

**United Nations/India Workshop on Use of Earth Observation Data  
in Disaster Management and Risk Reduction : Sharing the Asian  
Experience**

**Flood Forecasting and Early  
Warning System in India**

Central Water Commission



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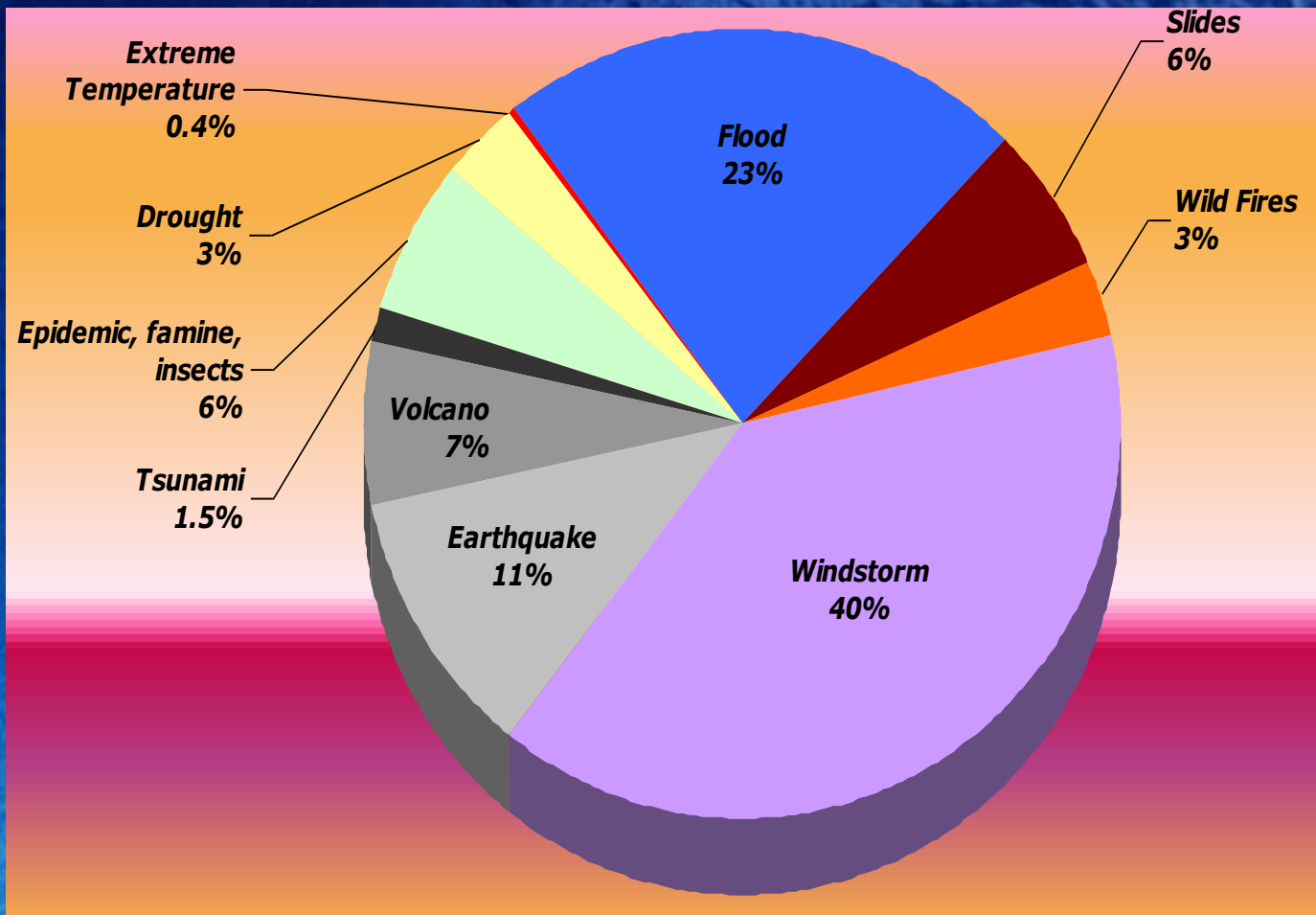
# FLOODS



