elevation of the tallest surfaces at a point that is, we are trying to compute what is this point. So, this one will give us the DEM. Similarly, in the case of DTM we are trying to compute the digital terrain model which represents the elevation of the ground that is in this case we are trying to compute this point.

Now, if you compute both of these points you will have a surface which is your DEM surface and you have another surface which is your ground surface. So, this is the digital terrain model surface and the difference between both of these is the height of your trees and this will give you the DCHM or the digital canopy height model.

So, if we use LiDAR we can compute the DEM the DTM and the digital canopy height model of the forest area. Typically, we make use of near infrared lasers in the case of topographic LIDAR and water penetrating green light in the case of bathymetric LIDAR to get the elevations of seafloor and riverbed elevations. Now, with this knowledge, how can we make use of it in the case of conservation. So, LIDAR is having a large number of applications these days in the case of forestry.

Because in forestry you require a knowledge about the topography and you require a knowledge about where different trees are growing, what is the amount of carbon that is being sequestered in all these different areas. And we can use LIDAR to get that information these days we are making use of scanning that is being done from the space.

So, in the international space station, there is a LIDAR probe in the name of JD experiment that has been installed and with that, now, we can have information about the DEM and DTM of all

around the earth. So, this is how the scanning happens. So, these are different points at which the readings are taken.

And if you have a tree then you will have a ground return which is happening here and you will have a highest reflecting surface height which will be given by the top of the canopy and this curve is telling us that at different elevations, we are getting a different amount of return of the energy and with these we can draw these two surfaces.

We can draw the terrain surface and we can draw the elevation surface and the difference between both of these will give us the height of the canopy. But not just that if you look at this curve, you will find that this also has a particular shape telling us the amount of energy that is getting reflected from different heights of the tree and that can be used to compute the characteristics of the tree.

So, the in the first level we can compute the topography then we can compute the vegetation canopy height followed by the cross sections of the trees that is what is the amount of mass or what is the amount of reflecting surface that is there at different heights in these trees. And with that, now we have an ability to see through the forest. So, if we make a plot of the LIDAR data we get a plot like this. So, this is telling us that this portion is a dense upper canopy, this portion is an open understorey and so on. So, you are able to get a visualization of the trees as they would be seen from the side.

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## Forest structure with Terrestrial Laser Scanner

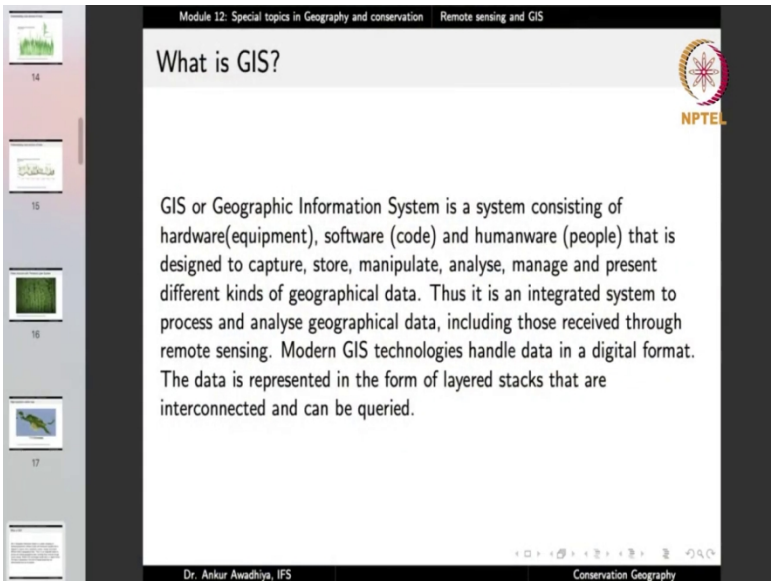
Source: NASA https://earthobservatory.nasa.gov/images/90309/below-the-mangrove-canopy

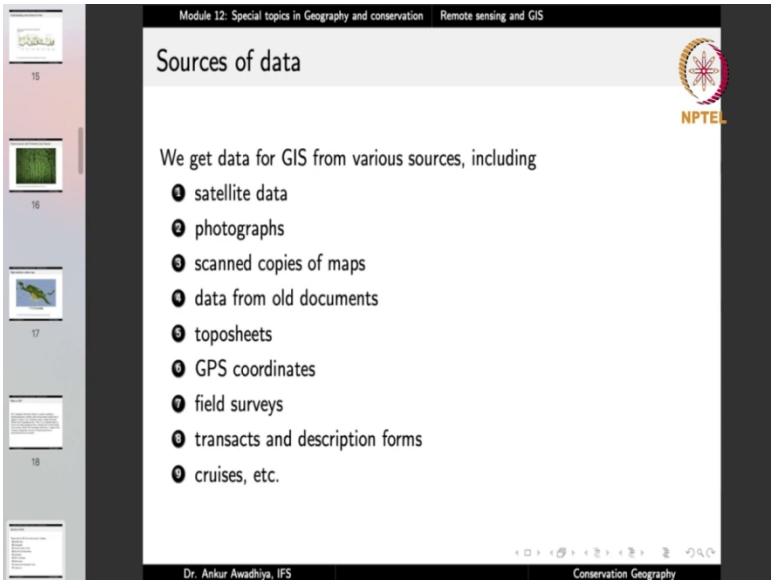




## High-resolution carbon map


Source: NASA https://earthobservatory.nasa.gov/images/76953/measuring-carbon-and-trees-in-the-tropics




Now, we can add that information with the information from terrestrial laser scanners. So, we can use LIDAR even from the ground surface. And if we use it from the ground surface, we are seeing a 3-d model of the forest area in which we are doing the scanning. So, a 3-d model of the forest will look like this.

Now, this is a forest structure from the terrestrial laser scanner. You can incorporate both of these together. So, essentially, we can use the terrestrial data to calibrate the readings of this space data and we can generate a high resolution carbon map of different areas. So, this is an information that would have been very difficult to determine just by using the manual methods.

So, LIDAR is playing a big role in forestry these days. So, we can compute what is the amount of carbon and we can use it to say data mine, what would be the loss of different ecosystems, what would be the loss to the ecosystem services that these forests are providing. And now, we have a foolproof method to quantify these different values.

Now, doing all of these computations comes under the purview of GIS, which is geographic information system, a system consisting of hardware or equipment, software or code and humanware of people that is designed to capture, store, manipulate, analyze, manage and present different kinds of geographical data.

Thus, it is an integrated system to process and analyze geographical data including those received from remote sensing. So, what we are doing in the case of GIS is that we are taking data from different platforms we can have data from remote sensing platforms like LIDAR data or satellite photographs or we can have data from other sources such as data from the books data from tables.

That were made previously data from field measurements, and we can provide each of these data with the geographical coordinates. Now, you will remember that in the last lecture, we saw that we can superimpose the drone data on top of the satellite data. Now, this is done by given both of these data a certain geographical reference so that it is possible to overlay them one on top of the other.

Now, the GIS is a suite that permits us to do that. So, it is a combination of hardware which is computers, software, and people that are able to capture, store, manipulate, analyze, manage and present different kinds of geographical data converted into the form of information and process and analyze geographical data including those received from remote sensing.

Modern GIS technologies handled data in a digital format and the data is represented in the form of layered stacks that are interconnected and can be queried. That is, if you have the digital data, say if you have remote sensing data you can compute what are the locations where you have a river or say a water body now you can ask a query. That I want to know the all the locations that are say 100 meters from any water body then you can have another layer that gives you the amount of forest biomass that is in different areas and you can ask the question.

What are those locations that are say 100 meters from the water bodies and they have a dense forest vegetation or say an open forest vegetation, because with that information, you can plant different habitat manipulations. And GIS permits you to compute these locations by querying these geographical data.

Otherwise, it would have been very difficult, you will have to take different maps, overlay them one on top of the other by say converting them into a transparent sheets and it would have been a very labor intensive exercise. But with the modern GIS software, you are able to do them in no time.

The data that we use in GIS comes from various sources such as satellite data, photographs, scanned copies of maps, data from old documents, toposheets, GPS coordinates, field surveys, transacts and description forms, cruises and so on. So, any data that you have that has a geographical importance can be provided with geographical coordinates, and then that data can be incorporated in a model and you can figure out certain information from that model that is GIS.

