**Surface Water Hydrology**
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**Lecture: 40**
**Flood Control and its Status in India**

In this lecture, we will discuss different flood control majors and also along with that, what is the status in India. So, this is our focus for this particular lecture.

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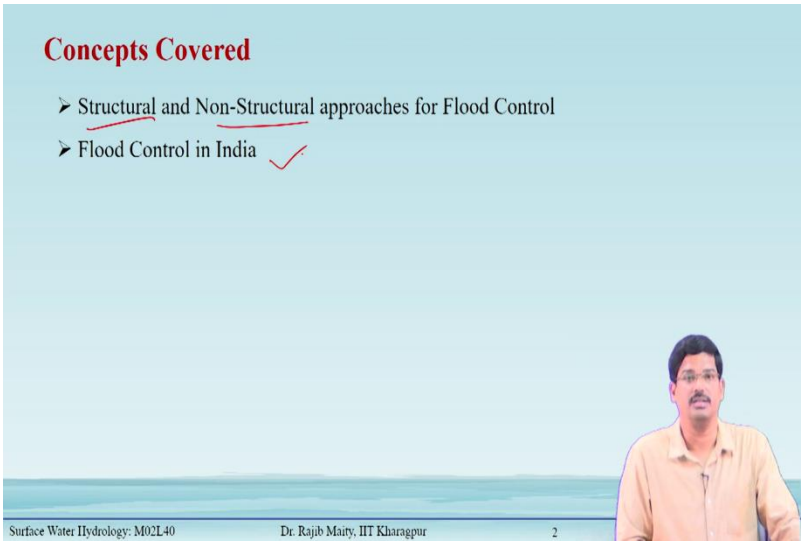


The concept cover will cover two major categories of this flood control those are known Structural Control and Non-Structural Control and then flood control in India.

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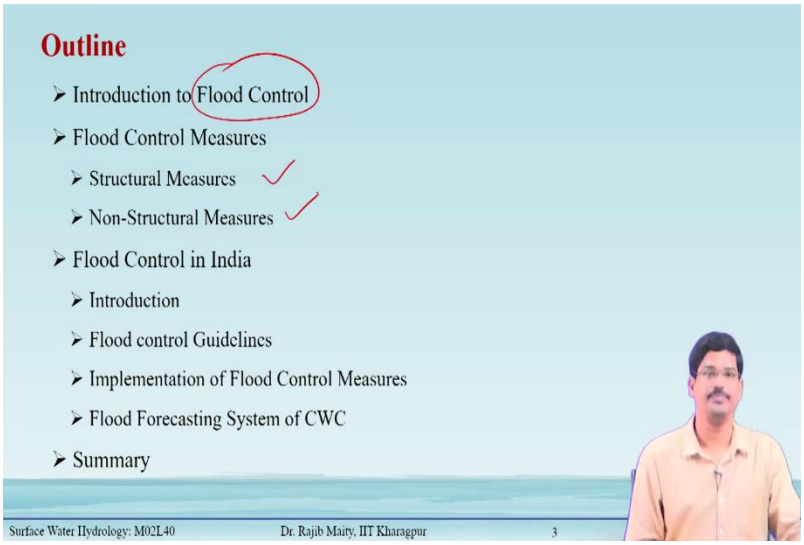


The outline of this course goes like this. First, we will give some introduction to flood control. Secondly, it comes that flood control majors, there are two broad categories are there, the first one is structural measures. And the second one is nonstructural measures. And next, under flood control in India, we will see there are different guidelines are there.

There is a different implementation of different majors are there and what is the status of the flood forecasting systems, that is under Central Water Commission CWC those things we will briefly discuss before we go to the summary.

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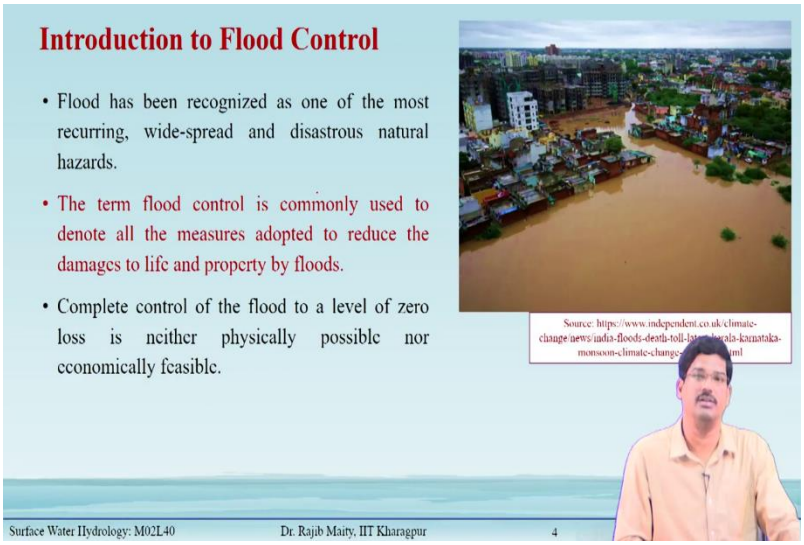


**Introduction to Flood Control**

Flood has been recognized as one of the most recurring widespread and disasters natural hazard and many times hinders our day-to-day life due to the waterlogging and due to the various effects, that are come it is not only during the flood, sometimes it causes after the floods also there are some aftermaths is thereafter the flood water reduce also.

So, all these things considering different hazards that are considered, so, in different places, flood control or flood management becomes very essential and our target is to reduce the damages to life as well as property by this natural hazard. It is also understood that complete control of the flood to a level of zero loss or that is zero damage to the property is not possible at all. It is not either possible physically or economically feasible also. So, sometimes some of the measures we need to take depend on the ground condition depending on the region at hand.

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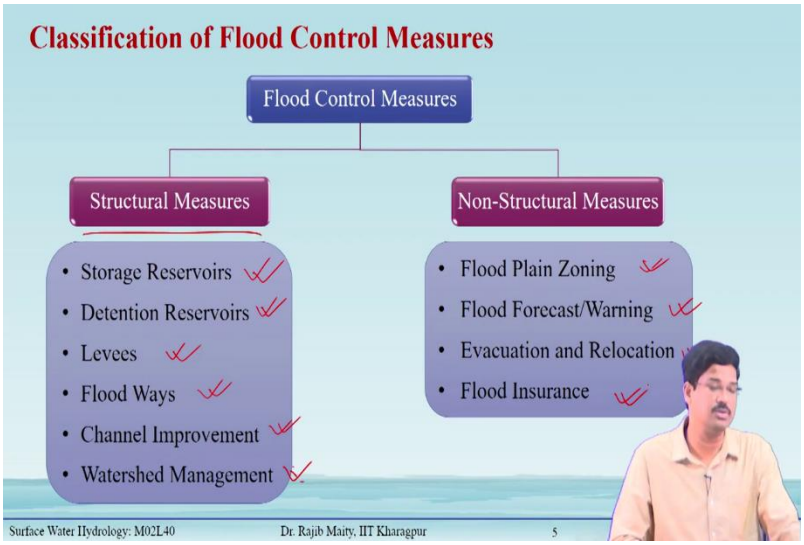


**Classification of Flood Control Measures**

The classification of flood control measures are two categories are there one is known as structural measures and another one is nonstructural measures.

