REMOTE SENSING FOR NATURAL HAZARD STUDIES

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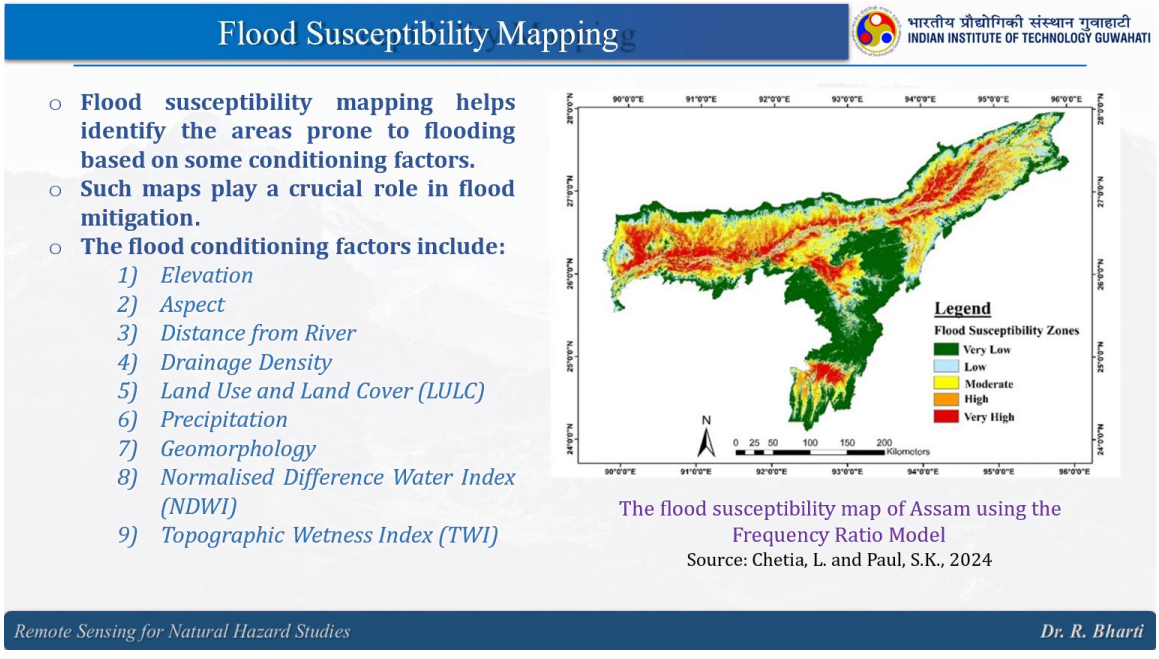
Lec 14a: Introduction to Floods - II Part A

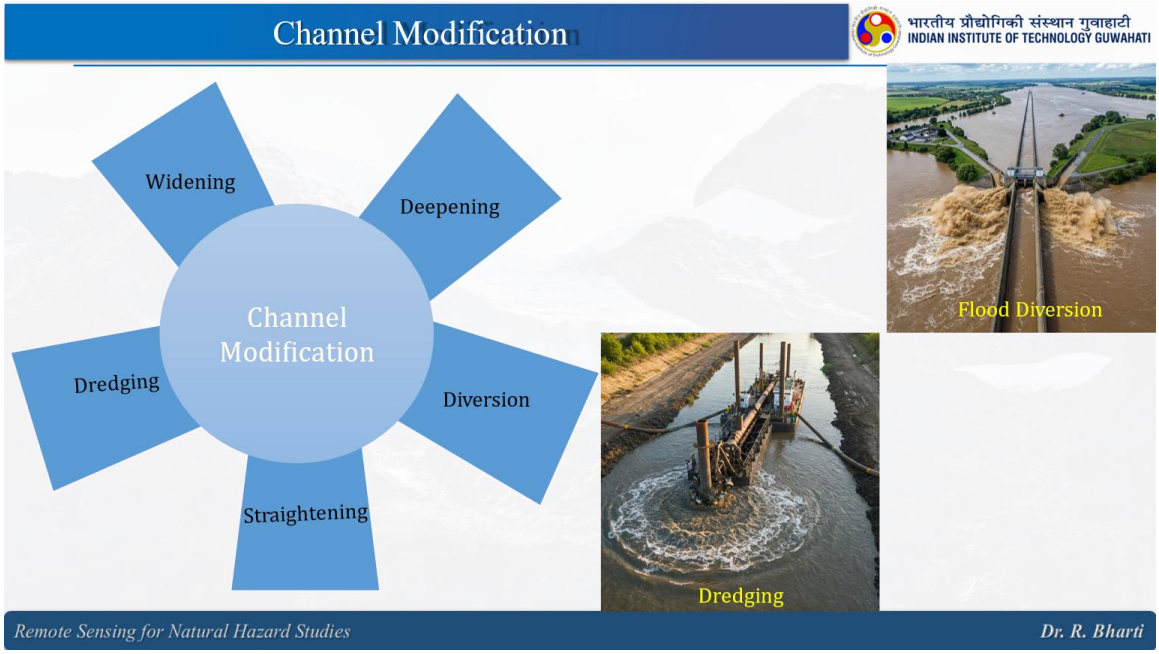
Hello, everyone, today we will continue with Module 5, which is on Flood Studies. So, here we will start lecture 14. In the last lecture, Lecture 13, we learned about the basics of floods, saw different types of floods, discussed the different parameters that play a critical role in floods, and learned that floods can have both positive and negative impacts. So, today we will start this lecture on flood control measures. So, here you can see that when we talk about flood control measures, there are two different types. So, the first one can be your structural measures, and the second can be non-structural measures. When we talk about the structural measures, they involve the physical construction to reduce the flood impacts. So, here the construction work is involved in controlling the impact or managing the flood situation.