Photo by Jerry Ryan, USGS

**FLOODS ARE – A WATER RELATED DISASTER**

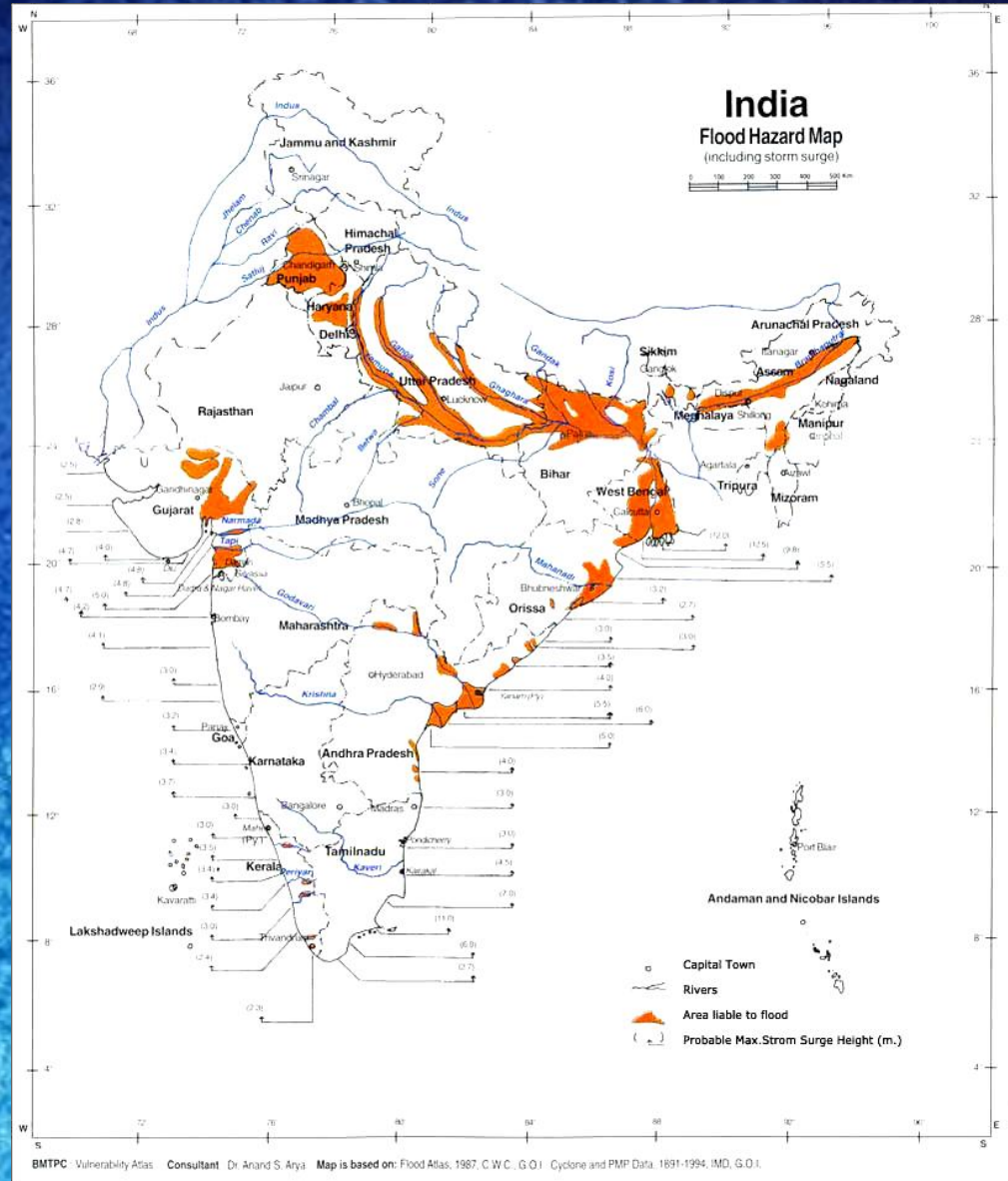
# Distribution of Disasters

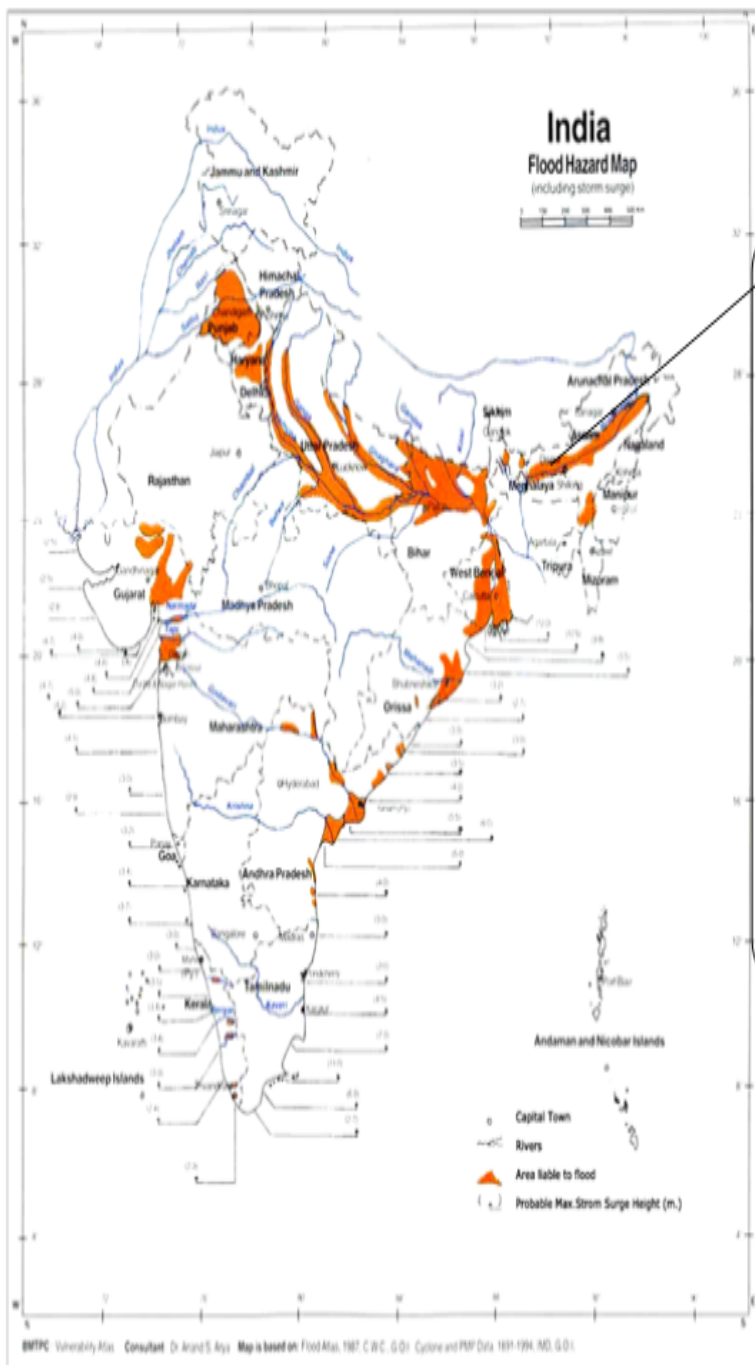




# THE FLOOD PROBLEM

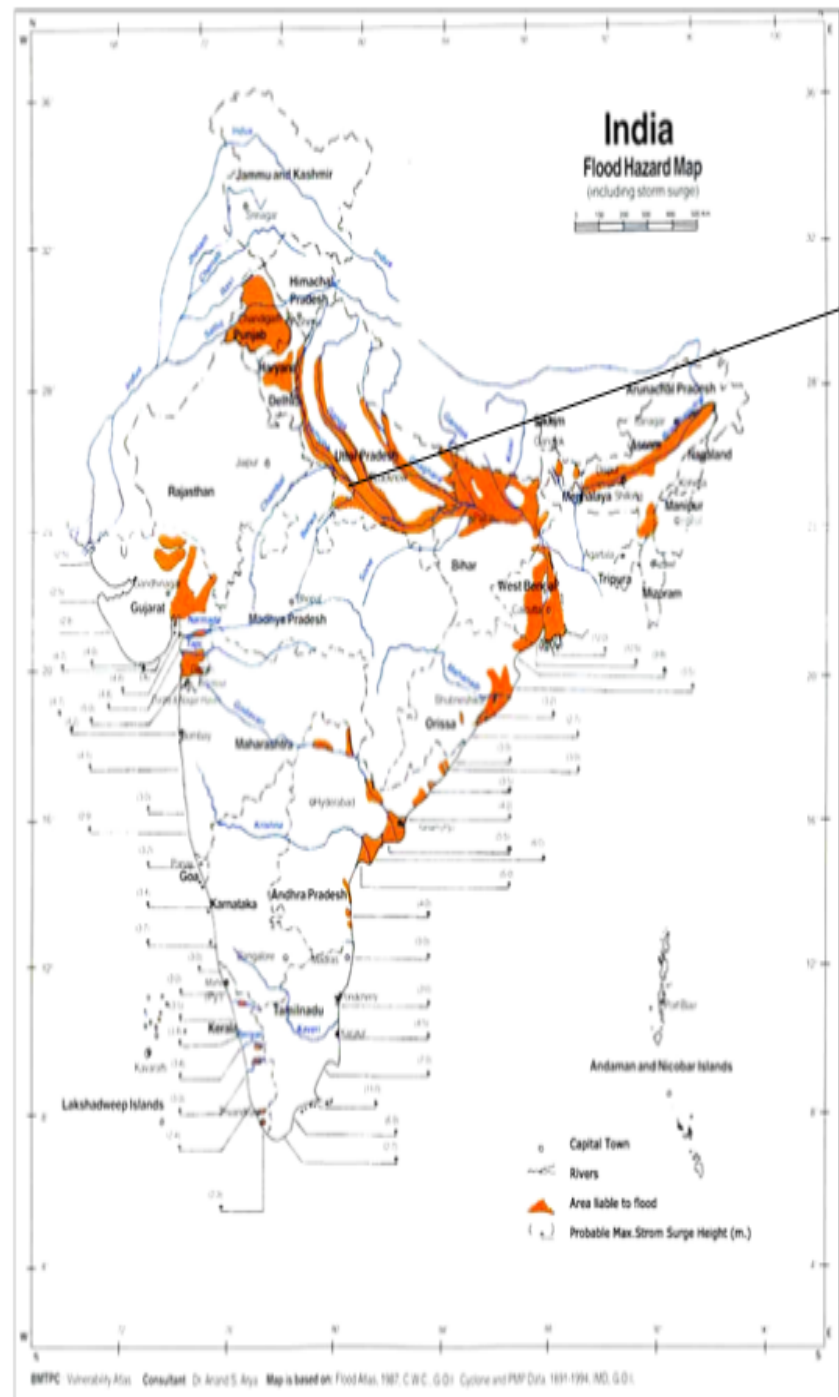
The rivers in India can be broadly divided into **FOUR** regions





## Brahmaputra Region

- 1) This region consists of the rivers Brahmaputra & Barak and their tributaries covering seven states Assam, Arunachal Pradesh, Meghalaya, Mizoram, Northern parts of West Bengal, Manipur, Tripura and Nagaland.
- 2) The catchments of these rivers receive very heavy rainfall ranging from 110 cm. to 635 cm. a year which occurs mostly during the months of May / June to September resulting severe and frequent floods in this region.
- 3) The predominant problems in this region are the flooding caused by spilling of rivers over their banks, drainage congestion and tendency of some of the rivers to change their courses.