The Storage Reservoirs then called the Detention Reservoir, Levees, Flood Ways, and then Channel Improvement, Watershed Management, are some of the points the structural measures that we can take to reduce the effect of floods.

Similarly, there are some Non-structural measures also, such the Flood Plain Zoning, Flood forecasting/Warning, Evacuation, Relocation, and Flood Insurance are under nonstructural measures.

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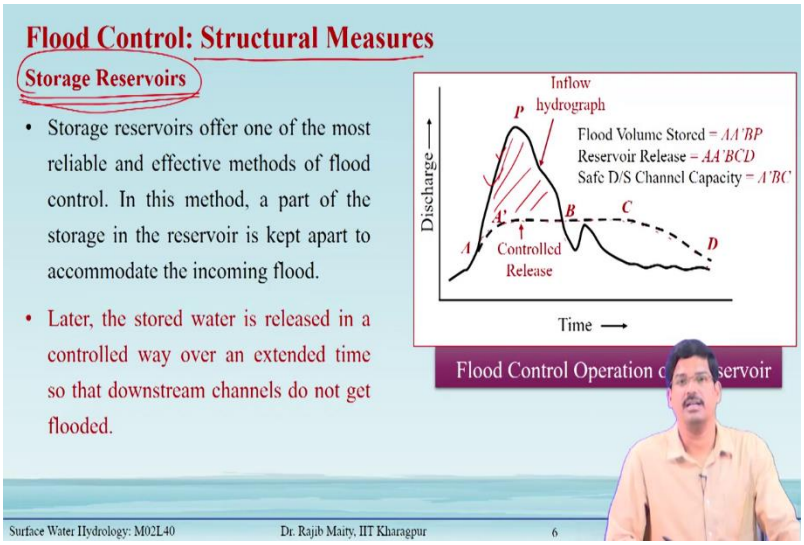


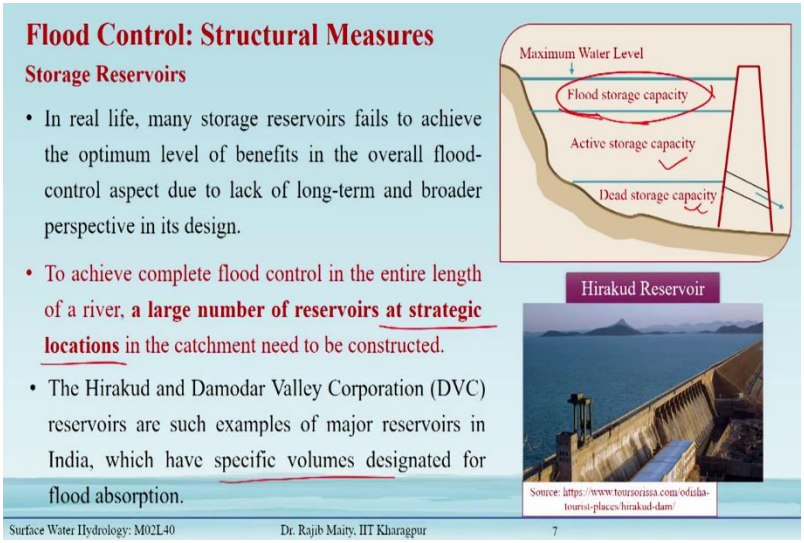


**Flood Control: Structural Measures**

**Storage Reservoirs**

Storage reservoir offers one of the most reliable and effective methods of flood control in this method a part of the storage in the reservoir is kept apart to accommodate the incoming flood.

We try to take up some volume of this flood away from the channel and keep it in some storage reservoirs, then control the flow. When the natural hydrograph would have been received, that time also we can continue releasing the high amount of the volume not exceeding the channel

capacity. The stored water which we keep in the storage reservoir, so that is released in a controlled way over an extended period. So, that the downstream channel does not get flooded

So, they are generally meet different criteria and different benefits to society. Sometimes those things are conflicting with each other. In real-life many storage reservoirs fail to achieve the optimum level of benefit in the overall flood control aspect due to the lack of long-term and a broader perspective in their design. Now, to achieve this complete flood control in the entire length of the river.

A large number of reservoirs at a strategic location is important, that has to be decided and that has to be constructed. At the same time, there are most of these reservoirs are multipurpose. So, it has to be considered the other purposes also like irrigation or hydropower generation or other issues that we need to maintain.

In India generally the Hirakud dam or the Damodar Valley Corporation, these reservoirs are the example of major reservoirs in India where the specific volume is designated for flood absorption.

Active storage, Dead storage, and maximum water level are utilized for different purposes, the hydropower generation or irrigation requirement and all these things that are there apart from this flood control. Now, its design aspects are crucial, and this particular aspect the design of different reservoirs and how to estimate how much should be the storage volume.

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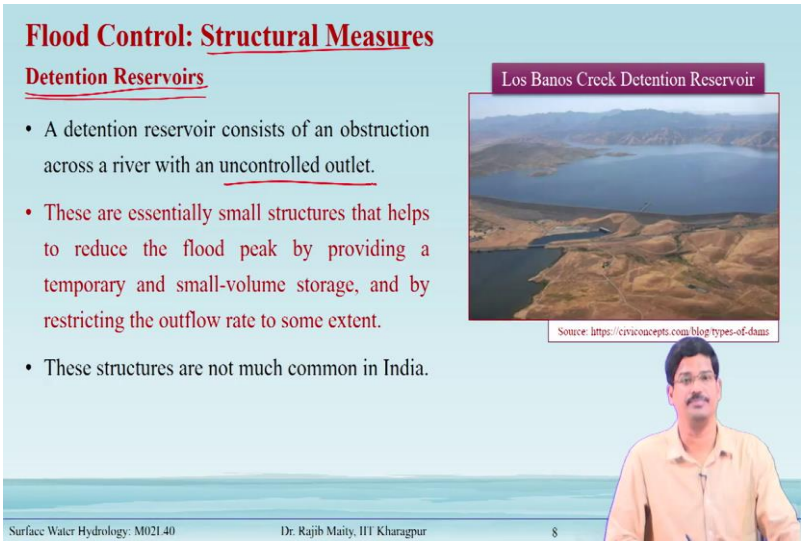


**Detention Reservoirs**

The Detention reservoir consists of an obstruction across the river with an uncontrolled outlet. So, this uncontrolled outlet means that there is no gated operation is required. We have put some obstruction like weir so that if it crosses some height automatically water overflow on this one.

But some amount of water is escaped as a detention reservoir these are essentially small structures of course, that help to reduce the flood peak by providing temporary and small volume storage and by restricting the outflow rate to some extent. So, whatever the inflow that comes from the entire catchment.

If we just put this kind of obstruction at some upward some strategic locations or locations or a determination of the location is very important. So, some amount of the floodwater can be stored within this one. And of course, those waters are not only the flood control, but it also serves many other purposes during lean time as well. So, however, these are not very common in India.