So, the first one can be a storage or detention reservoir. It can be levees, flood embankments, or floodways that we modify; then we can improve the channel to enhance

navigation. When we talk about channel improvement, we try to improve the channel, the fluvial system, so that it can accommodate the extra water that comes during a flood event. Then comes watershed management. So, there are different types of structural measures. So, this is an example of the embankment you can see, so that you will be able to perceive what exactly I am telling you. So, these two are different types of embankments. Here you can see this is an example of a dam and barrage. Then come the levee and flood walls. So, levees are elongated elevated ridges that develop at the channel floodplain border when overbank flow occurs. So, here you can see that this is what I am saying: this is the levee. So, this is the elevated ridge that develops at the channel floodplain. This is because of the sediment that is carried during the flood, which gets deposited and slowly takes the form of these ridges, known as levees. This is a flood wall. You can see here that these are the flood walls, which were created to restrict the water during a flood event.

Then comes the natural detention basin. So, you might have seen this kind of pond in your surroundings or this kind of structure. So, this is the natural detention basin. So, during a flood, what happens is that they work as a storage for that floodwater. So, the spilling will be less when we talk about flood water harvesting. So, here we can have two different categories: one where we are using the storage structure to store this flood water. So, it can be check dams, Nala bunds, or percolation tanks. In some other cases, the water spread over the command area correctly. So, that is also for recharging the groundwater.



Then comes the channel modification; in the channel modification, we have the deepening of the channel, diversion of the channels, and straightening of the channel,

because when you have a main ring and more water, the flood situation will be more severe. So, we tried straightening our channel, then dredging, and then widening the river

channels. So, here you can see that this is one example of dredging. And this is an example of flood diversion. So, you can see how it is being diverted. Then come the non-structural measures for flood control. So, here we talk about the knowledge that is used in floods. So, when we talk about the non-structural measures, they involve the use of knowledge practices to reduce the hazard and various awareness programs. So, here we will see some examples like floodplain zoning, flood forecasting and warning, evacuation and relocation, and flood insurance. These are different types of non-structural measures that try to reduce the severity of floods. So, these are the measures. We will see each other one by one. So, here is the first one: floodplain zoning.

Flood Plain Zoning

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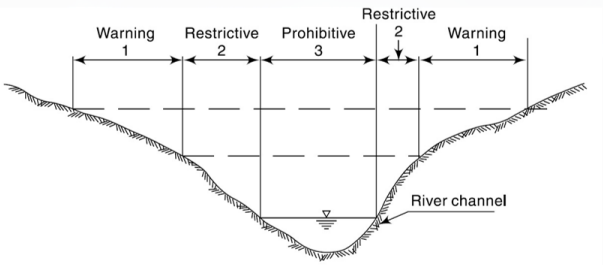
Floodplain management helps identify flood-prone areas and regulates land use to reduce and restrict flood damage.

- ✓ Usually affected by the floods of various return periods.
- ✓ Different measures can be taken based on the zone to reduce damage.