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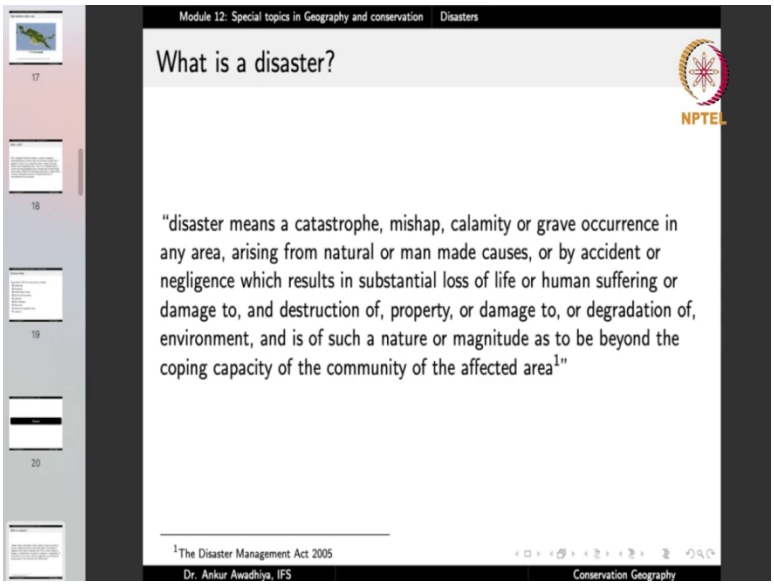
Module 12: Special topics in Geography and conservation
Disasters
What is a disaster?
NPTEL
"disaster means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area[1]"
[1]The Disaster Management Act 2005
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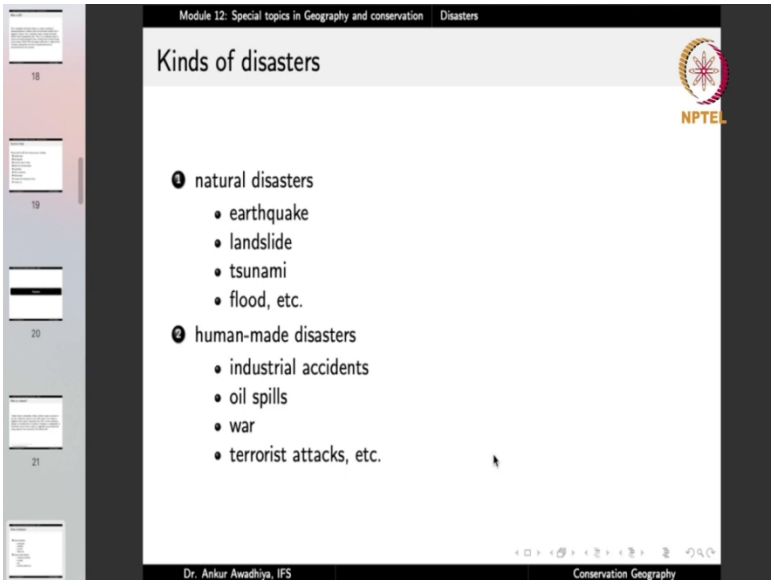
Module 12: Special topics in Geography and conservation
Disasters
Kinds of disasters
NPTEL
1. natural disasters
• earthquake
• landslide
• tsunami
• flood, etc.
2. human-made disasters
• industrial accidents
• oil spills
• war
• terrorist attacks, etc.
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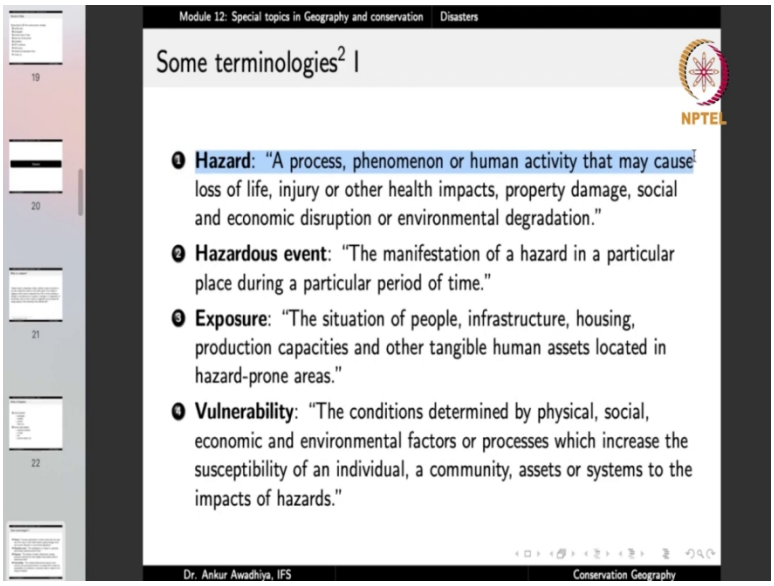


Now, coming to today's topic of disasters, what is a disaster? Disaster means a catastrophe, mishap, calamity or grave occurrence in any area arising from natural or manmade causes or by accident or negligence, which results in substantial loss of life or human suffering or damage to and destruction of property or damage to or degradation of environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Now this is the definition from the Disaster Management Act 2005. That is disaster can be in the form of a catastrophe mishap calamity or grave occurrence in any area. So, it is not the situation that disaster occurs only in some areas it can occur in any area and can take various forms, it can be a catastrophe, it can be a mishap, it can be a calamity or it can be a grave occurrence, a disaster can arise from natural causes or manmade causes or we accident or negligence.

So, you can have natural disasters, things like earthquakes, you can have manmade disasters like release of industrial effluents or you can have disasters because of certain accident or negligence. And the common feature is that any of these disasters results in a substantial loss of life or human suffering or damage to and destruction of property or damage to or degradation of environment.

So, it can result in a loss of life, it can result in a huge amount of human suffering or it can damage or destroy property or it can damage or degrade the environment. So, if there is a loss of the environment, if there is a degradation of the environment that too is a form of disaster. So, if

there is a large scale industrial pollution or if there is a release of noxious chemicals into the water bodies, these are all different kinds of disasters and is of such nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Now, disasters are natural or manmade natural disasters include things like earthquakes, or landslides or tsunamis or floods and human made disasters include industrial accidents, oil spills, war, terrorist attacks and so on. Now, in this context, we can look at certain terminologies. Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health aspects, property damage, social and economic disruption or environmental degradation. So, we have looked at all of these words they were there in the in disaster, but in this case, hazard is a process phenomenon or human activity that may cause all of these.

So, if you have the possibility of something that may lead to a disaster, then we say that, that is a hazard. So, hazard is something that may cause all of these things that disaster causes loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Now, if you have a hazard in an area, say you have the accumulation of a huge quantity of a toxic chemical in an industrial warehouse that is a hazard.

But, if the hazard manifests itself, then we will get a hazardous event the manifestation of a hazard in a particular place during a particular period of time. Exposure is the situation of people infrastructure, housing, production capacities and other tangible human assets located in hazard prone areas.

Now, when we talk about hazard prone areas, then mostly in the case of things like a natural hazard, there are certain areas that have the hazard of flooding and there are certain areas that are safe from flooding. Now, if you have a situation of flooding, then those areas in which you have the hazards and there are people infrastructure housing production capacities and other tangible human assets that are located there.

Then this situation will be known as in exposure, the situation of all of these being located in hazard prone areas. So, we will see that exposure of people who are living in flood prone areas is very high. Similarly, the exposure of people who are living in cyclone prone areas is very high. Now that is exposure because the hazard has not manifested itself, it is just that the area is hazard prone, then we say that there is exposure.

Now, when you have exposure you can have vulnerability, the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, community, assets or systems to the impacts of hazards. So, the hazard is the same, but the susceptibility may be high or it may be low the susceptibility is high when you have people who are living in houses that are not made in a manner as to be able to resist the hazard.

The susceptibility is high when you have a situation where the means of transport and communication are not well developed, when you do not have a social net or an economic net to protect the people, then the susceptibility is high and then the people are more vulnerable as compared to other situations where they are less vulnerable.