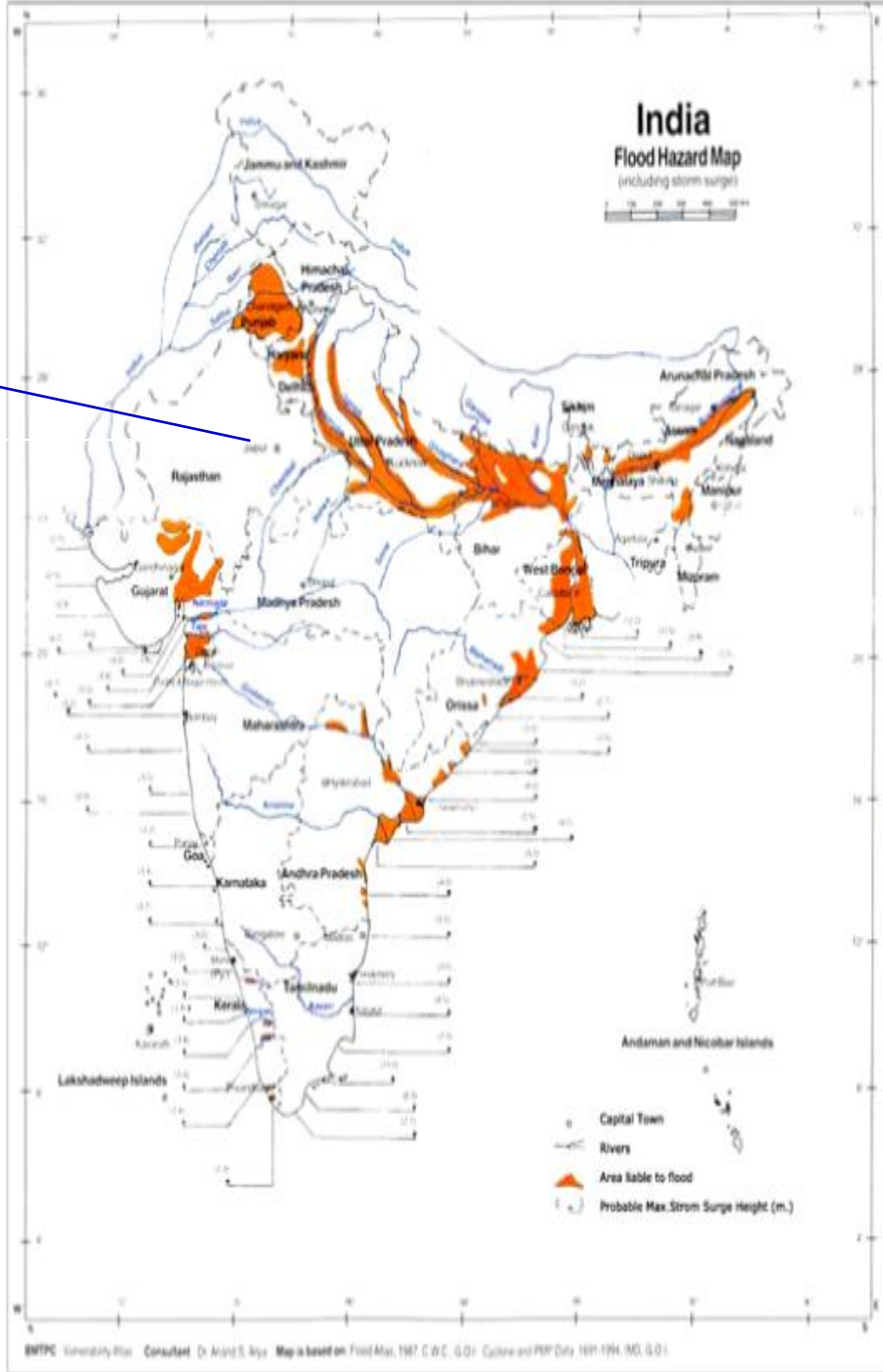
## Ganga River Region

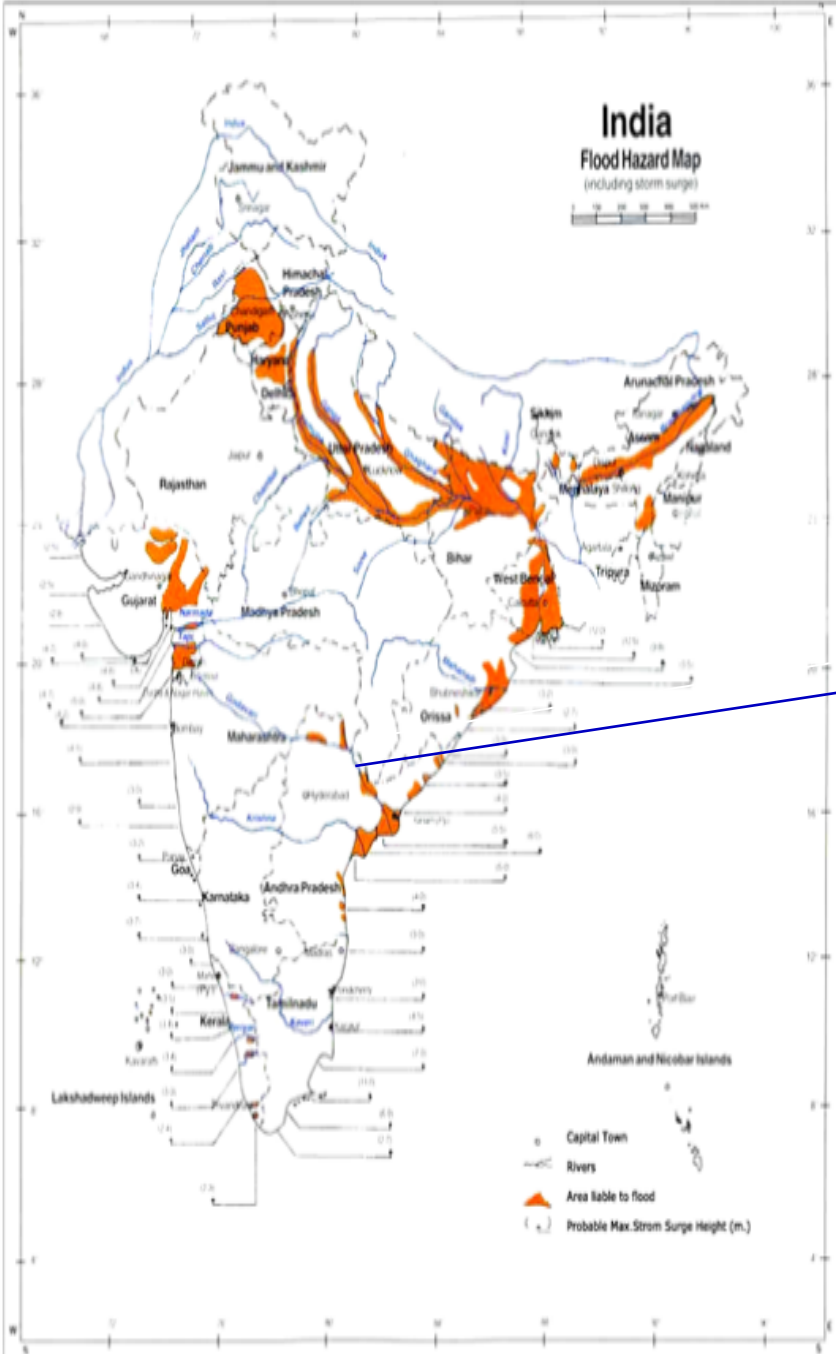
- 1) The river Ganga and its numerous tributaries, of which important ones are the Yamuna, the Sone, the Ghaghra, the Gandak, the Kosi and the Mahananda, constitute this river region. It covers ten states of Uttaranchal, Uttar Pradesh in its basin area, Jharkand, Bihar, South and Central parts of West Bengal, parts of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and Delhi.
- 2) The normal annual rainfall in this region varies from 60 cm to 190 cm of which more than 80% occurs during the south west monsoon. The rainfall increases from West to East and from South to North.
- 3) The flood problem is mostly confined to the areas on the northern bank of the river Ganga which is mainly caused by northern tributaries which spill their banks



# North West River Region

- 1) The main rivers in this region are the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum, the tributaries of Indus, all flowing from the Himalays.
- 2) The region covers the State of Jammu and Kashmir, Punjab and parts of Himachal Pradesh, Haryana and Rajasthan.
- 3) The flood problem is little less in this region compared to Ganga.