Conceptual zoning of a flood plain
Source: Subrayamanya, 2023

Zone	Return Period of Flood	Example of uses
1	100 years	Residential Areas, Factories, and Offices
2	25 years	Parks
3	Frequent	No Encroachment/Construction

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Floodplain management helps to identify flood-prone areas and regulates land use to reduce and restrict flood damage, which is usually affected by floods of various return periods. So, here you can see 100 years, 25 years, or very frequently. Different measures can be taken based on the zone to reduce damage. So, when we talk about the 100-year return period, how are we utilizing that particular area? So, we can utilize that area to build residential areas, factories, or offices. If the return period is 25 years, then we can go for parks; if it is very frequent, we do not utilize that particular area. So, here we can see that the encroachment and illegal constructions are more prevalent because these are not officially allowed. So, here you can see this is the floodplain zoning; this is an example of floodplain zoning.

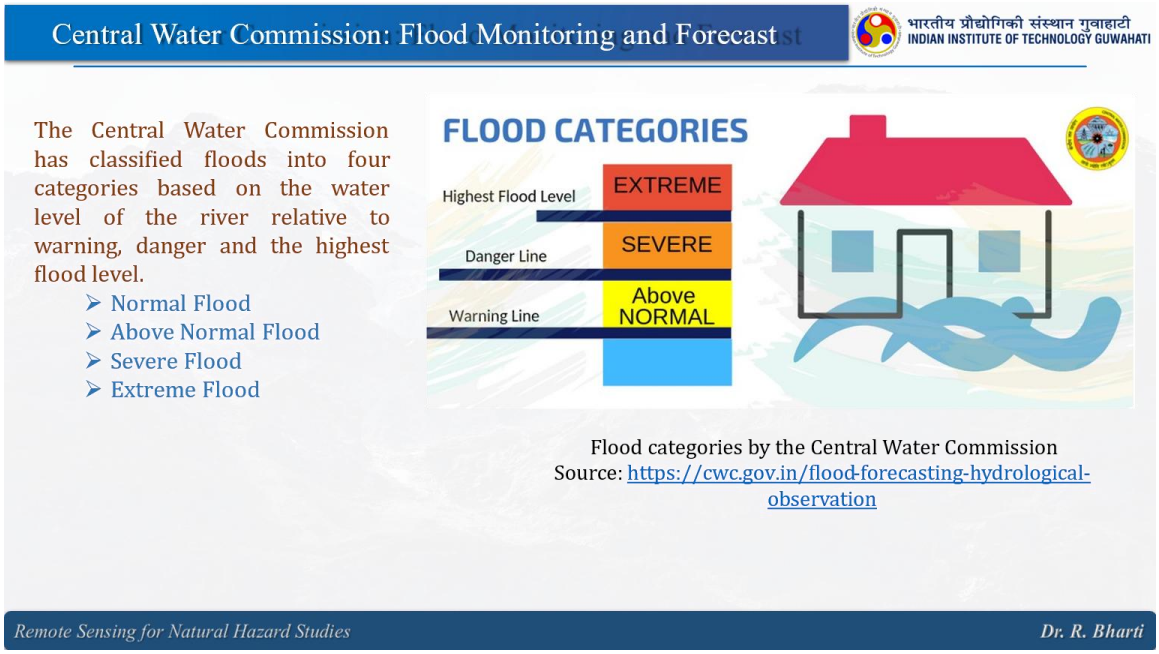
So, here you can see this is the zone where you have warning, then restrictive, then prohibited, then warning again, and this is the cross-section of a river channel, and this is

the water level. When we see the flood forecast warning, it can be a short-range forecast, medium-range forecast, or long-range forecast. When we talk about short-range forecasts, the river stages at the successive stations on a river are correlated with different hydrological parameters, like rainfall and antecedent precipitation, which is the condition of precipitation in the last 5 days, as well as the stage variation at the upstream base location. Stage variation means how it changes in the cross-section. So, during the flood period, advance warnings of 12 to 40 hours are given using this method. So, this is called a short-range forecast; here, we talk about 12 to 40 hours. Medium-range forecasts of the relationship between rainfall and runoff are studied, and flood levels are predicted with a warning of 2 to 5 days. Here you can see it has increased from 12 to 40, then to 2, and finally to 5 days. Long-range forecasts, in this case, the information regarding the critical storm-producing weather system, the potential for rain, as well as the time of occurrence, are predicted using radar and meteorological satellite data. So, this will be before these 5 days.