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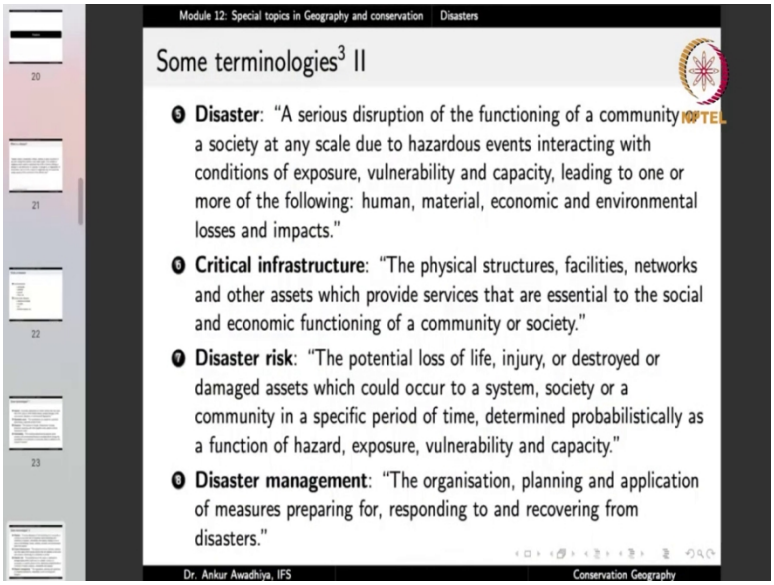


Disaster is a serious disruption of the functioning of a community or a society at any scale due to the hazardous events interacting with the conditions of exposure, vulnerability and capacity leading to one or more of the following human material economic and environmental losses and impacts another way of saying the same thing, but in this case, we are emphasizing that if there are hazardous events.

Now, hazardous events are the manifestation of the hazard. So, the hazard has happened, but you also have a condition of exposure vulnerability and a reduced capacity of the community to cope then you will have a disaster. So, when we say that it is beyond the coping capacity, here we are talking about the capacity.

So, you need to have hazardous events together with a situation of exposure vulnerability and reduced capacity only then you will have a disaster. Now, this definition is important because it also tells us how to reduce the disaster, you can increase the capacity, you can reduce the vulnerability, you can reduce the exposure or you can make sure that the hazardous events do not happen.

For example, if we talk about a situation of flood and if there is a river that is flooding every year, then we can reduce the hazardous event by say building a dam or building good embankments well maintained embankments or by creating a wetland so that the water gets stored in an area and it does not result in a flooding.

So, we can work at the level of the hazardous event or we can reduce exposure, we can reduce exposure by say making laws that make it illegal to make a housing in the flood prone area. So, we create those situations where people are not exposed to the flood. So, even if a flood happens, there are no people who live in that area.

So, that would reduce the exposure or we can work at the level of vulnerability that is even if flood happens and people are living there, we create their houses in such a manner that they are not susceptible to the floods. In that case, we are working on the vulnerability of people or we can try to increase the capacity of the community see by providing things like crop insurance or by providing things like building insurance or by providing means like infrastructure to save the people whenever flood happens.

So, in that case people are exposed to the flood people are vulnerable to the hazards that are caused by flood, but you have increased the capacity of the community to cope. So, you can work on either of these four levels or you can work on all of them. So, the best situation is when we work on all of them, we try to ensure that the floods do not happen even and we also try to ensure that people are not living in that area.

And those people who are living they are having good houses. And we also provide them with other means of support so that the coping capacity of the community is high. Now critical infrastructure is defined as the physical structures, facilities and networks and other assets, which provides services that are essential to the social and economic functioning of a community or society.

So, critical infrastructure consists of all of those structures that are essential to the social and economic functioning of the community or society and whenever you have a situation of disaster, we need to ensure that the critical infrastructure is protected or if it is not protected, then it is rebuilt as soon as possible, because it is critical for the functioning of the society.

We talk about disaster risk, which is the potential loss of life, injury or destroyed or damaged assets, which could occur to a system, society or community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. What is the risk of a disaster? The risk of a disaster is again given by a function of hazard, exposure, vulnerability and capacity.

So, we can compute the level of risk to a disaster, which is the disaster risk. And in those areas where we have a huge risk of a disaster, we can take certain preemptive steps. So, computation of disaster risk is important, especially for planning purposes. And we can work on disaster management, the organization, planning and application of measures preparing for responding to and recovering from disasters.

Once you have computed the disaster risk, you can prepare for these disasters. So, before there is a disaster, you can prepare for the disaster. Once the disaster has happened, you can respond to the disaster you can try to reduce the loss of life and property. And after the disaster, you can try to recover from the disaster and a combination of all of these the organization, planning and application of measures that are for preparation, response or recovery from the disasters are known as disaster management.

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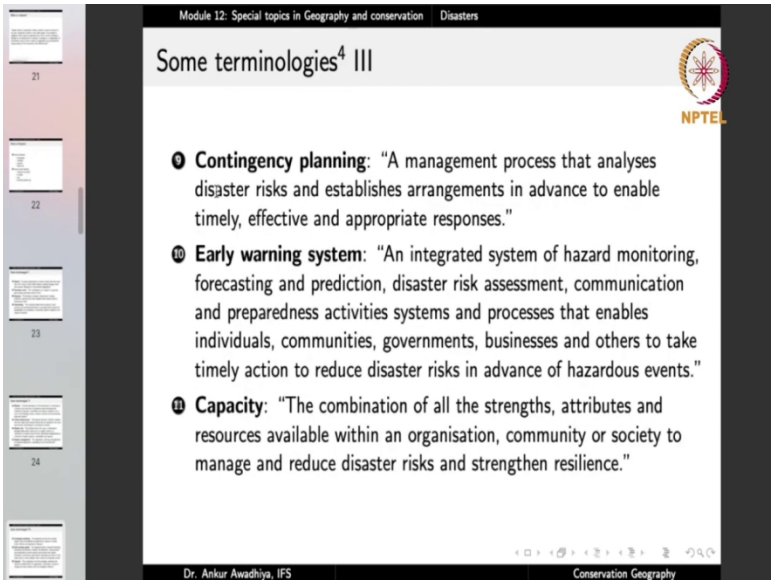

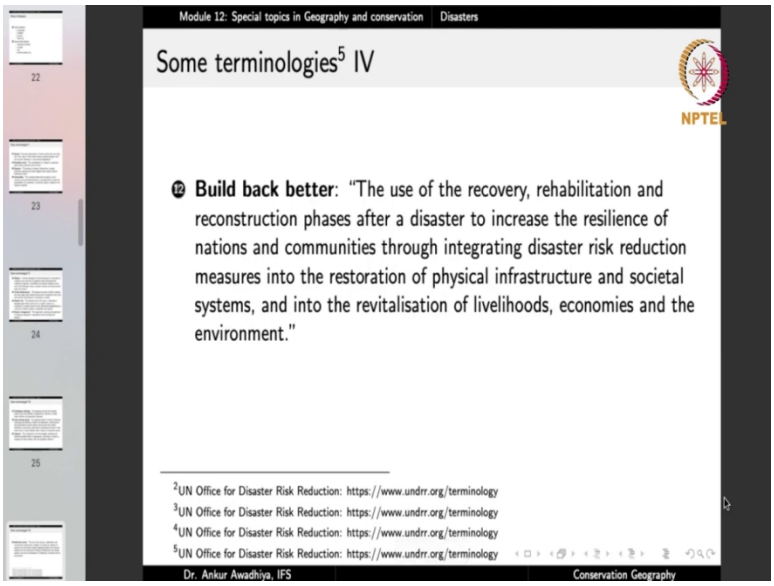


Then we have contingency planning, which is a management process that analyzes the disaster risks and establishes arrangements in advance to enable timely, effective and appropriate responses. So, if you have a process that analyzes this risk and establishes the arrangements in advance.

So, you are doing the preparation in advance, to enable timely, effective and appropriate responses, they should be timely meaning that they should have they should be ready to work as soon as the disaster has happened. They should be effective, which means that you should have substantial amount of infrastructure, substantial amount of resources.

So, as to enable a proper response to the disaster and appropriate they should take into account the physical factors, the climate, the people, the socio economic conditions of people, and they should be appropriate for those situations. So, you cannot have a response that caters to only one portion of the society, you should have a response that helps everybody.

So, it has to be an appropriate response. And it has to be effective in such a large amount as to be effective, to save people to save property and to bring their lives back on track. So, that is contingency planning everything and want to analyze the disaster risk and establish arrangements so that you have a timely, effective and appropriate response, to come up with a timely response we often make use of early warning systems.

An early warning system is an integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enables individuals, communities, governments, businesses, and others to take timely action to reduce disaster risk in advance of hazardous events.

So, in the case of early warning system for floods, we will have systems that monitor the rivers that tell us in advance when the rivers are swelling that have a mechanism of simulating the floods. So, if water is increasing in the reverse at a certain location, in how much time will that water be able to reach to the other locations?