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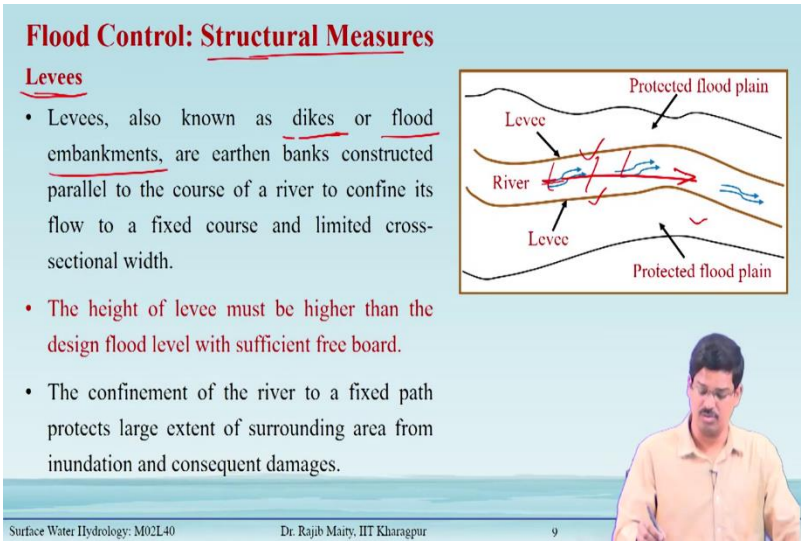


**Levees**

Levees, also known as dikes or flood embankments, are earthen banks constructed parallel to the course of a river to confine its flow to a fixed course and limited cross-sectional width. The height of the levee must be higher than the design flood level with sufficient freeboard.

The confinement of the river to a fixed path protects a large extent of the surrounding area from inundation and consequent damages.

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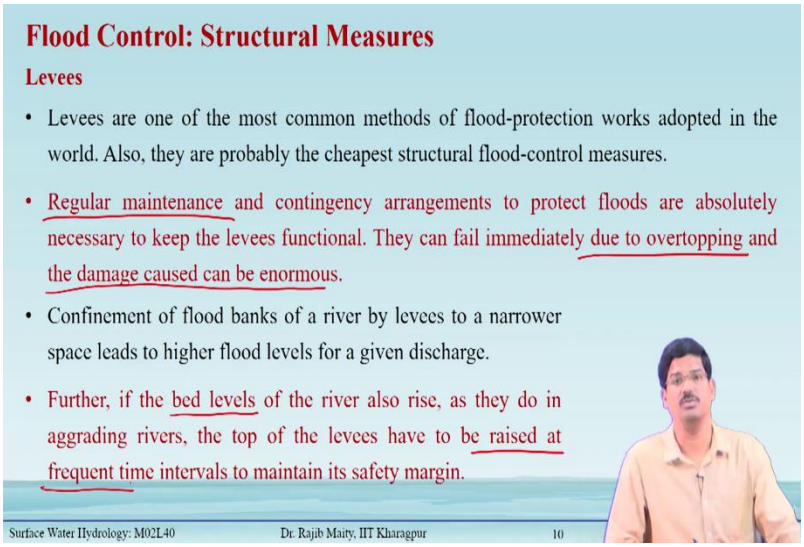

Levees are one of the most common methods of flood-protection works adopted in the world. Also, they are probably the cheapest structural flood-control measures.

Regular maintenance and contingency arrangements to protect against floods are necessary to keep the levees functional. They can fail immediately due to overtopping and the damage caused can be enormous.

Confinement of flood banks of a river by levees to a narrower space lead to higher flood levels for a given discharge.

Further, if the bed levels of the river also rise, as they do in aggrading rivers, the top of the levees have to be raised at frequent time intervals to maintain its safety margin.

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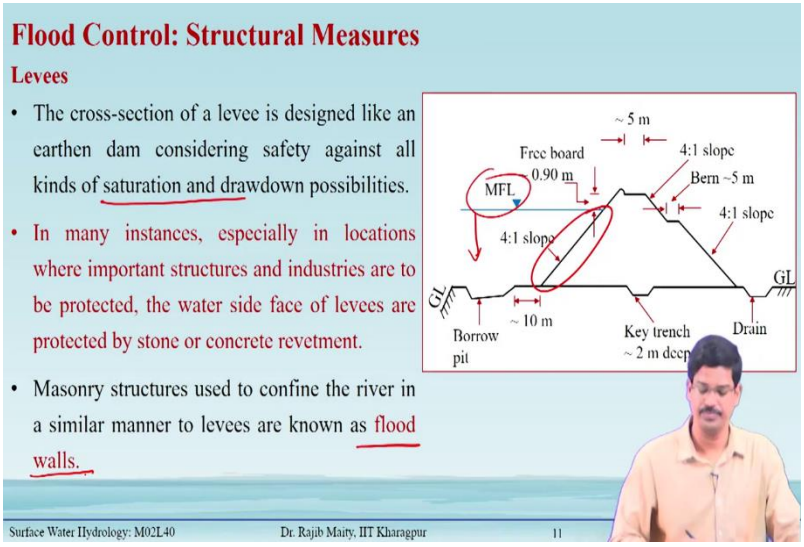


The cross-section of a levee is designed like an earthen dam, which is similar considering the safety against all kinds of saturation and drawdown possibilities. In many instances, especially in locations where important structures and industries are to be protected, the waterside face of levees is protected by stone or concrete revetment.

So, all these conditions are considered when we are designing these levees in many instances, especially in the location where the important structures or industries are there sometimes the waterside this part of this levee, is protected by the stones or the concrete revetment. Masonry

structures are used to confine the river in some places it is similar to the levees and these are known as the floodwalls.

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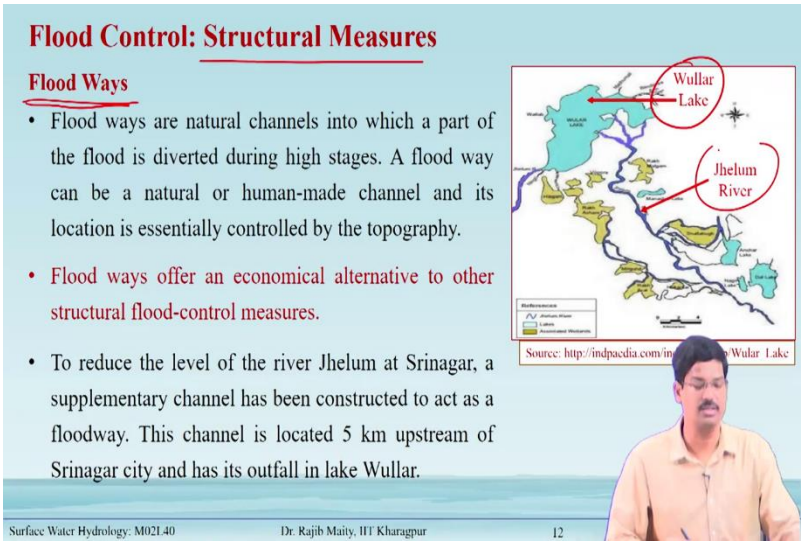


**Flood Ways**

Floodways are natural channels into which a part of the flood is diverted during high stages. A floodway can be a natural or human-made channel and its location is essentially controlled by the topography. Flood ways offer an economical alternative to other structural flood-control measures.

To reduce the level of the river Jhelum at Srinagar, a supplementary channel has been constructed to act as a floodway. This channel is located 5 km upstream of Srinagar city and has its outfall in Lake Wullar.