The Central Water Commission (CWC) in India is actively engaged in flood monitoring and forecasting services. CWC monitors the flood situation in the country by observing the water levels and discharge along the major rivers. They have a very good network so that they can collect the in-situ measurements. The CWC network is spread across 10 major river systems of the Ganga and its tributaries, the Indus or Jhelum, the Brahmaputra and its tributaries, the Barak and the eastern rivers, and the Mahanadi, Godavari, Krishna, and west-flowing rivers, covering 72 rivers and sub-basins over 17 states. So, you can see how actively they are engaged in flood monitoring and forecasting services.

The flood forecasting and advance warning for 148 low-lying areas and 28 reservoirs help in deciding on mitigation measures such as the evacuation of people and the shifting of their movable property. The inflow forecast of 28 reservoirs is used by the dam authorities for opening the reservoir gates to control the floodwater and ensure adequate storage in the reservoir for meeting irrigation and hydropower generation. So, that is also done by the dam authorities using this CWC forecasting. Such services are normally available during the monsoon period because, in the monsoon, we are more vulnerable to floods.

The overall accuracy of the forecast issued by the CWC over the past few years is 97%. So, you can see how actively and precisely they are predicting and forecasting the flood events. On the CWC website, you can see that this content is freely available. So, the Central Water Commission has classified floods into four categories.



So, the first one is a normal flood, then above normal, then severe, then extreme flood. So, based on the water level, they decide whether it is normal, above normal, severe, or extreme. So, here you can see the warning line and the color they are using; it is different. A normal flood at a flood forecasting location occurs when the river stays below the alert level. So, if you see the cross-section, this is the level. If the water stays below this, it is a normal flood. Above-normal flood is indicated by yellow; this occurs when the river reaches or surpasses the warning level while remaining below the danger level. Then severe flood is orange is sent out every 3 hours to indicate a severe flood, which is defined as when the water level surpasses the danger level but stays below the maximum flood level, and this is the extreme flood. So, this is the highest flood level. which is recorded in that particular area.

When we talk about the hydrological model, we are talking about predicting floods and forecasting alerts correctly. So, in such a situation, what are the expectations? What are the minimum things that you should know that I have listed here? So, you can see that the hydrological cycle is very, very important; knowledge about precipitation and knowledge about runoff are required. So, when we talk about this hydrological cycle, we include evaporation, transpiration, precipitation, infiltration, interflow, groundwater storage, and runoff. All of these are explained here: precipitation, which is one of the very important factors when we talk about flood modeling.

How to Create a Flood Model?

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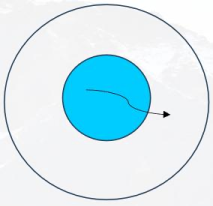
Hydrological Cycle

The combination of various processes is observed such as

- Evaporation
- Transportation
- Precipitation
- Infiltration
- Interflow
- Groundwater Storage
- Runoff

Precipitation

- It is the basic driving factor required in the hydrological model.
- Thus, it is important to represent rainfall accurately.
- Small river channels are extremely sensitive to precipitation.



Runoff

It consists of three components i.e., overflow flow, rain that falls directly on the surface water bodies and interflow.
Thus, from the storm event's onset, the amount of rainfall in the surface water in a short period is computed.

Courtesy: NOAA

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So, it is the basic driving factor required in the hydrological model; thus, it is important to represent rainfall accurately. So, we should have very accurate measurements of the precipitation because your model will have this as an important input. Small river channels are extremely sensitive to precipitation. Then comes the runoff: how the area is responding to a particular rainfall or how it is responding to a particular inflow. It consists of three components: overflow, rain that falls directly on the surface water bodies, and interflow. Thus, from the onset of the storm events, the amount of rainfall on the surface water in a short period is computed.

How to create a model? (Cont.)

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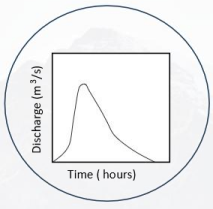
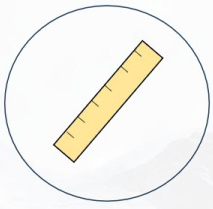


Unit Hydrograph

The hydrograph in discharge units is calculated after the basin runoff is computed.



Streamflow Data

The streamflow measurements are taken at various river levels and their corresponding stages (Height) are noted. This helps to establish a relationship between discharge and stage for a given area.

Routing

A technique that helps predict how the flood wave changes while moving through the river channel or a reservoir i.e., the hydrographs' shape change is observed.