And with this information, and with the information of the risk of the disaster and vulnerability of people, we should be able to plan in advance which are the locations where we should be putting up a response and this will be accompanied by suitable communication mechanisms, so that this information is transmitted to those that need that information in a timely fashion and then it will become an early warning system.

So, it is an integrated system, because you have several parts like simulation, like monitoring of the river, like communication systems. So, all of these are integrated together to make the early warning system. So, it is an integrated system of hazard monitoring, forecasting and prediction or disaster risk assessment with communication and preparedness activities, systems and processes that enable individuals, communities, governments, businesses and others to take timely action.

Now, why do we have this early warning system so that we can make a timely action to reduce the disaster risk in advance of the hazardous events. So, early warning systems give us a warning in advance before the disaster has struck. So, that we can do something to reduce the impact of the disasters.

Similarly, we have a tsunami warning system in our oceans. So, if there is any tsunami that is coming to our coast, we should have a prior warning, we are using satellite systems to track the clouds to track the wind patterns. So, that if there is any cyclone that is going to strike us we should know in advance where it is coming, when is it going to come where it will make landfall, what is the intensity?

Which are the people who will be affected. And if we have this information in a timely fashion, only then we will be able to perform things like evacuation of people so that less number of lives are lost. We can do things like boosting up the infrastructure of certain locations, so that the impact of the disaster is reduced.

So, all of these systems become part of early warning systems. Then we have capacity, the combination of all the strengths, attributes and resources available within an organization, community, or society to manage and reduce disaster risk, and strengthen resilience. So, it is a combination of everything, all the strengths of a society or a community, all the attributes, all the resources that are available within the community or the organization to manage and reduce the disaster risk and strengthen the resilience.

Resilience is the property of coming back once the disaster has happened. And in the context of resilience, we talk about build back better the use of recovery, rehabilitation and reconstruction phases after a disaster, to increase the resilience of nations and communities, through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and environment.

So, the philosophy of build back better see is that once the disaster has occurred, and you are trying to rebuild the society, then you can make use of this rebuilding process as an opportunity to integrate with this building the principles of disaster risk reduction. So, we create the buildings, once a disaster has occurred, we construct buildings in such a manner that they are better able to withstand the next disaster.

And that is the philosophy of build back better. And we use it not just in the case of physical infrastructure, but also for social systems and for the revitalization of livelihoods economies in the environment.

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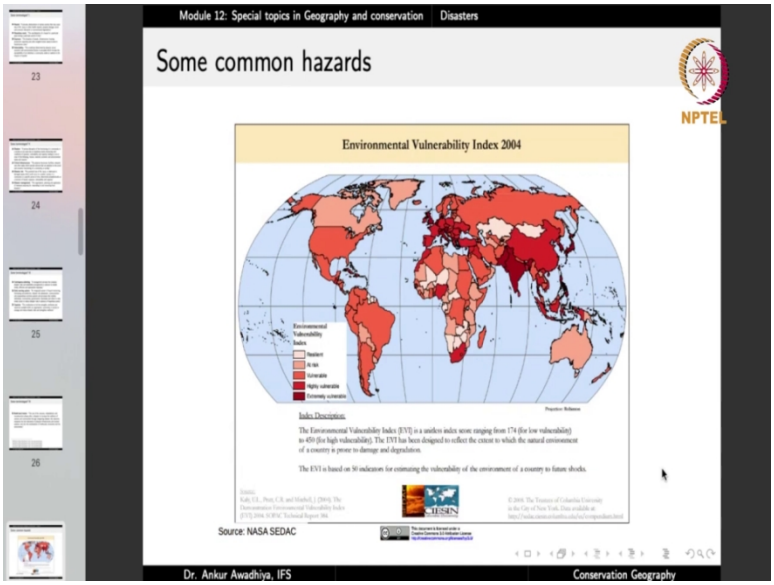
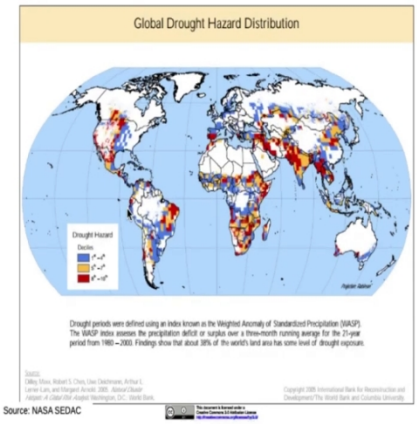



## Some common hazards




Drought periods were defined using an index known as the Weighted Anomaly of Standardized Precipitation (WASP). The WASP index assesses the precipitation deficit or surplus over a three-month running average for the 21-year period from 1980 – 2000. Findings show that about 38% of the world's land area has some level of drought exposure.

Source: NASA SEDAC



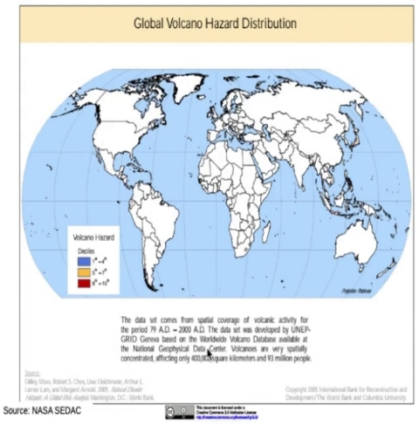


## Some common hazards


The cyclone data set is comprised of data collected from more than 1,600 storm tracks during the 21-year period from 1980 – 2000 for the Atlantic, Pacific, and Indian Oceans. At least 6.7% of the world's land area was subject to at least one instance of tropical storm or hurricane-type conditions.

Source: NASA SEDAC

## Some common hazards

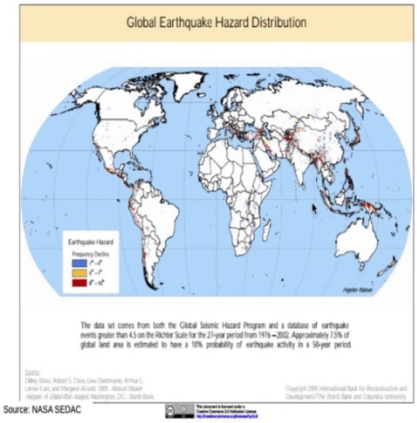



Source: NASA SEDAC

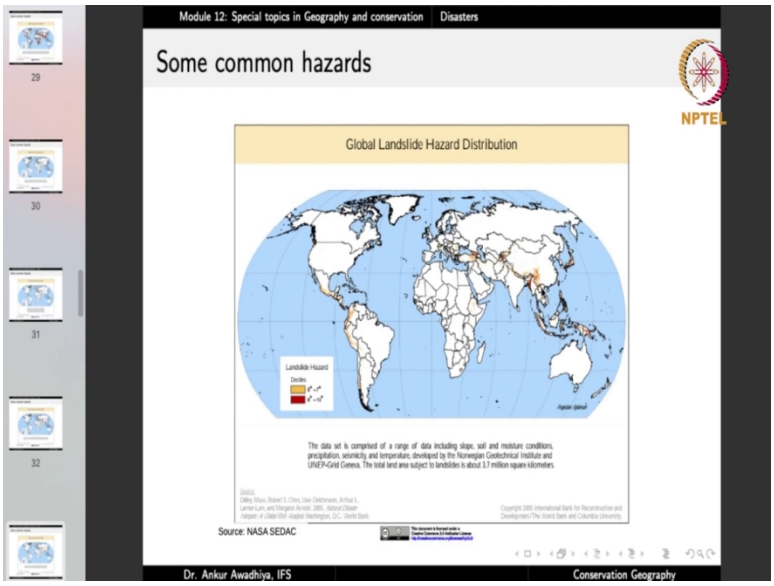




## Some common hazards




Source: NASA SEDAC




Now some common hazards include things like the environmental vulnerability, in this context, we can see that our country is having a very, is extremely vulnerable to environmental vulnerability. Now, environmental vulnerability index is based on 50 indicators for estimating the vulnerability of the environment of a country to future shocks.

So, this is an integration of various hazards. And we are looking at the vulnerability to the environment. If you look at the hazard of floods, so this is the global flood hazard distribution. Here again, we can find that our northern plains have a very high hazard of floods. But we also have areas in the eastern coast that have a very high hazard of floods.

Now these eastern coast areas have a high flood hazard primarily because of the activity of cyclones. Then we also have certain other patches in Maharashtra and Gujarat where the amount of flood hazard is very high. At the global level, we have high flood hazards in eastern Asia, Europe, certain parts of Africa, western parts of South America, and eastern parts of the US.