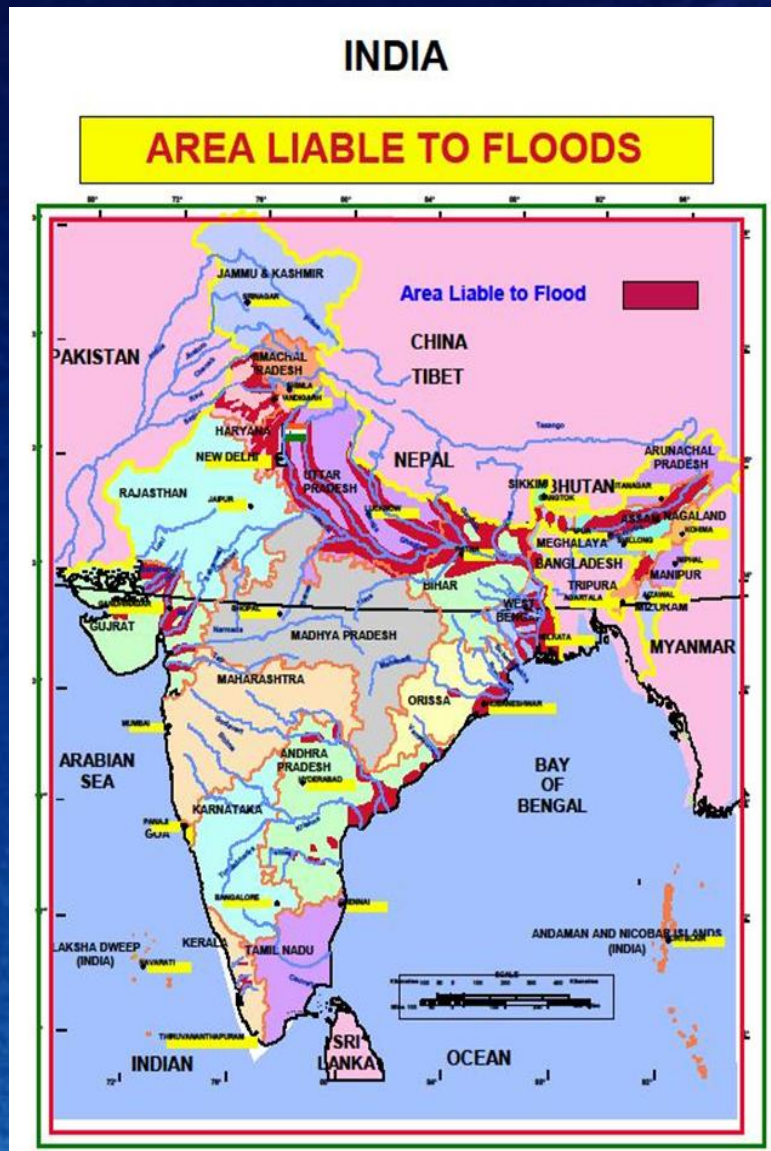


### Central India and Deccan Region

The important rivers in this region are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Cauvery. These rivers have mostly well defined stable courses. They have adequate capacity within the natural banks to carry the flood discharge except in the delta area. The lower reaches of the important rivers on the East Coast have been embanked, thus largely eliminating the flood problem.



# Flood Problem in India



- Uneven spatial & temporal distribution of rainfall leads to flood & drought
- Due to flood on an average annually
  - 7.08 mha area is affected
  - 31.6m population is affected
  - 3.8mha crop area is affected
  - 1645 human lives are lost
  - 95225 cattle lives are lost
  - Total damage of Rs 3823 crore



# INDIA

## FLOOD MANAGEMENT

### AREA (M. Ha)

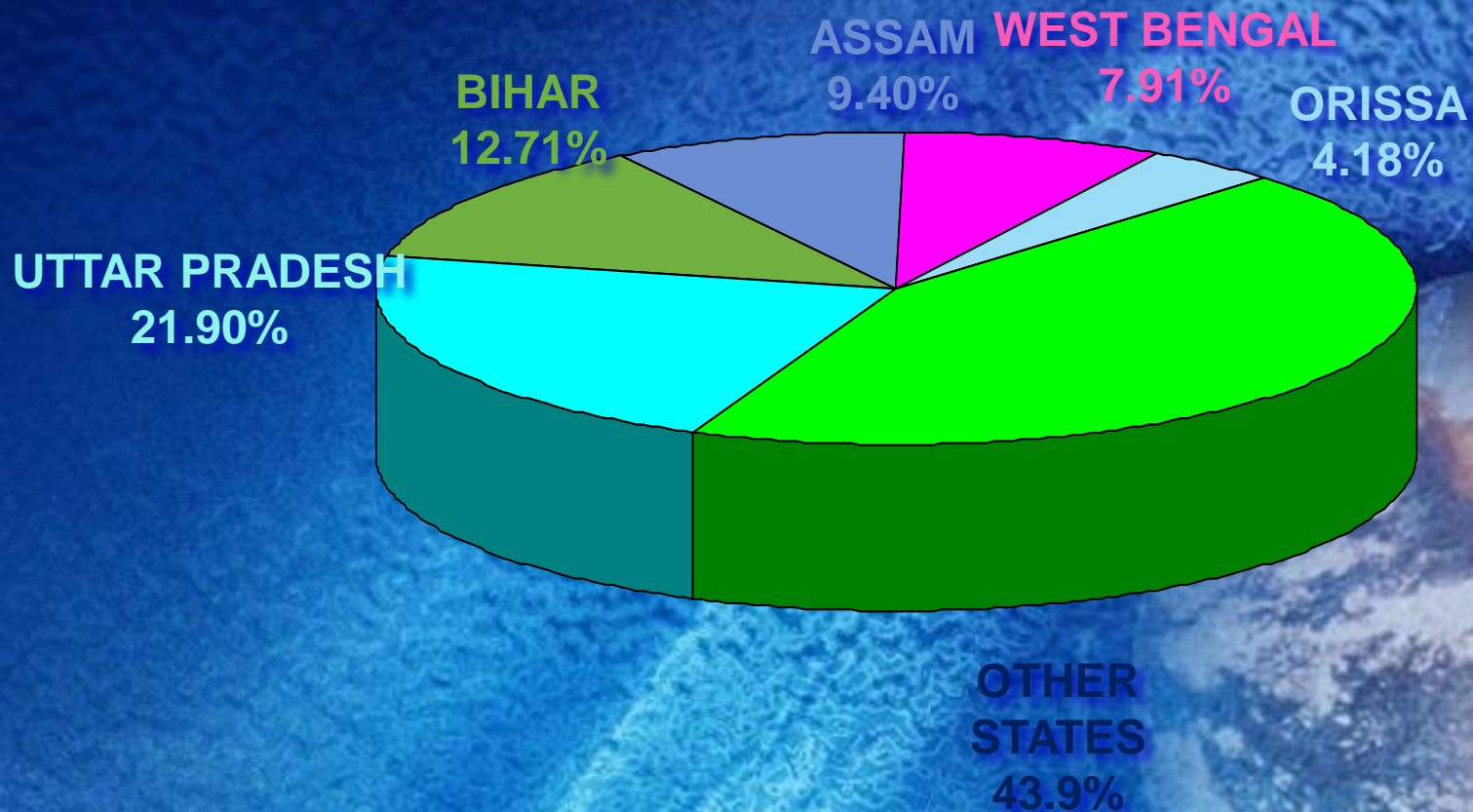
GEOGRAPHICAL	328	
FLOOD PRONE	49.8	15%
PROTECTABLE	32	80%
PROTECTED	20.4	64%
FLOOD AFFECTED		
◆ AVERAGE	7.08	
◆ MAXIMUM	17.5	(1978)
◆ MINIMUM	1.5	(1965)



# INDIA

## FLOOD MANAGEMENT

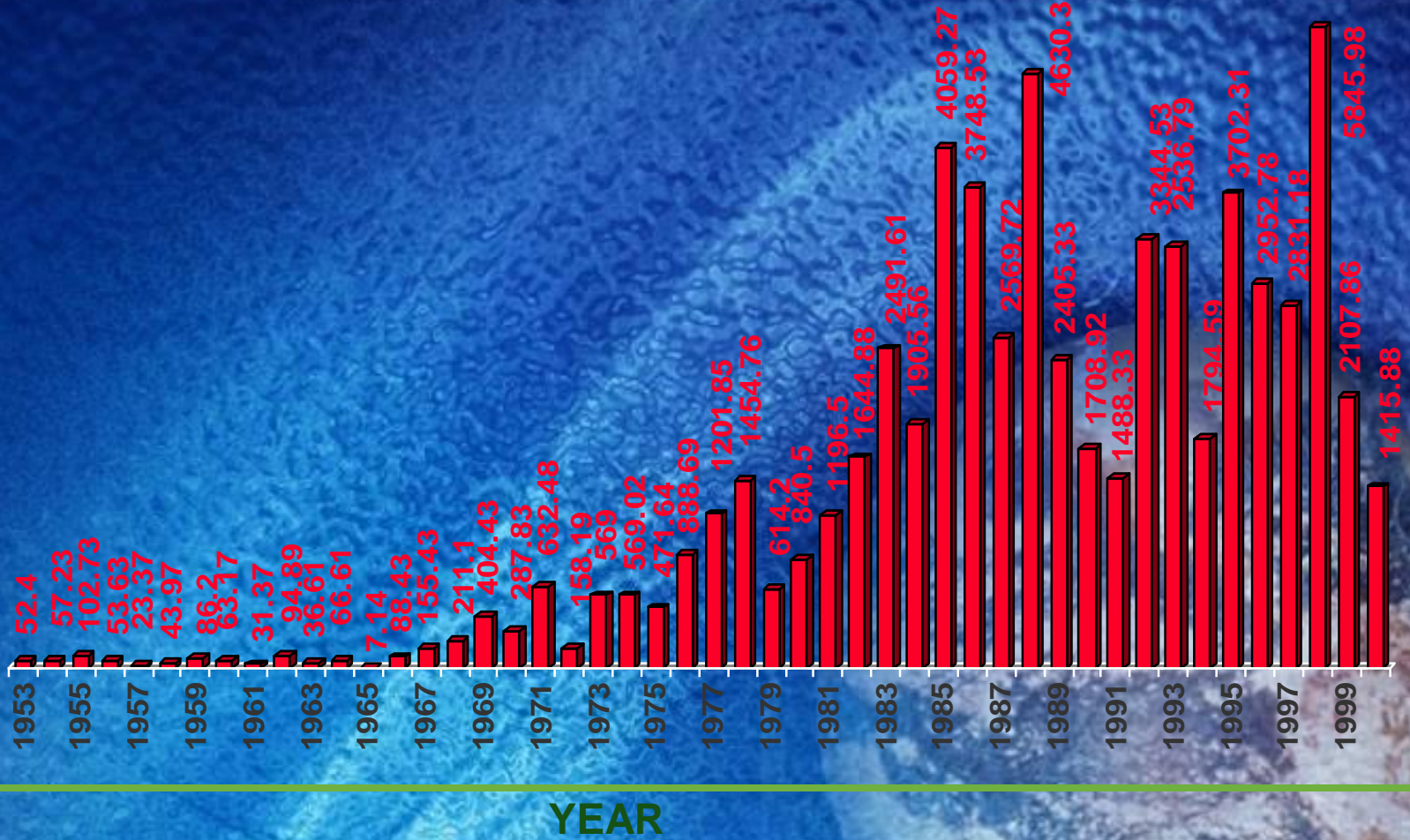
FLOOD PRONE AREA – 49.8 M.Ha.