Courtesy: NOAA

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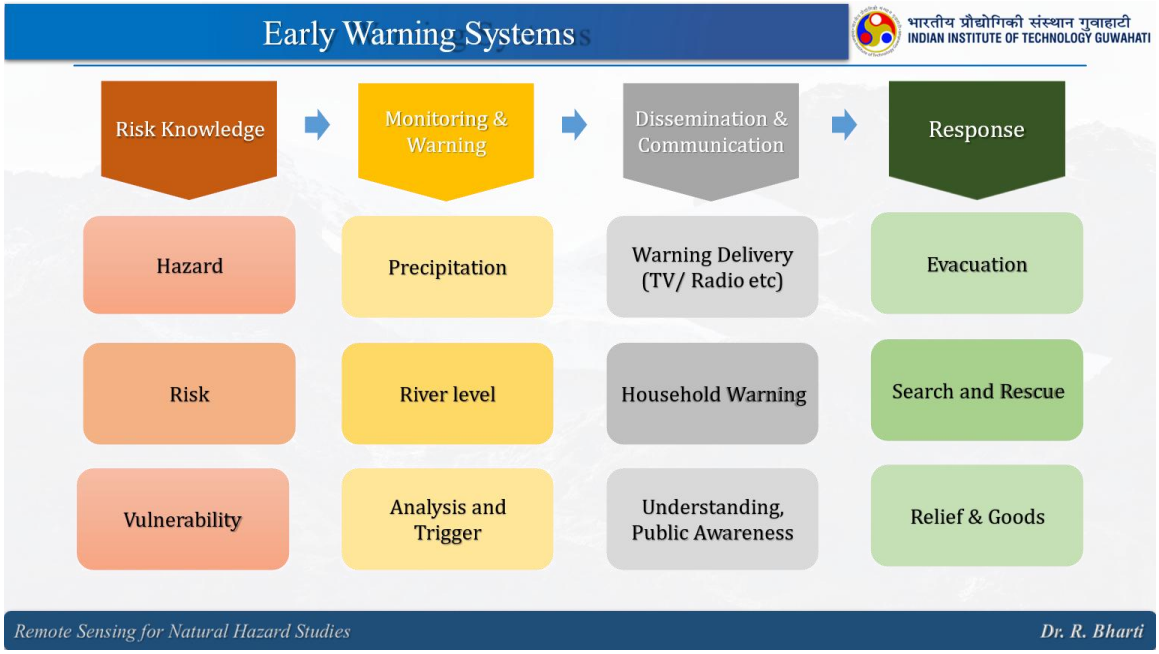
Then we have the unit hydrograph. We learned this in the previous lecture: what a hydrograph is and how it is used to define the characteristics of a particular precipitation or a particular catchment area, and how it behaves with respect to precipitation.

So, the hydrograph in discharge units is calculated after the basin runoff is computed. So, this streamflow discharge will be measured in the river, and then we will proceed with the routing. It is a technique that helps to predict how the flood waves change while moving through the river channel or a reservoir, and that is when the hydrograph shape changes are observed. So, here is basically what happens in the flood routing. We try to see how the river behaves and how the hydrograph of an upstream area is changing as it flows into the low-lying area. So, this is being studied here. Then comes the evacuation and relocation. So, evacuation and relocation are very, very important because we need to help the people who are suffering from this flood in the area. So, if we shift them permanently, then it becomes a structural measure, but if it is temporary, it will be a non-structural measure. Then comes the floodproofing. So, in flood proofing, we try to raise the building or the walls so that the floodwater will not enter the other areas.

Then comes the flood insurance; it is very, very important for some of the areas. Flood insurance is a specialized policy that helps provide financial stability and protection against losses caused by flooding. It is like any other insurance. It reduces the impact of the loss burden because people who have suffered from a flood have lost their property or assets. So, in such a condition what happens this flood insurance will help them to recover fast.