If you look at the global drought hazards distribution. So, this is telling us the various areas where there is a great probability of having a drought. And drought periods are defined using an index known as the weighted anomaly of standard precipitation, or the wasp index, which assesses the precipitation deficit or surplus over a three month running average for 21 years.

So, this is over a long period of time. And it shows that 38 percent of the worlds land area has some level of drought exposure. And if you look at our country, practically every area has an

appreciable level of exposure to droughts. So, our country is very much drought prone. If you look at the global cyclone hazard distribution in our country, we have the eastern portions and some parts in Gujarat that have a high hazard of cyclones.

In the world, we have a high hazard in eastern Asia, high hazard in Madagascar, and eastern US and Central America. It is 6.7 percent of the worlds land area is subject to at least one instance of tropical storm or hurricane type situations. When we look at a long time span of 1980 to 2000.

If you look at global volcano hazard distribution, we find that we do not have the volcano hazards in a very large number of areas. We do find volcanic hazards here or here or here. But overall, volcanoes are very spatially concentrated, affecting only 400,000 square kilometers and 93 million people.

If you look at global earthquake hazard, it is much more prominent. In our country. The Himalayan belt has a very high concentration of earthquakes. But even in other areas, we do have the earthquakes. Approximately 7.5 percent of the global land area is estimated to have a 10 percent probability of earthquake activity in a 50 year period. If you look at global land slide hazard distribution, here again we find that in our country, the Himalayan belt, because it is tectonically active be and made out of weak materials.

So, we have a large amount of landslide in the Himalayas. Otherwise, we find the landslides to be high in Japan, in Southeast Asia, in Central Asia, in Central America, and in the western parts of the South America. The total land area subject to landslides is about 3.7 million square kilometers.

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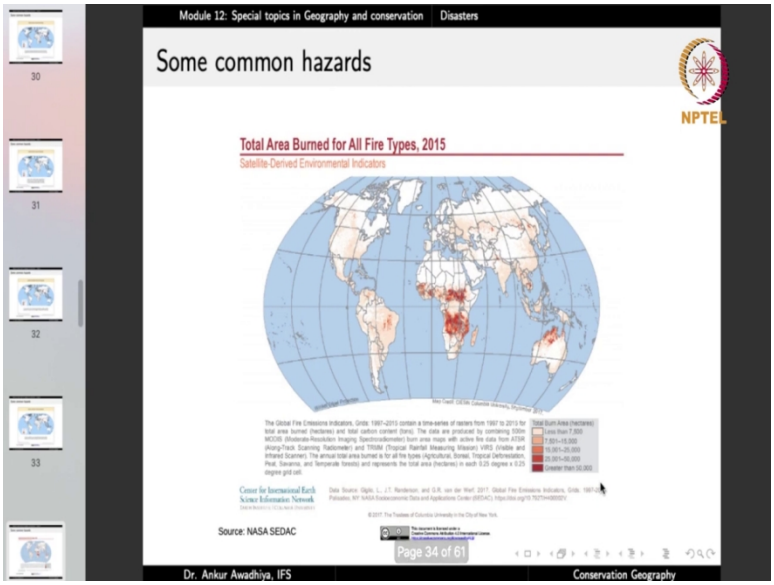
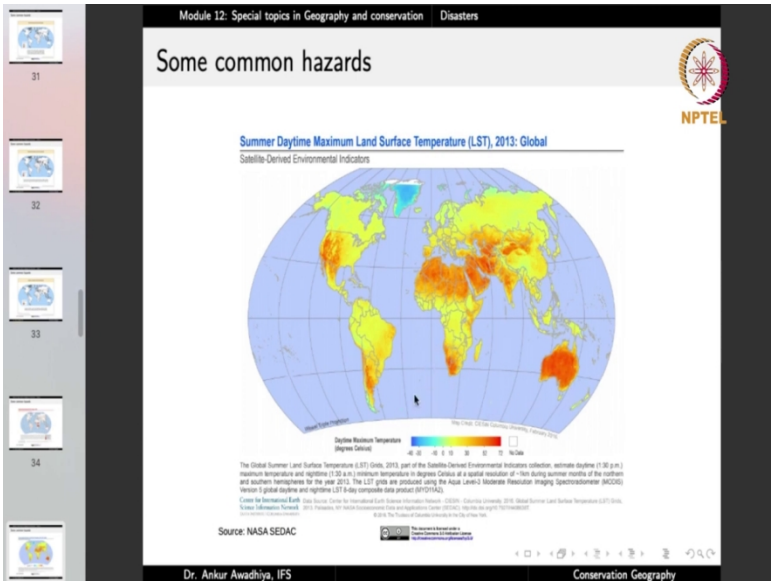
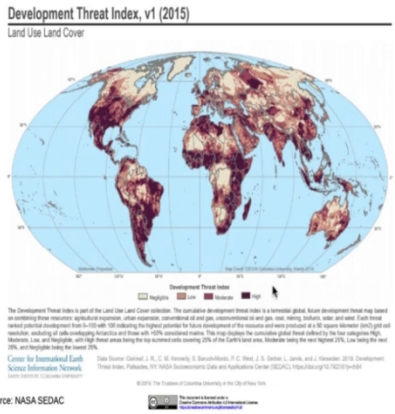


## Some common hazards

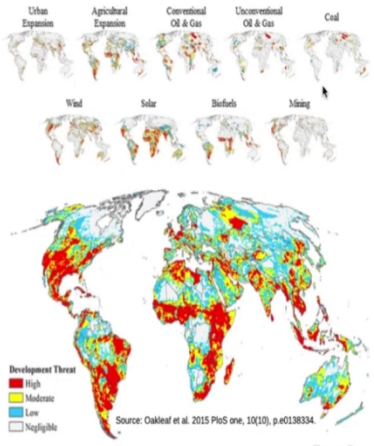



Source: NASA SEDAC





## Some common hazards




Source: Oakleaf et al. 2015 PloS one, 10(10), p.e0138334.


If we look at forest fires, then we have a very high amount of forest fires that are observed in Central and South Africa, Northern Australia, and Brazil. But other areas like most of South America, most of North America, most of our country, most of Asia, we have an appreciable amount of forest fires in these areas.

If you look at the hazard of say heat waves, so heat waves can be seen by looking at the temperature distribution of different areas. And if we look at the maximum land surface temperature, we find that most of Australia, most of southern portion of Africa, most of northern portion of Africa, large portions of Asia and Europe, a very large portion of the US and Mexico and large number of areas in South America have a very high temperature maximum in the summer season.

Then we can also look at the developmental threat index. Now, this index incorporates a large number of developmental activities and we look at their impacts on the environmental threats. Now, we can look at things like urban expansion, agricultural expansion, conventional oil and gas, unconventional oil and gas, especially things like fracking, coal, wind, solar, biofuels, and mining.

And if we incorporate all of them together, then we find that there are certain areas where the threat because of the developmental activities on the environment is very high. And we find that a large portion of our country most of US and Mexico, large portions in South America, large portions in Africa, large portions in Australia.

So, you find a threat of development or a threat because of development that is there in large number of areas. Now, if you look at the global distribution of significant exposure to hazards by number of hazards, we find that large portions in the world have some amount of exposure to hazards, most of the areas have exposure to one hazard, which are shown in blue, there are certain areas with exposure to two hazards shown in yellow and three or more results in red.

Now, overall, more than half of the world's population lives in areas subject to at least one hazard at a significant level. Now, it tells us that when we talk about disaster management, it is not a theoretical exercise, it is a practical exercise, because as much as half of the world is living under the threat of a significant hazard or a significant threat of having a disaster very soon. So, we need to have a planning for this disaster in most of the areas.