# FLOOD DAMAGE IN INDIA DURING 1953-2000

RUPEES IN CRORE





# INCREASED VULNERABILITY

## CAUSES

- UNPLANNED DEVELOPMENT OF CITIES ALONG RIVERS
- INCREASING ECONOMIC AND DEVELOPMENTAL ACTIVITIES IN FLOOD PLAINS
- LACK OF REGULATIONS
- INADEQUATE DRAINAGE SYSTEM
- INADEQUATE MAINTENANCE
- LACK OF DISASTER PREPAREDNESS



# UNPLANNED DEVELOPMENT OF CITIES ALONG RIVER





# Flood Control and Mitigation

- Complete immunity from flood not possible, however, their impacts can be minimized.

<b>Structural Measures</b>	<b>Non-Structural Measures</b>
•Dams and Reservoirs	•Flood Forecasting and Warning
•Embankments, Flood Walls, Sea Walls	•Flood Plain Zoning
•Natural Detention Basins	•Flood Proofing
•Channel Improvement	•Disaster Preparedness and Response Planning
•Drainage Improvement	•Disaster Relief
•Diversion of Flood Water	



# International Dimensions of Flood Control in India

- Three major river systems of India namely Ganga, Brahmaputra and Indus cross international borders.
- Have bilateral co-operation on flood management with Bangladesh, Bhutan, China, Nepal & Pakistan.



# Indo-Pakistan Co-operation

- Under the Indus Water Treaty 1960, India and Pakistan have created two permanent posts of Commissioners for Indus Waters, one each in India and Pakistan. Each Commissioner is representative of his Government for all matters arising out of the Treaty and is to serve as the regular channel of communication on all matters relating to implementation of the Treaty. The two Commissioners together form the Permanent Indus Commission.
- As cooperation in the matter of flood management, Flood warning communications are made by India to Pakistan for their benefit through priority Telegrams, Telephones and Radio Broadcasts during monsoon every year for Indus system of rivers.



# India-Bangladesh Cooperation

- An Indo-Bangladesh **Joint Rivers Commission (JRC)** is functioning since 1972 with a view to maintain liaison in order to ensure the most effective joint effort in maximizing the benefits from common river systems which is headed by Water Resource Ministers of both the countries
- A Treaty was signed by the Prime Ministers of India and Bangladesh on 12<sup>th</sup> **December 1996** for the sharing of Ganga/Ganges waters
- A Joint Committee has been set up for implementing, joint inspection and monitoring of the sharing arrangements at Farakka in India and at Hardinge Bridge in Bangladesh for the dry season (Jan to May) every year



# India-Bhutan Cooperation

- A scheme titled “Comprehensive Scheme for Establishment of Hydro- meteorological and Flood Forecasting Network on rivers common to India and Bhutan” is in operation.
- The network consists of 35 hydro-meteorological/ meteorological stations located in Bhutan and being maintained by the Royal Government of Bhutan with funding from India.
- The data received from these stations are utilized in India by the Central Water Commission for formulating flood forecasts.



# India-China Cooperation

- Government of India had entered into an MOU with China in 2002 for sharing of hydrological information (Water level, discharge and rainfall) in respect of three stations, namely Nugesha, Yangcun and Nuxia located on Yaluzangbu/Brahmaputra river from 1<sup>st</sup> June to 15<sup>th</sup>, October every year.
- Another Memorandum of Understanding was signed during the visit of the Chinese Premier to India in April, 2005 for supply of hydrological information of Sutlej (Langquinzangbu) during each flood season beginning from monsoon 2006.



# India-Nepal Cooperation

- A Nepal – India Joint Committee on Water Resources (JCWR) headed by Water Resource Secretaries of both countries has been functioning with the mandate to act as an Umbrella Committee for all committees and groups.
- Nepal and India agreed to co-operate and provide facilities for flood forecasting on major tributaries of the Ganga that flow from Nepal into India.
- A network of 45 stations was identified during August, 1988 for flood forecasting purposes and established by India in Nepal for transmission of hydrometeorological data to India for utilising in Flood Forecasting.
- Storage projects in Nepal which also provide flood control benefits are under consideration between India and Nepal. Pancheshwar Multipurpose Project, Sapt Kosi High Dam Multipurpose Project and Sun Kosi Storage cum Diversion Scheme are under active consideration between the two countries.