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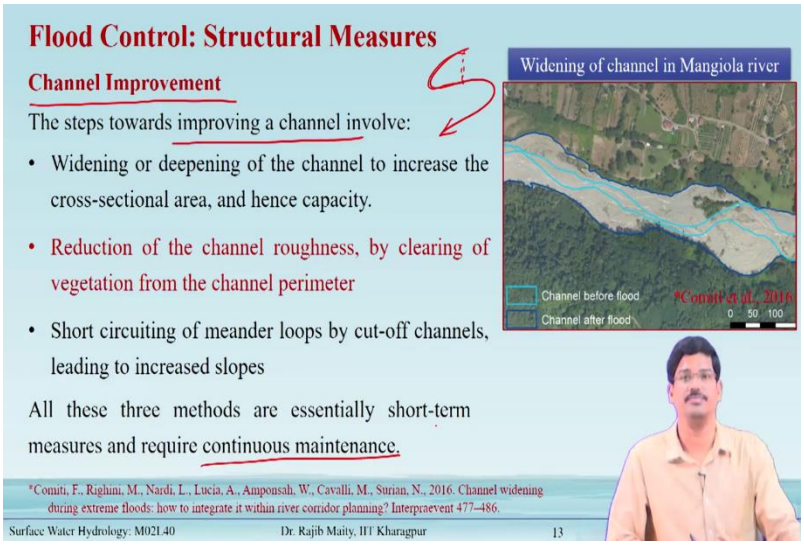


**Channel Improvement**

The steps towards improving a channel involve:

- Widening or deepening of the channel to increase the cross-sectional area, and hence capacity.
- Reduction of the channel roughness, by clearing vegetation from the channel perimeter
- Short-circuiting of meander loops by cut-off channels, leading to increased slopes

All these three methods are essentially short-term measures and require continuous maintenance.

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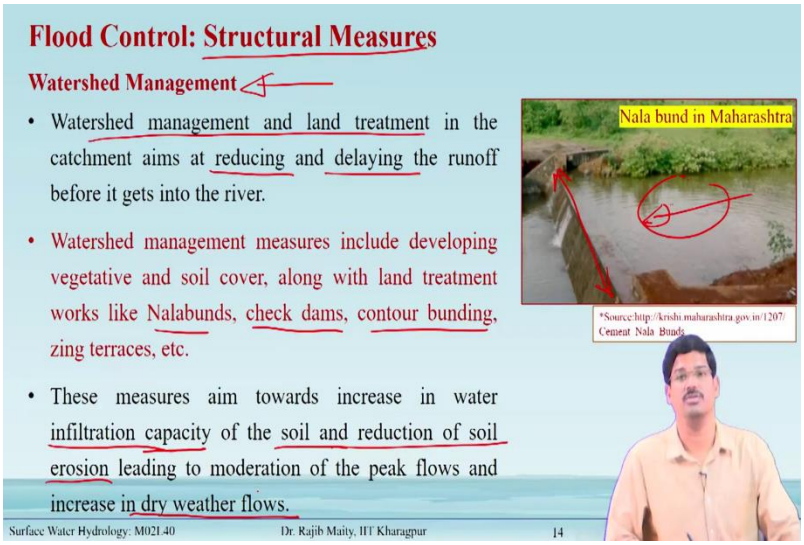


**Watershed Management**

Watershed management and land treatment in the catchment aim at reducing and delaying the runoff before it gets into the river.

Watershed management measures include developing vegetative and soil cover, along with land treatment works like Nalabunds, check dams, contour bunding, zing terraces, etc.

These measures aim towards an increase in water infiltration capacity of the soil and reduction of soil erosion leading to moderation of the peak flows and an increase in dry weather flows.

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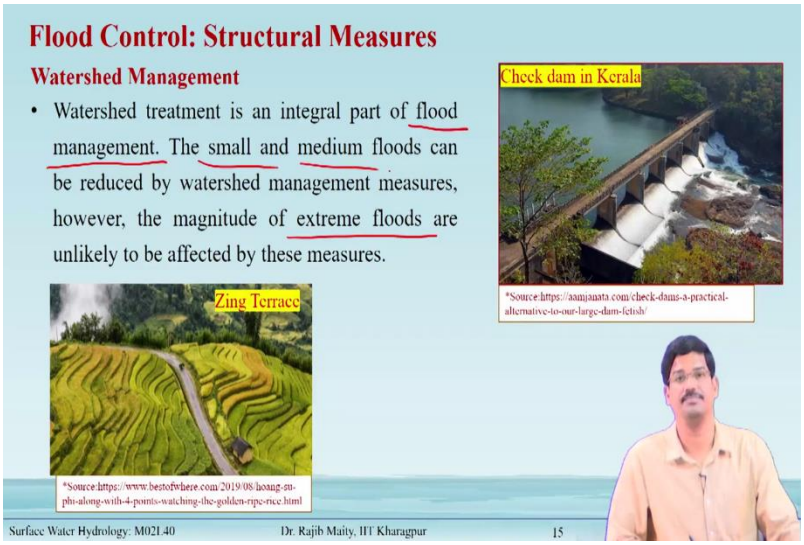


Watershed treatment is an integral part of flood management. The small and medium floods can be reduced by watershed management measures, however, the magnitude of extreme floods is unlikely to be affected by these measures.

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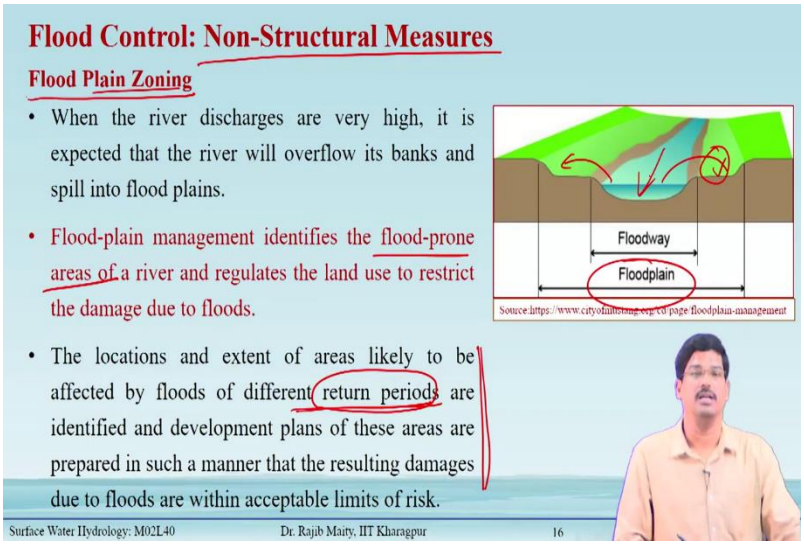

**Flood Control: Non-Structural Measures**

**Flood Plain Zoning**

When the river discharges are very high, it is expected that the river will overflow its banks and spill into flood plains.

Flood-plain management identifies the flood-prone areas of a river and regulates the land use to restrict the damage due to floods.

The locations and extent of areas likely to be affected by floods of different return periods are identified and development plans for these areas are prepared in such a manner that the resulting damages due to floods are within acceptable limits of risk.