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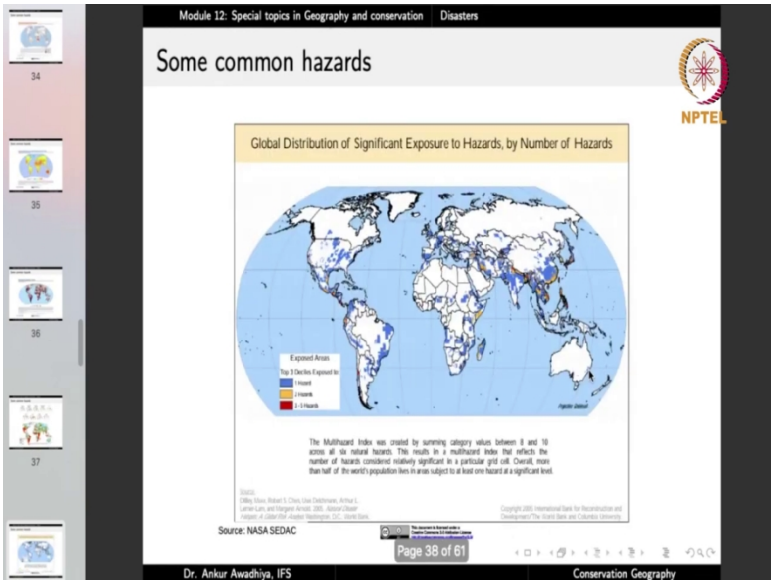
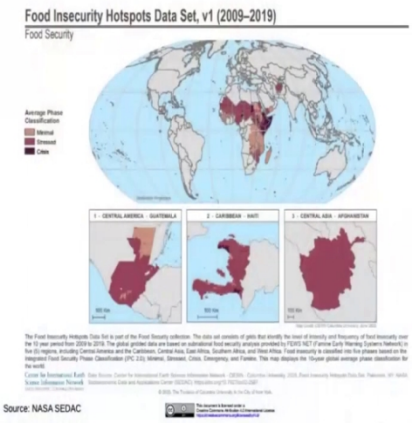