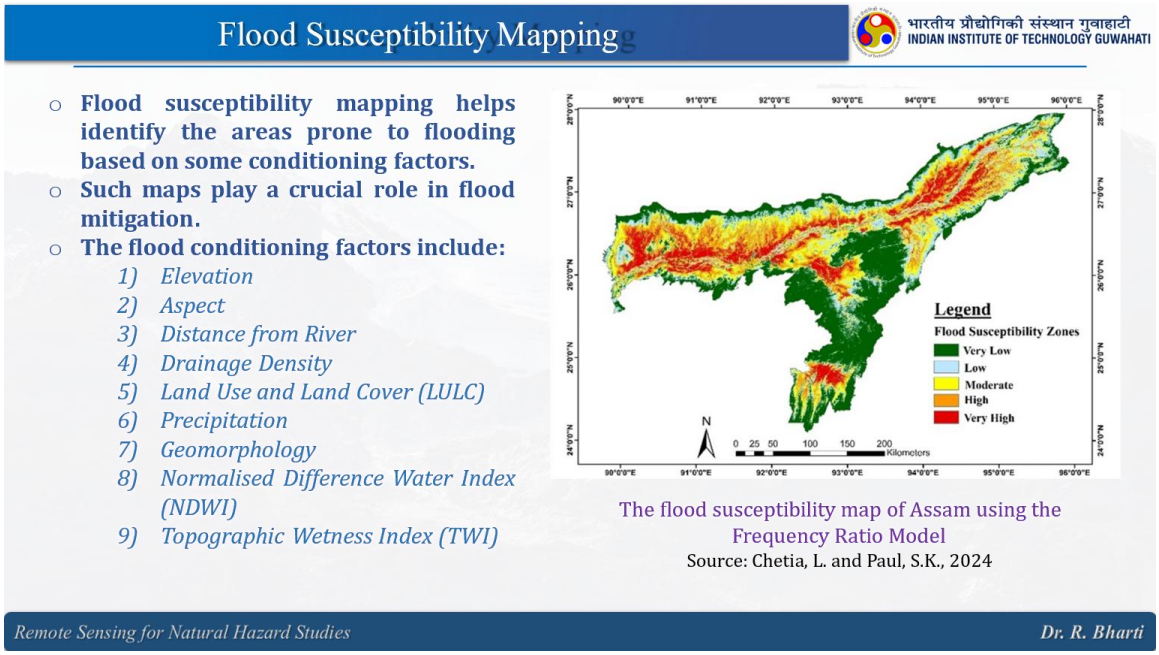


So, when we talk about this early warning system, it has four major criteria. The first one is risk knowledge, then we have monitoring and warning, then we have dissemination

and communication of the alert, and finally, response from the governance. Here, when we talk about risk knowledge, hazard, risk, and vulnerability are studied. In monitoring and warning, we have precipitation and river level; then, analysis and triggering factors are studied here. Then, the dissemination of information through mobiles, television, news channels, and newspapers aims to inform the people who are supposed to be suffering from this.

Then comes the response. So, the evacuation, search and rescue, relief, and supply of goods are also part of this response. So, this complete chain is known as an early warning system. If any of them fail, then this will not qualify as the definition of an early warning system. So, in India, we have major flood-affected states. So, starting from Bihar, we have West Bengal, then Uttar Pradesh, Odisha, Andhra Pradesh, and finally Assam.

These are major states that are affected by floods. So, when we talk about the Brahmaputra basin and see that flooding is a major problem, we have also observed that flash flood conditions sometimes occur here. The bank erosion is the major problem in the Brahmaputra basin. When we talk about the Ganga basin here, we have floods, then bank erosion, and then waterlogging or drainage congestion is also there, which was not present in the Brahmaputra basin. Then comes the Mahanadi basin; here, you have flooding, waterlogging, and drainage congestion, but bank erosion is absent.



The flood susceptibility map of Assam using the Frequency Ratio Model
Source: Chetia, L. and Paul, S.K., 2024

One important aspect is flood susceptibility mapping, which identifies the areas that are susceptible to flooding and have a high probability of flood occurrence.

So, there are different models that can be used to model the flood for a given area. So, the flood susceptibility mapping helps to identify the areas prone to flooding based on some conditioning factors. So, here such a map plays a crucial role in flood mitigation because once we know that this area is in the high probability zone and this is very high, that means this particular area needs special attention. The flood conditioning factors used in this flood modeling are elevation, aspect, and distance from the river. Drainage density, land use and land cover, precipitation, geomorphology, and then NDWI and topographic wetness index. These are used for flood susceptibility mapping. We will discuss this in detail in the next part of this lecture. For this part and the previous lecture, these are the suggested readings. So, if you are interested in working in this area, you can refer to these papers, and these are the references that I have used for lecture 13 and this part of lecture 14. So, if you are interested, you can refer to these. Thank you, and we will continue this lecture with the 14-second part.

Thank you.