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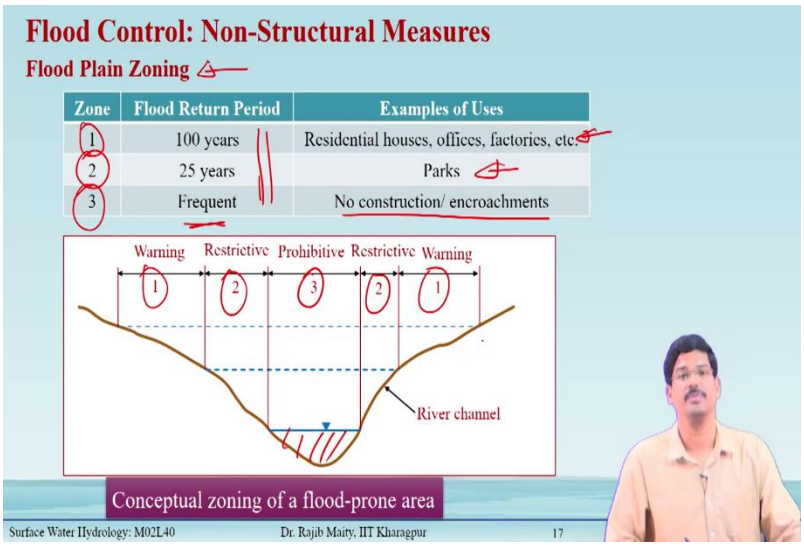


**Flood Plain Zoning**

| Zone | Flood Return Period | Examples of Uses |
|---|---|---|
| 1 | 100 years | Residential houses, offices, factories, etc. |
| 2 | 25 years | Parks |
| 3 | Frequent | No construction/ encroachments |

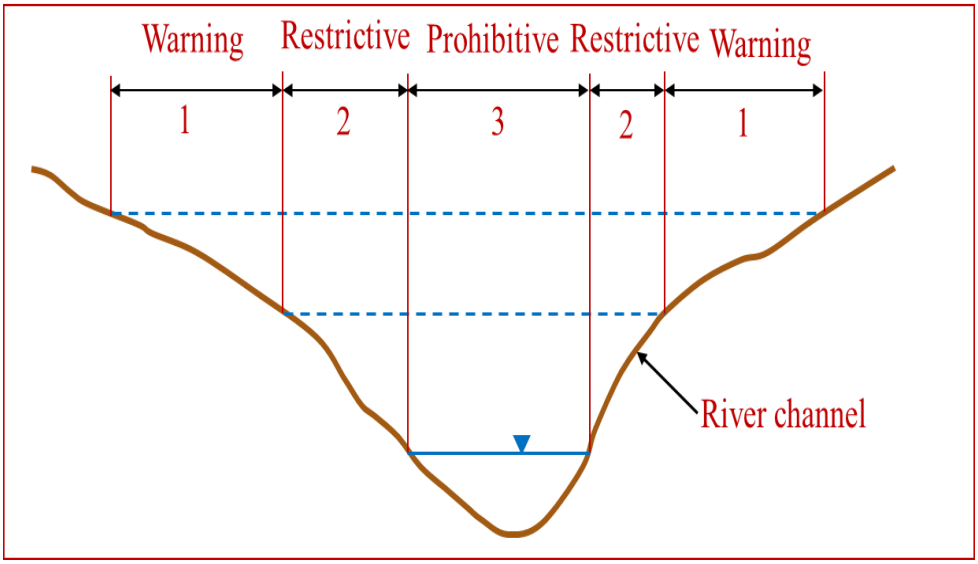


Fig.1 shows the Conceptual zoning of a flood-prone area

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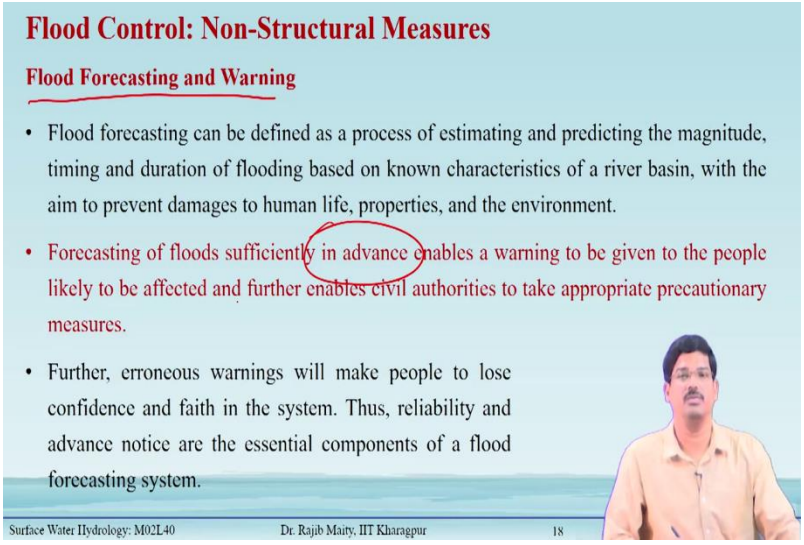


**Flood Forecasting and Warning**

Flood forecasting can be defined as a process of estimating and predicting the magnitude, timing, and duration of flooding based on known characteristics of a river basin, to prevent damage to human life, properties, and the environment.

Forecasting of floods sufficiently in advance enables a warning to be given to the people likely to be affected and further enables civil authorities to take appropriate precautionary measures.

Further, erroneous warnings will make people lose confidence and faith in the system. Thus, reliability and advance notice are the essential components of a flood forecasting system.

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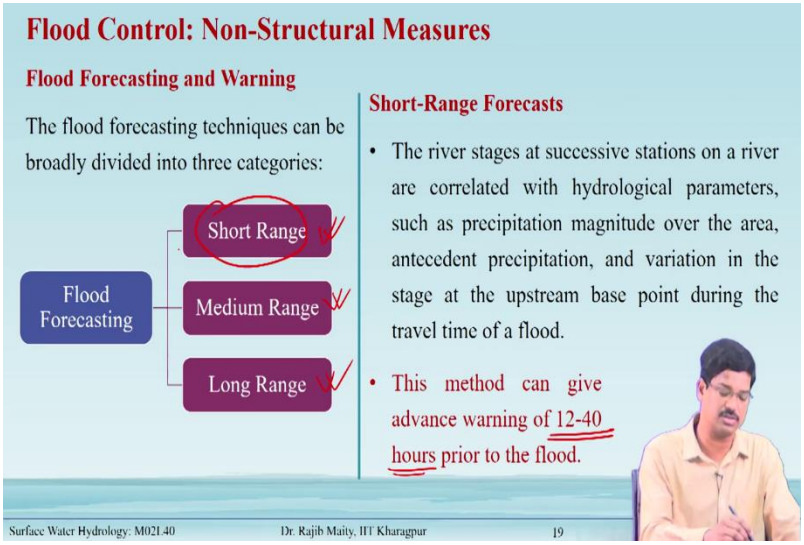


This flood forecasting system can be categorized into three major parts or categories Short Range, Medium Range, and Long Range.