## Relation to other hazards

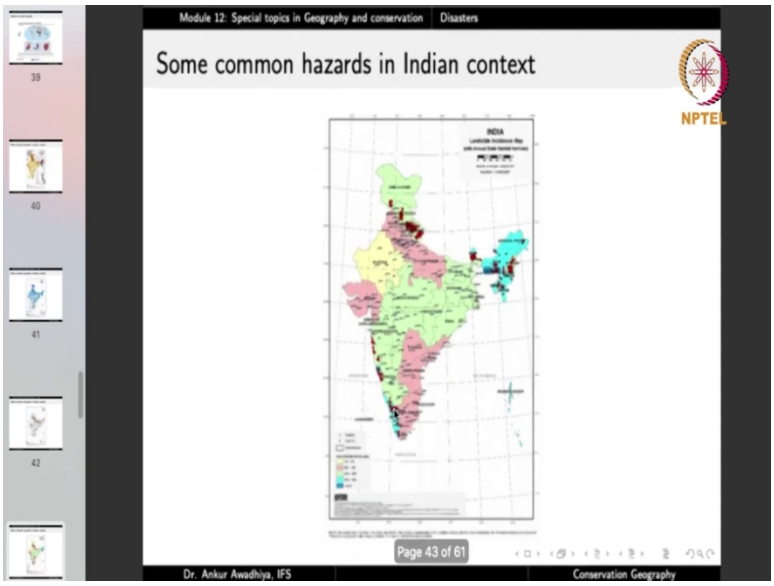



Source: NASA SEDAC





## Some common hazards in Indian context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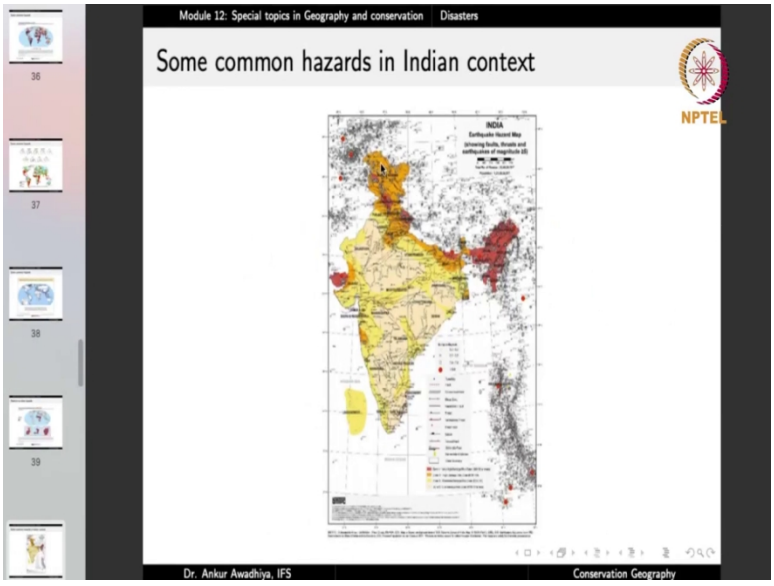
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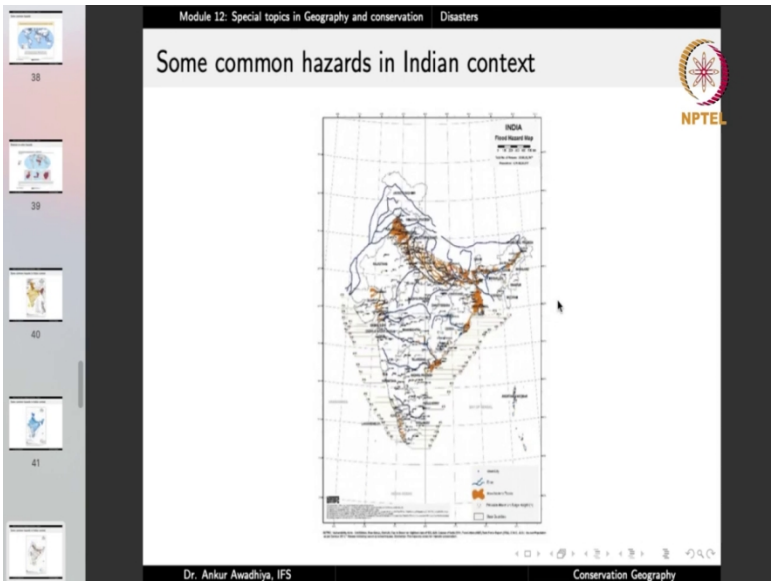
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Thus a need for disaster management.
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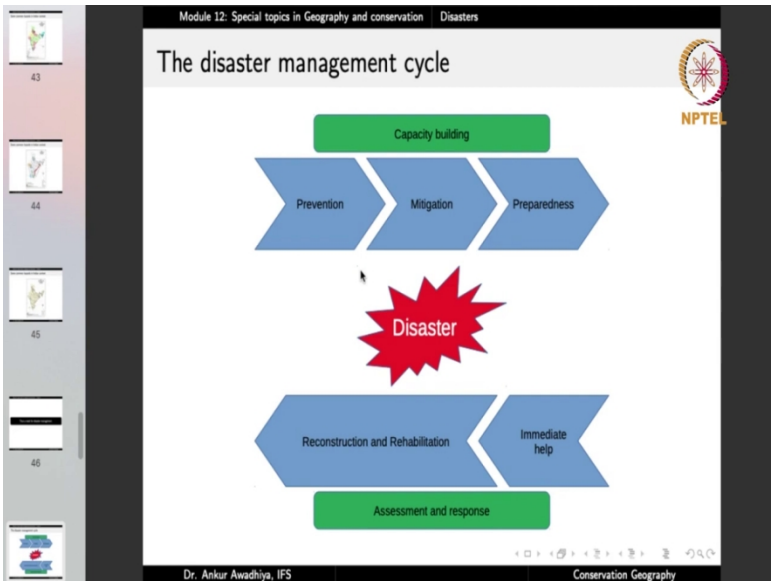
Module 12: Special topics in Geography and conservation
Disasters
The disaster management cycle
NPTEL
Capacity building
Prevention
Mitigation
Preparedness
Disaster
Reconstruction and Rehabilitation
Immediate help
Assessment and response
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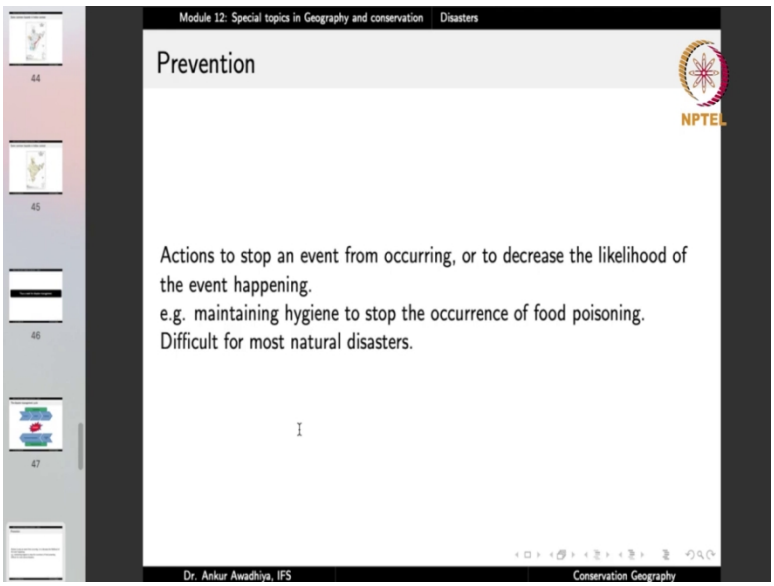
Module 12: Special topics in Geography and conservation
Disasters
Prevention
NPTEL
Actions to stop an event from occurring, or to decrease the likelihood of the event happening.
e.g. maintaining hygiene to stop the occurrence of food poisoning.
Difficult for most natural disasters.
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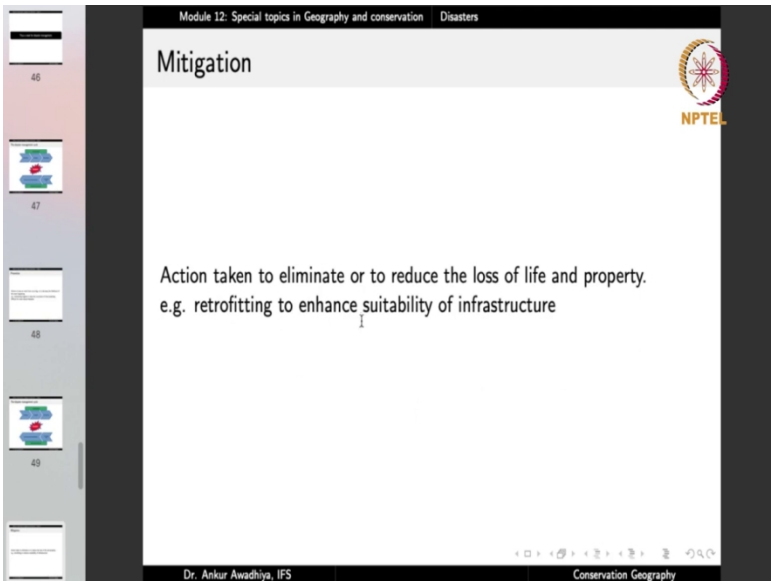
Module 12: Special topics in Geography and conservation
Disasters
Mitigation
NPTEL
Action taken to eliminate or to reduce the loss of life and property.
e.g. retrofitting to enhance suitability of infrastructure
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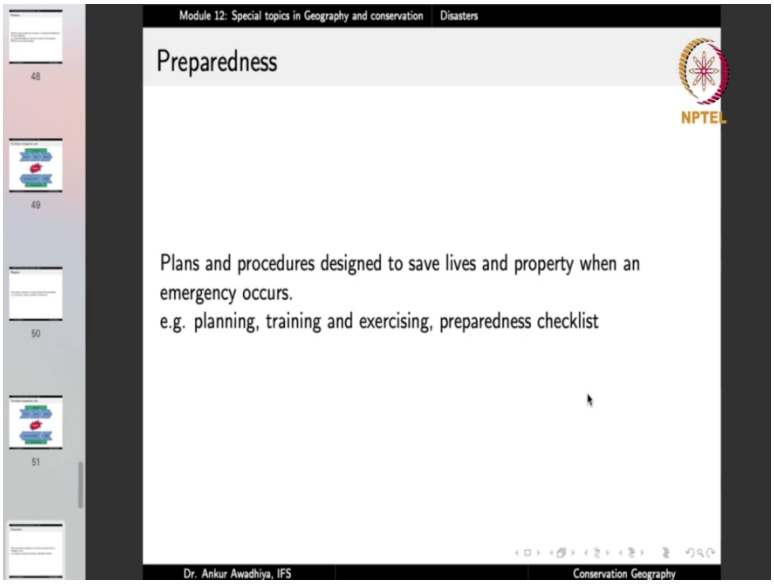
Module 12: Special topics in Geography and conservation
Disasters
Preparedness
NPTEL
Plans and procedures designed to save lives and property when an emergency occurs.
e.g. planning, training and exercising, preparedness checklist
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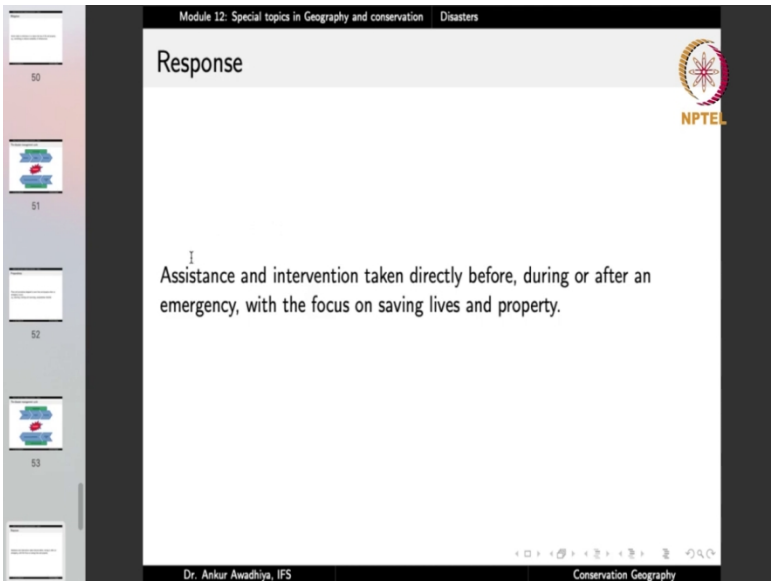
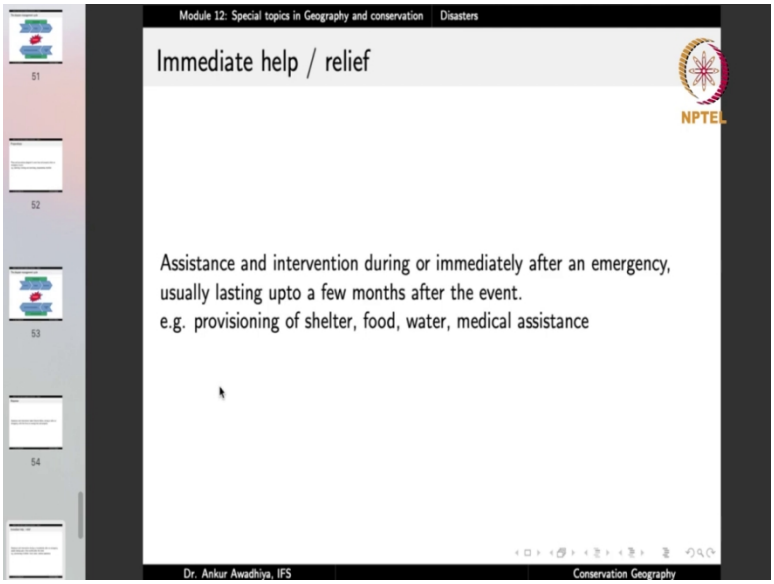
Conservation Geography




Now, these hazards also become important because they are related to other hazards as well which increase the vulnerability. For example, if you look at things like the food insecurity, so large portions in Africa, large portions in Asia have a threat of food insecurity. Now, if people are already living in a situation where there is an insecurity of food, then even if there is a small amount of hazard that will result in a very large consequence.

So, the vulnerability of the people is very high, they do not have a mechanism to fall back to and when we talk about the reduction of the disaster risk, we have to be very careful about these areas where there is food insecurity already in the Indian context, we can look at the earthquake hazard.

So, most of our northern areas, areas in Gujarat and Maharashtra they have suffered earthquakes in the recent past. If you look at the wind hazard, there are certain locations especially in Jammu and Kashmir and Ladakh, northeast India and large portions of our eastern coast and the northern plains where the wind speeds are very high.

If we look at the flood hazard, we find that large portions of our northern plains eastern coasts in western coast have a substantial amount of flood hazard. If you look at landslides, these are the areas where we have had landslides in the recent past. If we look at the cyclone occurrence, both our eastern coast and our western coast are exposed to cyclones.

If we look at thunderstorms, again most of the areas have had some form of thunderstorm and thus we have a great need for disaster management. Now, when we talk about disaster management, we can look at the disaster management cycle. Now, if this is the disaster, there are certain steps that have to occur before the disaster.

So, when we look at disaster management, certain steps have to be taken before the disaster and these are known as capacity building, capacity building means prevention, mitigation and preparedness, these three things come under capacity building. And once you have a disaster, you have to perform assessment and response including immediate help, reconstruction and rehabilitation.