# INDIA

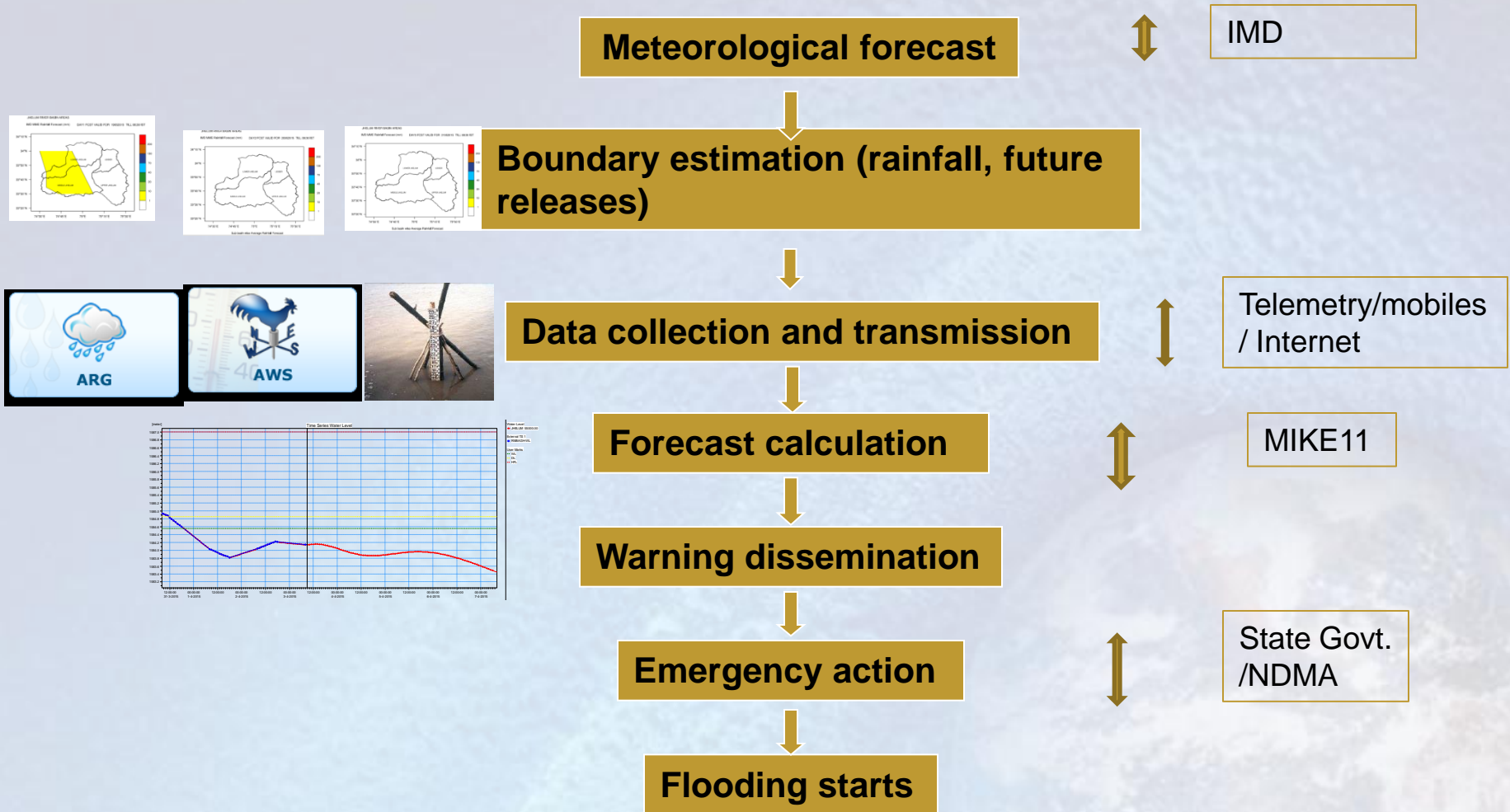
## FLOOD FORECASTING

### BEGINNING

- **STARTED BY** CENTRAL WATER COMMISSION
- **YEAR** 1958
- **RIVER** YAMUNA
- **FORECASTING STATION** DELHI RAILWAY BRIDGE



# Flow of Data/Information





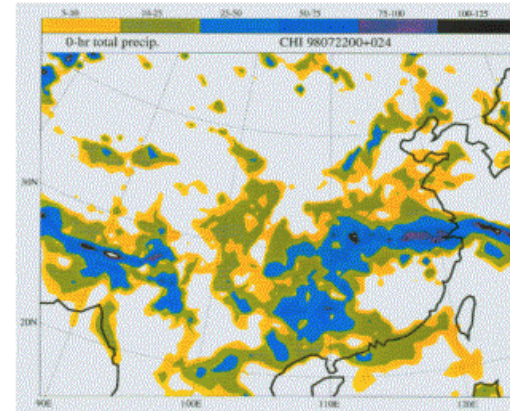
Remote automatic weather station in Switzerland



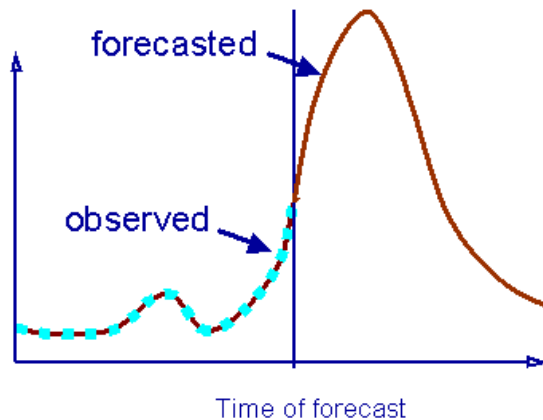
Sutron stations

Meteoro-  
logical  
forecasts

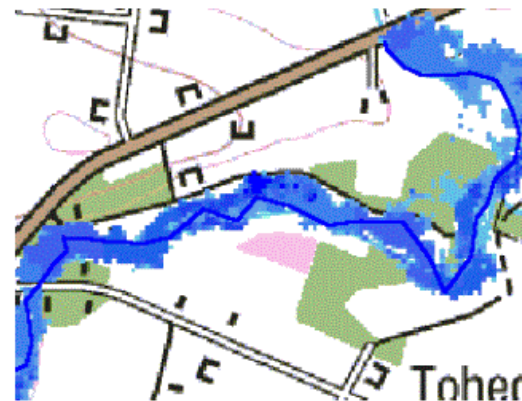
Local  
radar



## Flood Modelling



Forecasted hydrographs



Flood maps



# **Real Time Data Communication**

**Various systems of data transmission used are**

- ❖ **Tele Communication**
- ❖ **Wireless Communication**
- ❖ **Telemetry**



# **FLOOD FORECASTING**

## **DATA ANALYSIS & FORECAST FORMULATION**

- **CORRELATION**
- **MATHEMATICAL MODELS (Mike 11)**



## 2. INFLOW FORECAST

- For reservoir inflow forecast, the inflows into the reservoir are predicted whenever it is likely to exceed the criteria for a particular reservoir. This criteria is decided by the project authorities based on the flood moderation capacity of the reservoir, for example:

S.No	Name of Reservoir / Barrage	Criteria
1	Almatti, Narayanpur, P.D.Jurala & Srisaillam Reservoir	50,000 Cusecs
2	Prakasham Barrage	25,000 Cusecs
3	T.B.Dam	15,000 Cusecs

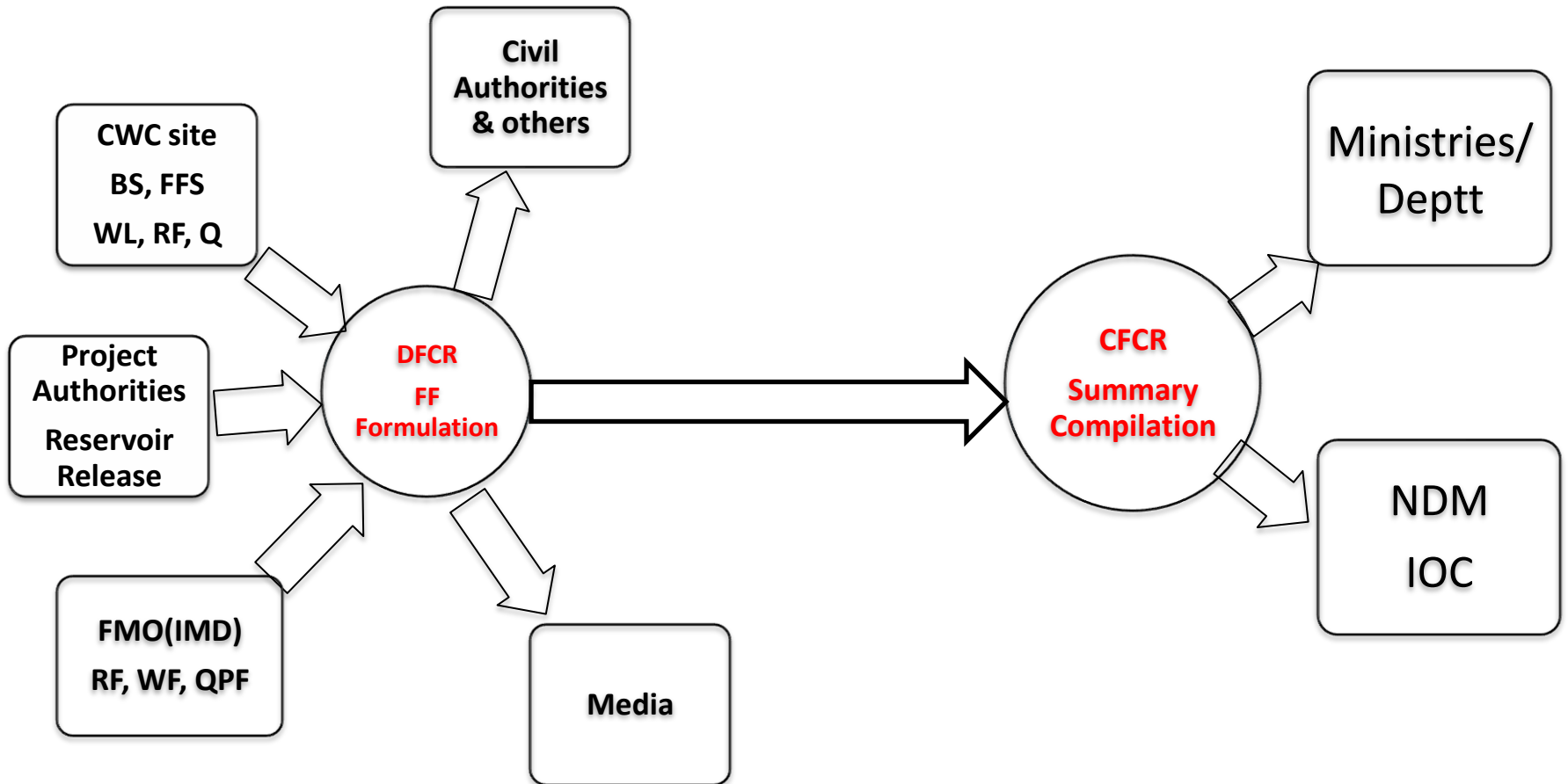


# Forecast Dissemination

- Mode of communication
  - Commonly used mode-Special Messenger, Telephone, Fax, Wireless
  - In addition-Email, SMS, Website (<http://india-water.com>, <http://india-water.gov.in>)
- Mailing List/ Beneficiaries
  - Commonly - civil/ engineering authorities of concerned States, defence, railways/ highways authorities, industrial and other important establishments located in the flood prone areas through telephone/ fax/ e-mail/ special messenger for taking advance action for flood fighting & evacuating population to safer places.
  - Also Media, Press for the benefit of the likely flood affected population