**Short-Range Forecasts**

In the Short-Range forecast, the river stays at the successive stations on a river are correlated with the hydrological parameters such as the precipitation magnitude over the area, antecedent precipitation, and variation in the stage at the different upstream location base points during this travel time of a flood. And this method can give advanced warning of this 12 to 40 hours in this. So, this is the approximate timeline that we can categorize as a short-range forecast of this flood warning.

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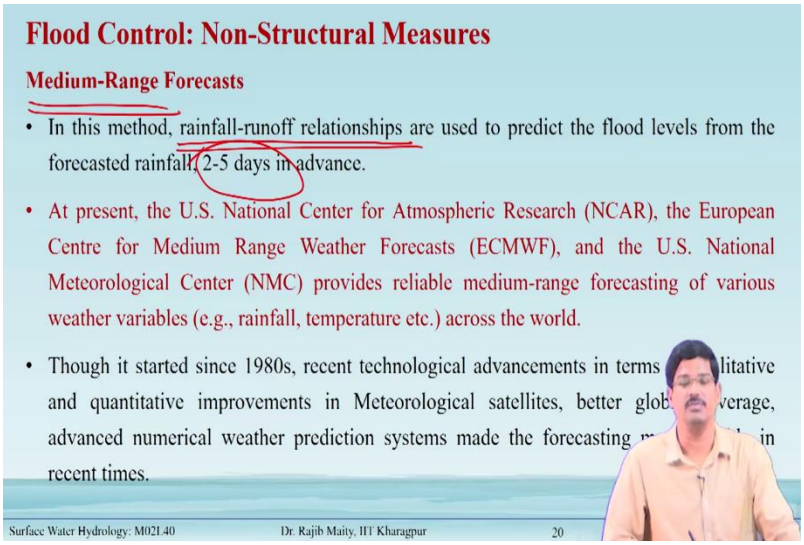


**Medium-Range Forecasts**

In this method, rainfall-runoff relationships are used to predict the flood levels from the forecasted rainfall, 2-5 days in advance.

At present, the U.S. National Center for Atmospheric Research (NCAR), the European Centre for Medium-Range Weather Forecasts (ECMWF), and the U.S. National Meteorological Center (NMC) provide reliable medium-range forecasting of various weather variables (e.g., rainfall, temperature, etc.) across the world.

Though it started in the 1980s, recent technological advancements in terms of qualitative and quantitative improvements in Meteorological satellites, better global coverage, and advanced numerical weather prediction systems made forecasting more reliable in recent times.

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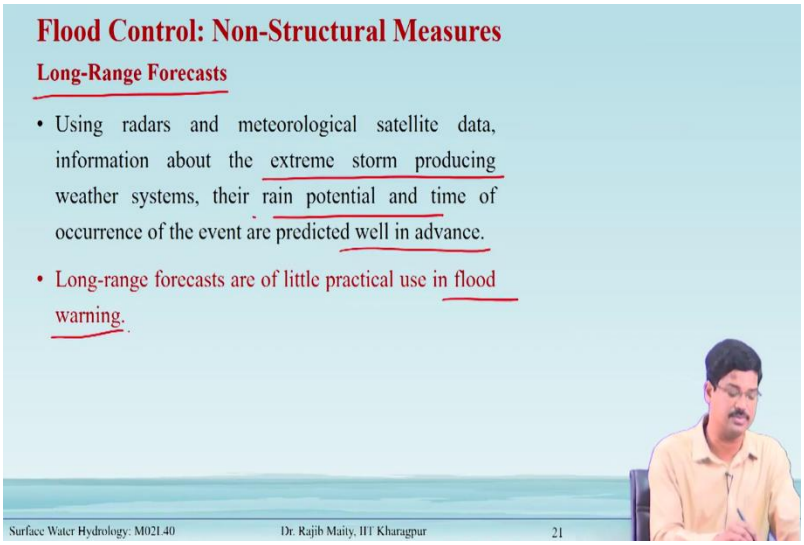


**Long-Range Forecasts**

Using radars and meteorological satellite data, information about the extreme storm-producing weather systems, their rain potential, and the time of occurrence of the event are predicted well in advance. Long-range forecasts are of little practical use in flood warnings.

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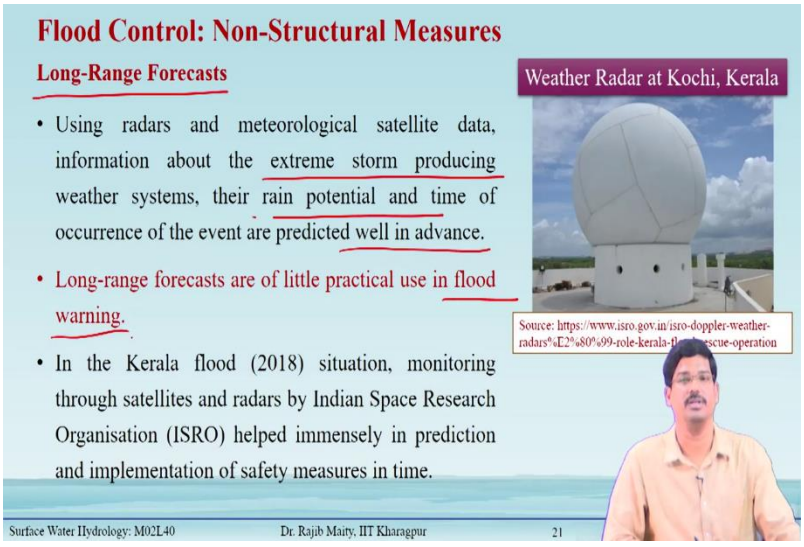

In the Kerala flood (2018) situation, monitoring through satellites and radars by the Indian Space Research Organization (ISRO) helped immensely in the prediction and implementation of safety measures in time.

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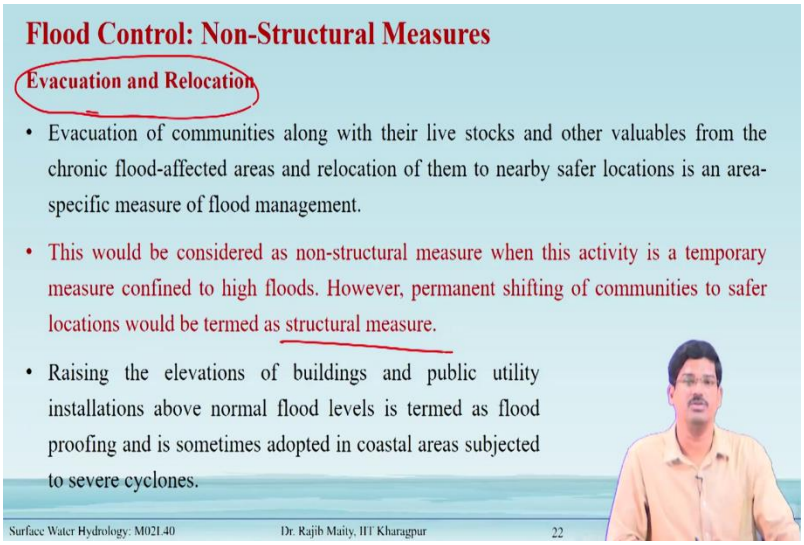


**Evacuation and Relocation**

Evacuation of communities along with their live stocks and other valuables from the chronic flood-affected areas and relocation of them to nearby safer locations is an area-specific measure of flood management.