So, let us now look at all of these, prevention is actions to stop an event from occurring or to decrease the likelihood of the event happening. So, just maintaining hygiene to stop the occurrence of food poisoning. So, that is prevention you are trying to prevent the hazard. But in most of the natural disasters, it is very difficult because we do not have much control over their occurrence.

Then we have mitigation, mitigation is action taken to eliminate or to reduce the loss of life and property such as retrofitting to enhance the suitability of infrastructure. So, in that case, we are saying that, we cannot do anything about the disaster, but at least let us make our infrastructure such that there is a reduction of loss of life and property. So, that is mitigation. Next, we have preparedness, preparedness is plans and procedures designed to save lives and property when an emergency occurs.

This includes making plans, training people, doing mock exercises, preparing checklists of the resources that you can make use of and all these steps. So, this is preparedness, then once you have the disaster, you have to do an assessment and response. Response is assistance and intervention taken directly before, during or after an emergency, with the focus on saving lives and property.

So, it is assistance that is help and intervention that are taken directly before during or after an emergency. When we say directly before, it means that we are trying to say bring in tends, stocking food supply or evacuating people, because we know that say a cyclone is just going to arrive.

So, we are making steps, we are making interventions. And we are helping out people to move away from that area that is directly before we can have certain interventions during the emergency and we can have certain interventions after the emergency. And here the focus is on saving lives and property. This includes giving immediate help or relief, which is assistance and intervention during or immediately after an emergency, usually lasting up to a few months after the event such as provisioning of shelter, food, water and medical assistance. So, that is immediate help.

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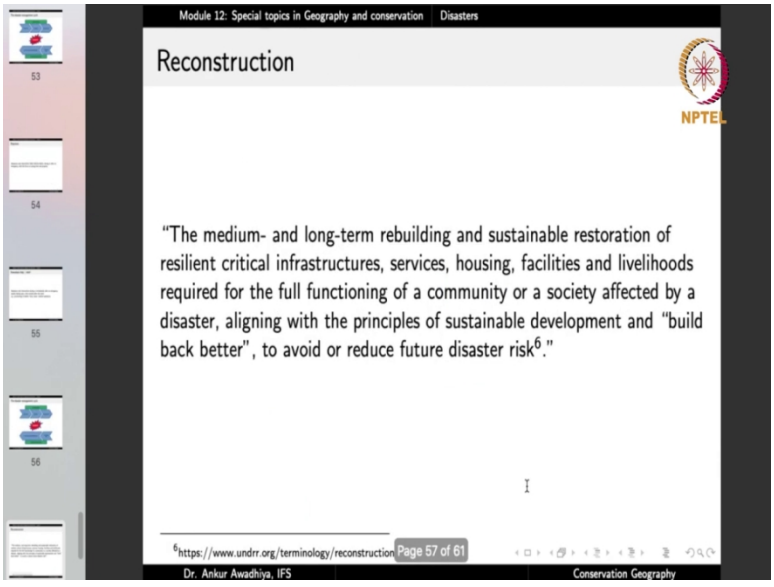

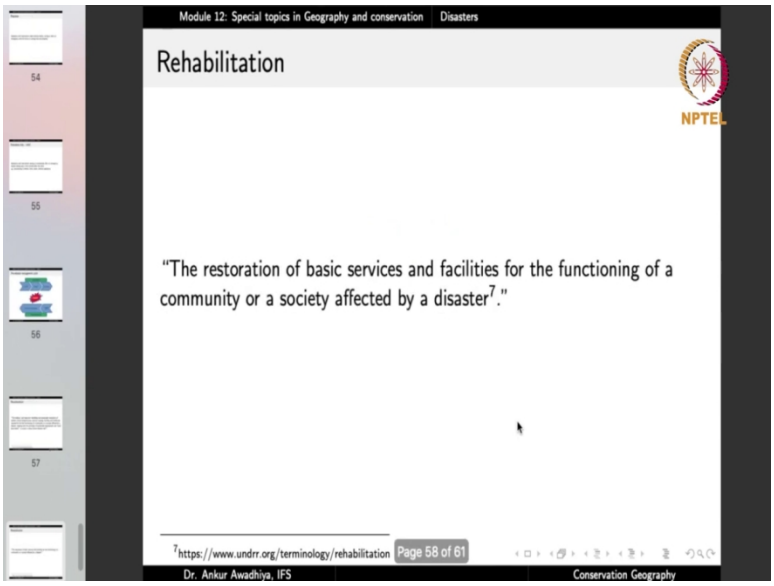
Module 12: Special topics in Geography and conservation
Disasters
Rehabilitation
NPTEL
"The restoration of basic services and facilities for the functioning of a community or a society affected by a disaster[7]."
[7]https://www.undrr.org/terminology/rehabilitation
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Module 12: Special topics in Geography and conservation
Disasters
Prime Minister's 10 point agenda for disaster risk reduction[8] I
NPTEL
1. All development sectors must imbibe the principles of disaster risk management
2. Risk coverage must include all, starting from poor households to SMEs to multi-national corporations to nation states
3. Women's leadership and greater involvement should be central to disaster risk management
4. Invest in risk mapping globally to improve global understanding of Nature and disaster risks
5. Leverage technology to enhance the efficiency of disaster risk management efforts
6. Develop a network of universities to work on disaster-related issues
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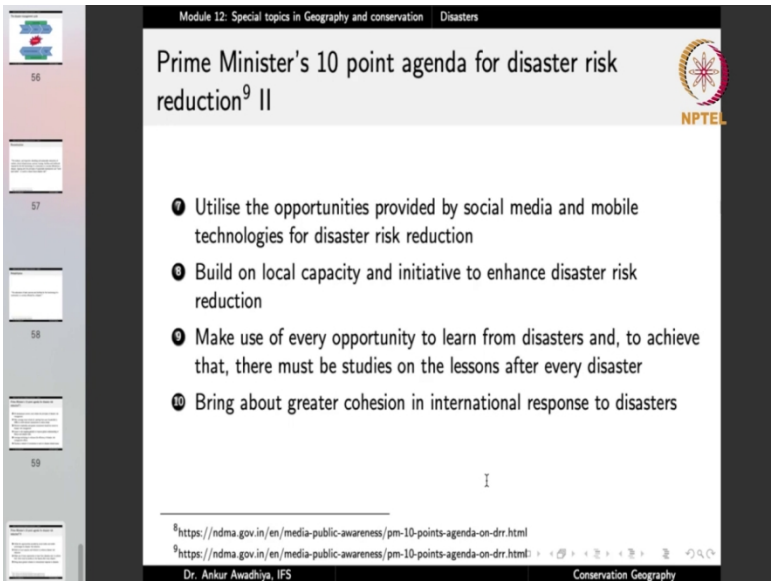


This can be followed by reconstruction, the medium and long term rebuilding. So, when we say reconstruction, it is constructing again, building again, rebuilding and sustainable restoration of resilient critical infrastructures, services, housing facility and livelihoods required for the full functioning of a community or a society affected by a disaster, aligning with the principles of sustainable development and build back better to avoid or reduce future disaster risk.

So, we need to reconstruct things and we need to rehabilitate the people into society, which is a restoration of basic services and facilities for the functioning of a community or society affected by a disaster. So, during the phase of rehabilitation, we are trying to bring the whole society back on its tracks.

And in this context, we can look at the Prime Ministers 10 point agenda for disaster risk reduction. It includes points like all developmental sectors must imbibe the principles of disaster risk management. Risk coverage must include all starting from poor households, to small and medium enterprises to multinational corporations to nation states.

Women's leadership and greater involvement should be central to disaster risk management. So, we need to make use of women's leadership, we need to involve them. We need to invest in risk mapping globally to improve global understanding of nature and disaster risk. Leverage technology to enhance the efficiency of disaster risk management efforts.

Develop a network of universities to work on disaster related issues, utilize the opportunities provided by social media and mobile technologies for disaster risk reduction. Build on local capacity and initiative to enhance disaster risk reduction. Make use of every opportunity to learn from the disasters.

And to achieve that there must be studies on the lessons after every disaster and bring about greater cohesion in international response to disasters. So, because all of us in different countries, we all face different disasters, so we have to come together, have a scientific approach, bring up all of our technologies and resources to fight these disasters. And only then we will be able to reduce the risk of disasters and reduce the suffering of our peoples. So, that is all for today. Thank you for your attention. Jai Hind!