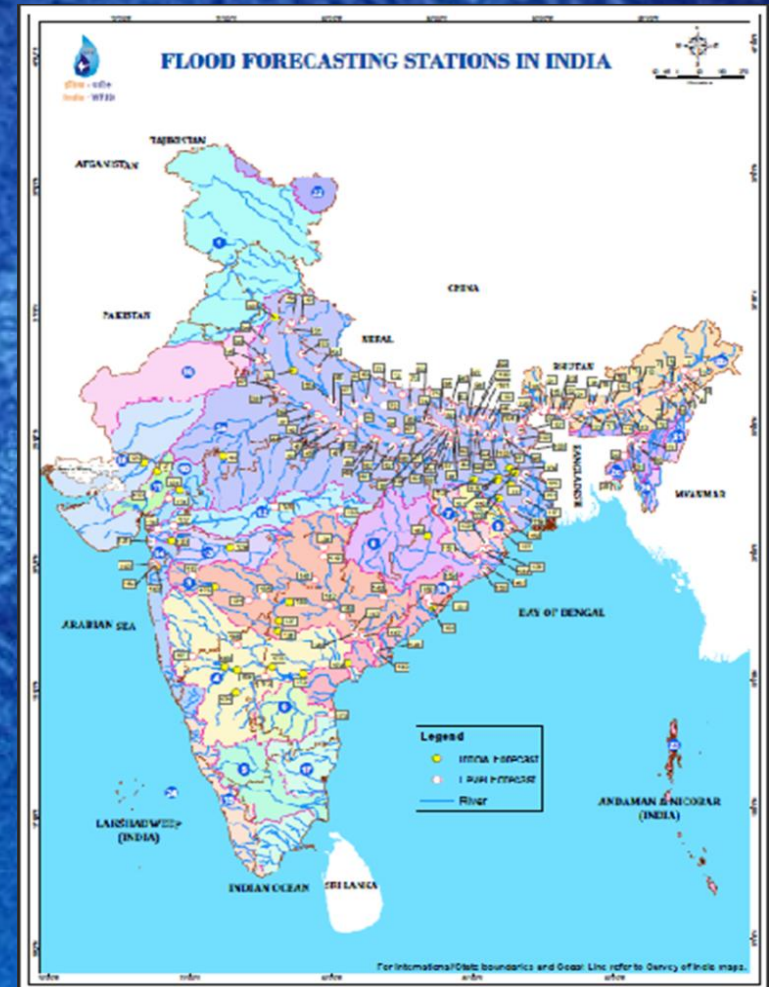


# Set Up



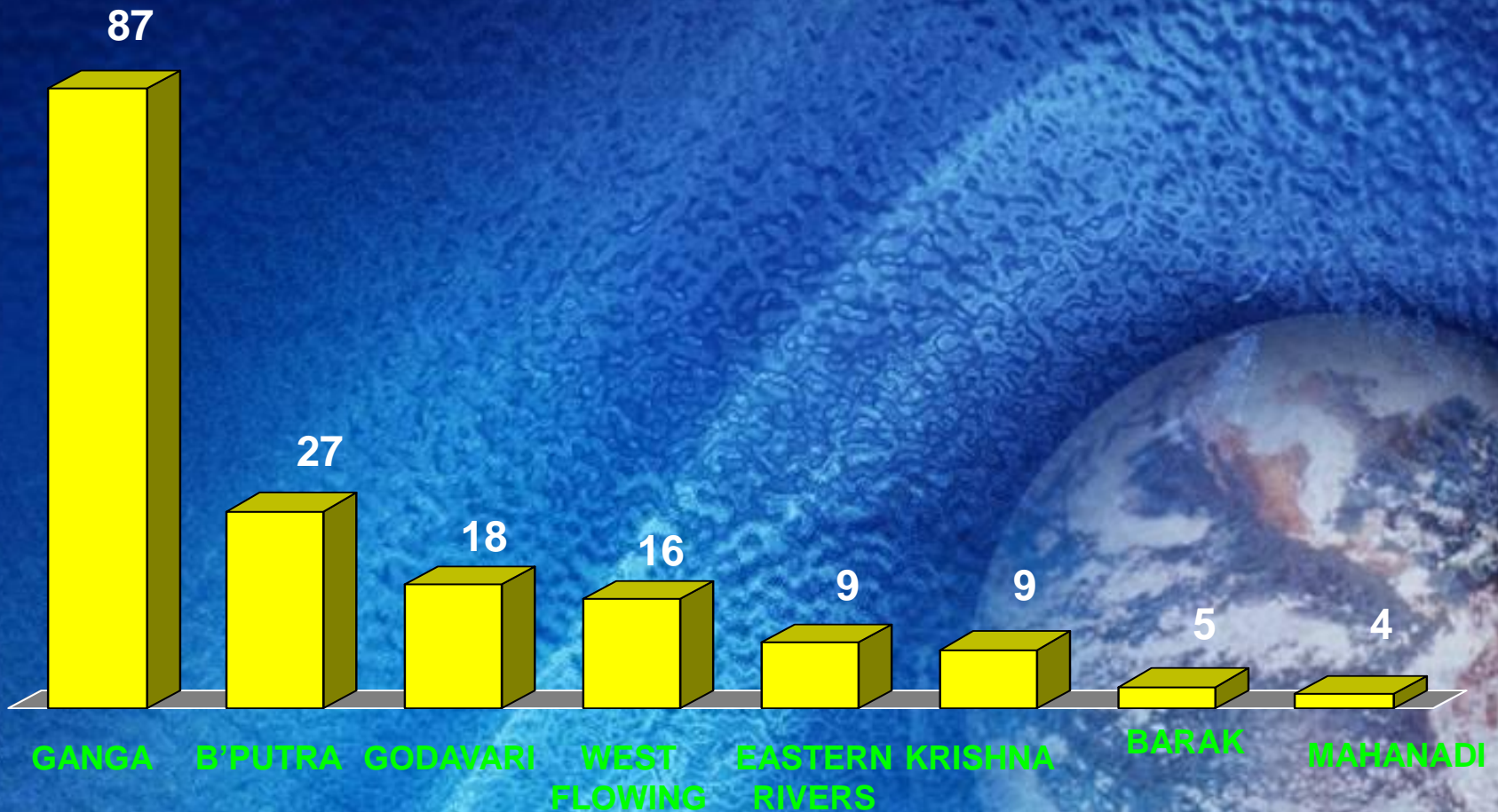
# Flood Forecasting Network of CWC

- The work of flood forecasting and warning in India is entrusted to CWC.
- First FF site- 1958 –Delhi
- Present network- 176 (148+28)
- 21 divisions
- 10 Major River Basins
  - 72 sub basins
  - 18 states/UTs





# INDIA – BASIN WISE DISTRIBUTION OF FLOOD FORECASTING STATIONS





# Forecast Frequency

- Major rivers (Travel time >24 hours)
  - Forecasts are being formulated based on 0800 hrs/ 0900 hrs
  - water level data and forecast issued once in a day at 1000 hrs with advance warning time from 24 hrs to 36 hrs
- Medium rivers (Travel time 12-24 hours)
  - Forecasts are being formulated based on 0600 hrs and 1800 hrs
  - water level data and forecast issued twice in a day at 0700 hrs and 1900 hrs with advance warning time from 12 hrs to 24 hrs
- Flashy rivers (Travel time < 12 hours)
  - Forecasts are being formulated based on any hr
  - Forecast issued multiple times (more than twice) in a day with advance warning time less than 12 hrs