This would be considered a non-structural measure when this activity is a temporary measure confined to high floods. However, the permanent shifting of communities to safer locations would be termed a structural measure.

Raising the elevations of buildings and public utility installations above normal flood levels is termed flood proofing and is sometimes adopted in coastal areas subjected to severe cyclones.

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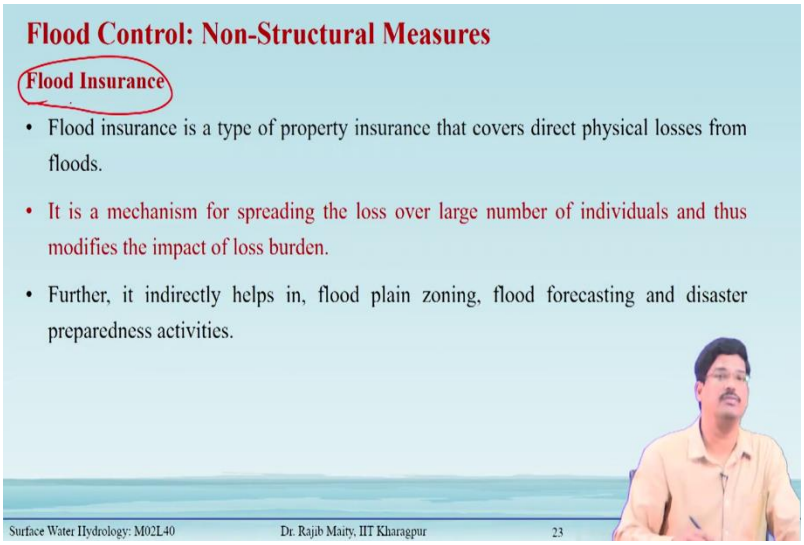


**Flood Insurance**

Flood insurance is a type of property insurance that covers the direct physical loss from the floods, it is a mechanism for spreading the loss over a large number of individuals and thus modifies the impact of the loss burden. Further, indirectly helps in flood plain zoning, flood forecasting, and disaster preparedness activities.

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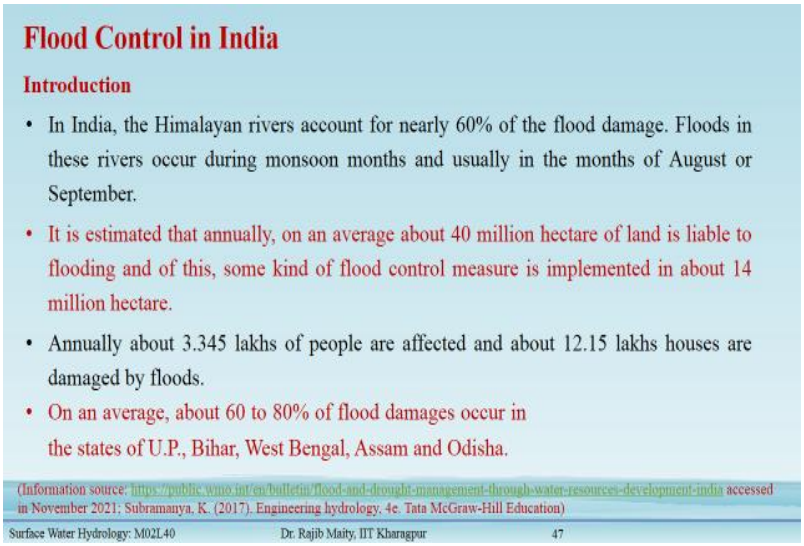

**Flood Control in India**

**Introduction**

Considering all these things, there are a few aspects are there, specific to our country the flood control in India. So, in India, particularly the Himalayan River which consists nearly 60 percent of the flood damage that occurs in that region. Floods in this reverse occur during monsoon months and usually in August or September.

It is estimated that annually on average about 40 million hectares of land are liable to flooding and of this, some kind of flood control measures were implemented for about 14 million hectares. Annually about say 3.345 lakhs of people are affected and about 12.15 lakhs of houses are damaged by floods. On average, about 60 to 80 percent of the flood damage occurs in the state of UP, Bihar, West Bengal, Assam, and Odisha in these regions.

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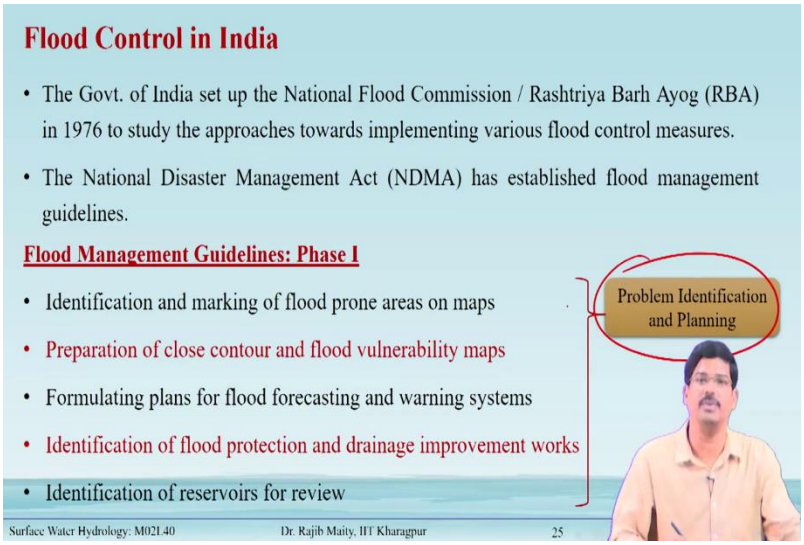


The Govt. of India set up the National Flood Commission / Rashtriya Barh Ayog (RBA) in 1976 to study the approaches to implementing various flood control measures.

The National Disaster Management Act (NDMA) has established flood management guidelines.

**Flood Management Guidelines: Phase I**

- Identification and marking of flood-prone areas on maps
- Preparation of close contour and flood vulnerability maps
- Formulating plans for flood forecasting and warning systems
- Identification of flood protection and drainage improvement works
- Identification of reservoirs for review

So, this is basically under the category of problem identification and planning.

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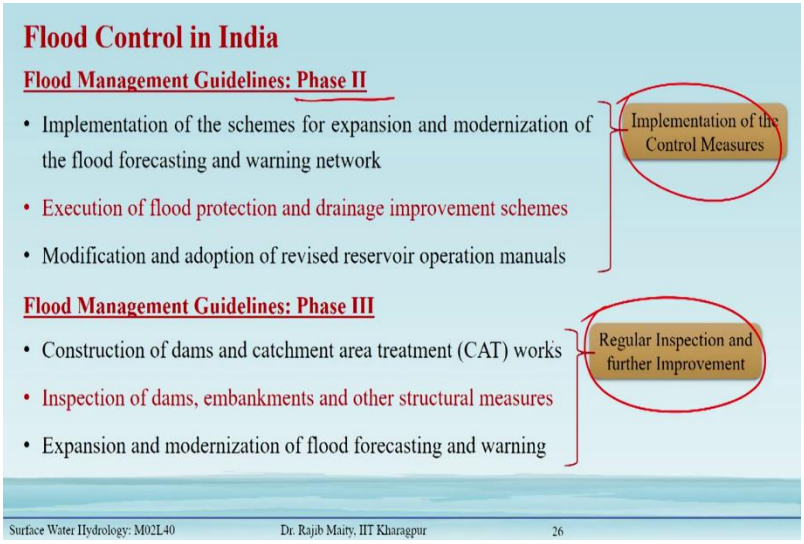


**Flood Management Guidelines: Phase II**

Secondly, comes the implementation of the control measures. So, in this thing it comes, it is under the PhaseII category,

- Implementation of the schemes for expansion and modernization of the flood forecasting and warning network
- Execution of flood protection and drainage improvement schemes

- Modification and adoption of revised reservoir operation manuals

**Flood Management Guidelines: Phase III**

Thirdly, it comes a regular inspection and further improvement which comes under maintenance.

- Construction of dams and catchment area treatment (CAT) works
- Inspection of dams, embankments, and other structural measures
- Expansion and modernization of flood forecasting and warning

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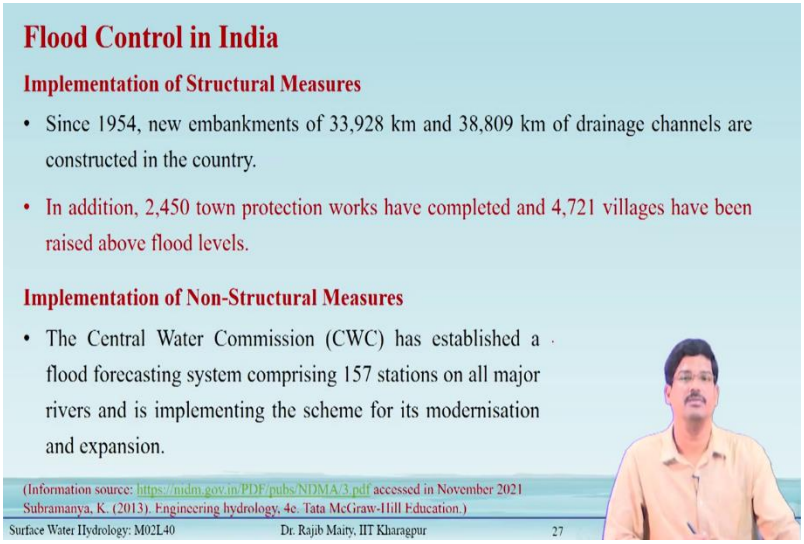


**Implementation of Structural Measures**

- Since 1954, new embankments of 33,928 km and 38,809 km of drainage channels are constructed in the country.
- In addition, 2,450 town protection works have been completed and 4,721 villages have been raised above flood levels.

## Implementation of Non-Structural Measures

The Central Water Commission (CWC) has established a flood forecasting system comprising 157 stations on all major rivers and is implementing the scheme for its modernization and expansion. (Information source: https://nidm.gov.in/PDF/pubs/NDMA/3.pdf accessed in November 2021

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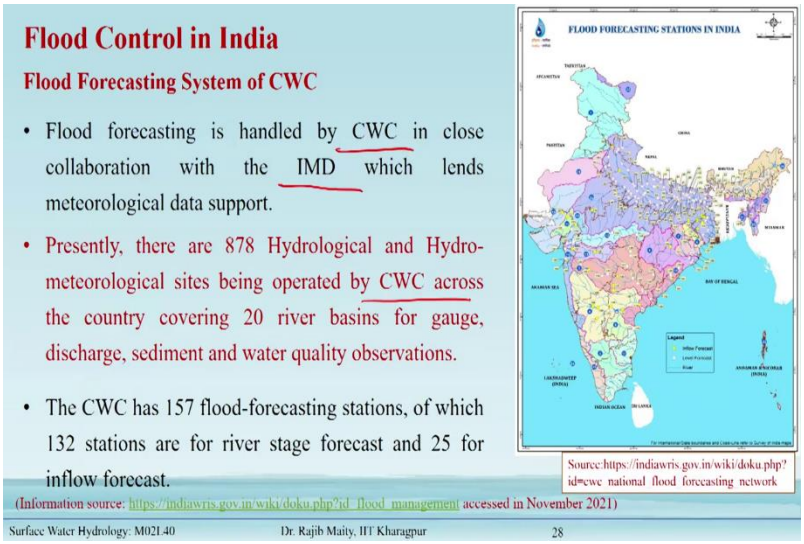


## Flood Forecasting System of CWC

Flood forecasting is handled by CWC in close collaboration with the IMD which lends meteorological data support.

Presently, there are 878 Hydrological and Hydrometeorological sites being operated by CWC across the country covering 20 river basins for gauge, discharge, sediment, and water quality observations. The CWC has 157 flood-forecasting stations, of which 132 stations are for river stage forecast and 25 for inflow forecast.

(Information source: https://indiawris.gov.in/wiki/doku.php?id=flood_management accessed in November 2021)

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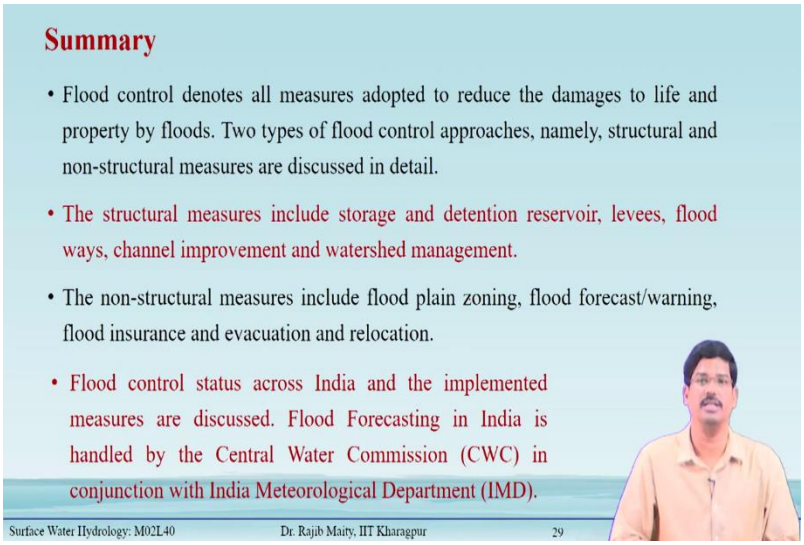


**Summary**

In summary, we learned the following points from this lecture:

- Flood control denotes all measures adopted to reduce the damages to life and property by floods. Two types of flood control approaches, namely, structural and non-structural measures are discussed in detail.
- The structural measures include storage and detention reservoir, levees, floodways, channel improvement, and watershed management.
- The non-structural measures include flood plain zoning, flood forecast/warning, flood insurance, and evacuation and relocation.
- Flood control status across India and the implemented measures are discussed. Flood Forecasting in India is handled by the Central Water Commission (CWC) in conjunction with India Meteorological Department (IMD).

## References


- Comiti, F., Righini, M., Nardi, L., Lucía, A., Amponsah, W., Cavalli, M., Surian, N., 2016. Channel widening during extreme floods: how to integrate it within river corridor planning? Interpraevent 477–486.
- Subramanya, K. (2017). Engineering Hydrology, 4th edition. Tata McGraw-Hill Education, New Delhi, India.