# **Real Time Transmission system**

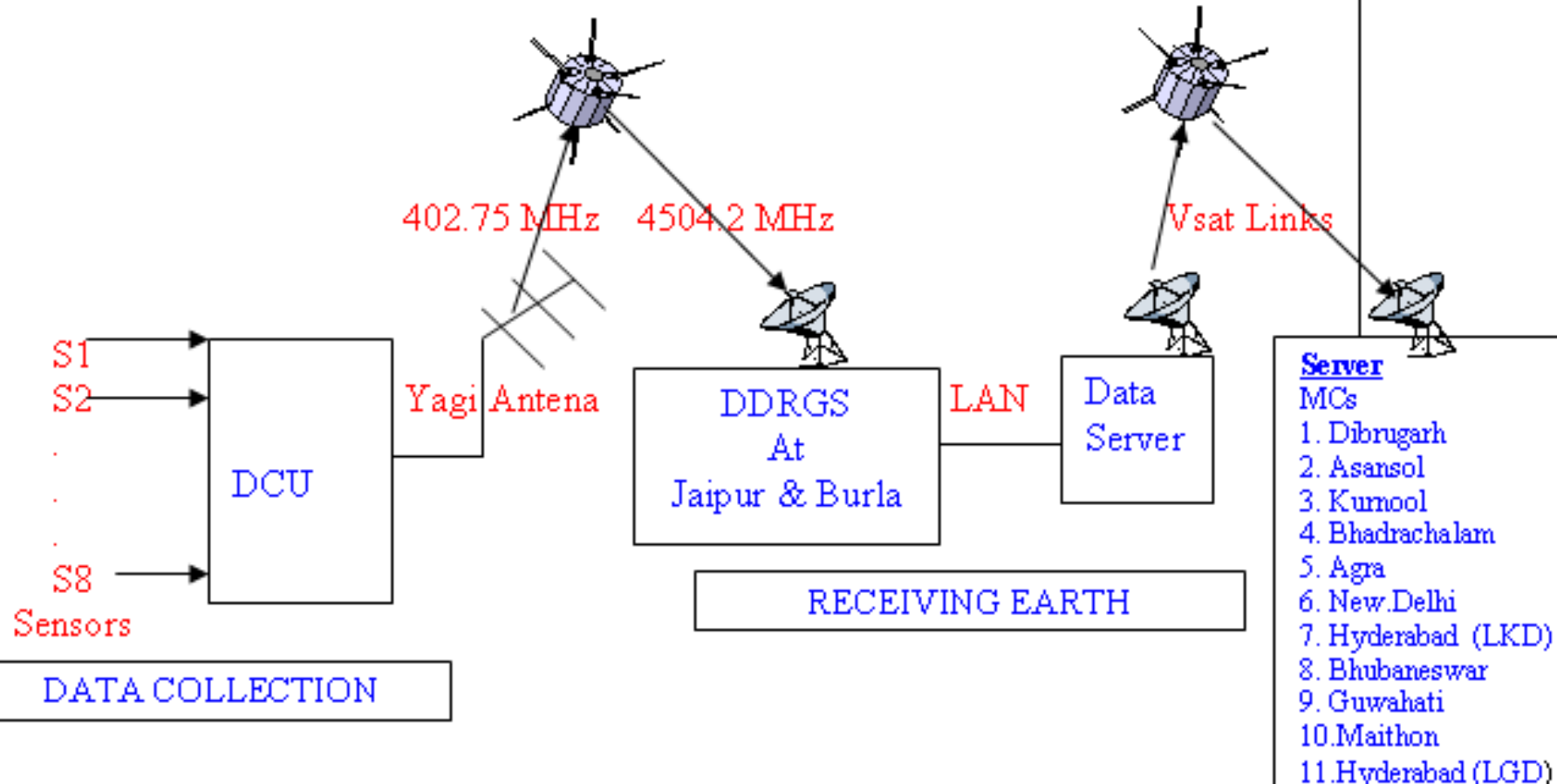
## **(Telemetry Network)**

Existing Telemetry stations – 445 created during IX, X and XI Plan periods.

Under XII Plan 787 new Telemetry stations were proposed.

INSAT/KALPANA-I  
Data Relay Transponder  
(DRT)

SATELLITE  
Commercial Transponder  
Vsat



**Abbreviations**

DCU Data Collection Units  
MCs Modelling Centres

DDRGS Digital Direct Receiving Ground Station

**INSAT DATA COLLECTION SYSTEM**



# India-WRIS Mobile App.

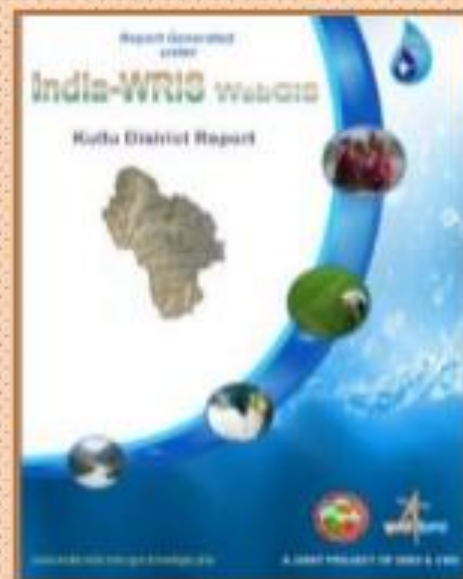


## Features

1. **About WRIS**  
A page explaining WRIS project.
2. **Explore WRIS:**  
Facilitating users to query or perform a textual search under following headings.
  - Basins
  - Dams
  - Rivers
  - Hydro Observation Stations
  - Tourist Spots
3. **Search Nearby**
  - Will fetch the locations of following
    - Dams
    - Tourist Places
    - Hydro Observation Station
  - Near the user location or near a specified city or town
4. **Updates :** Latest updates of WRIS



## Automatic Report Generation



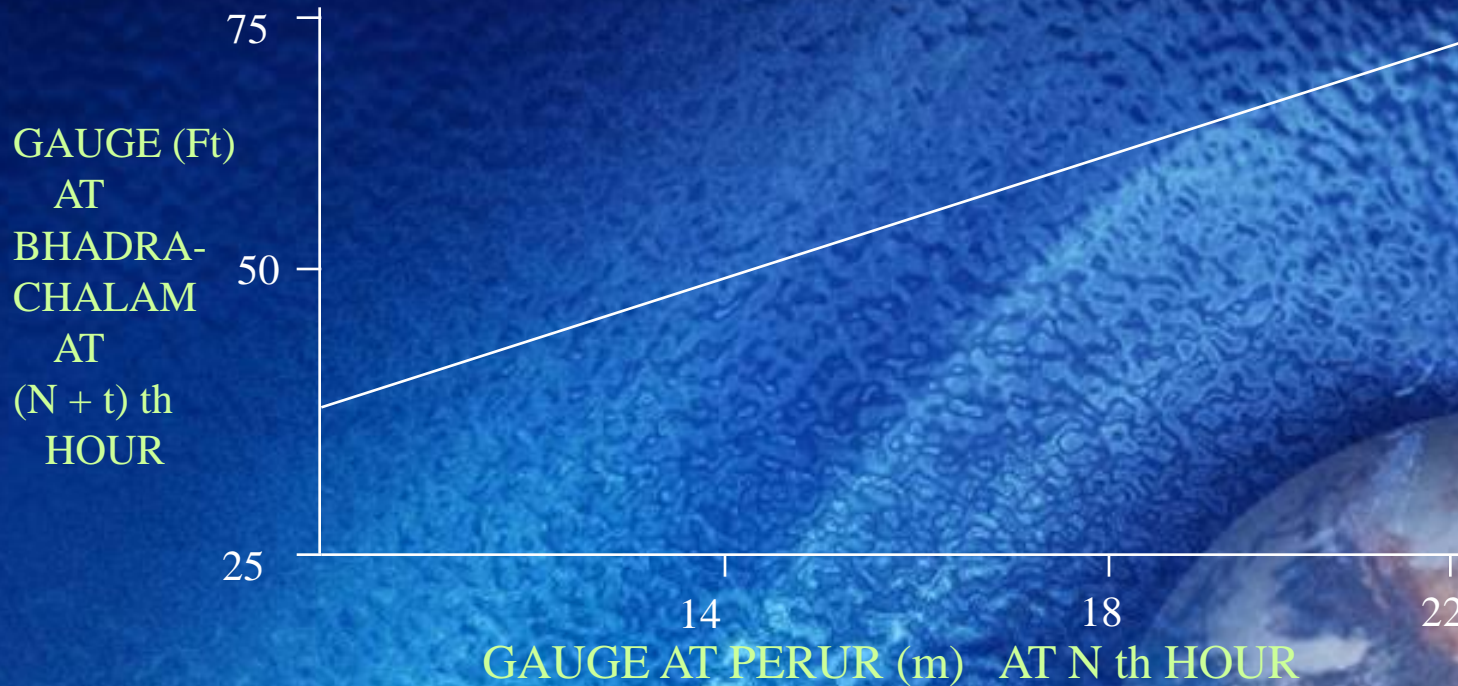






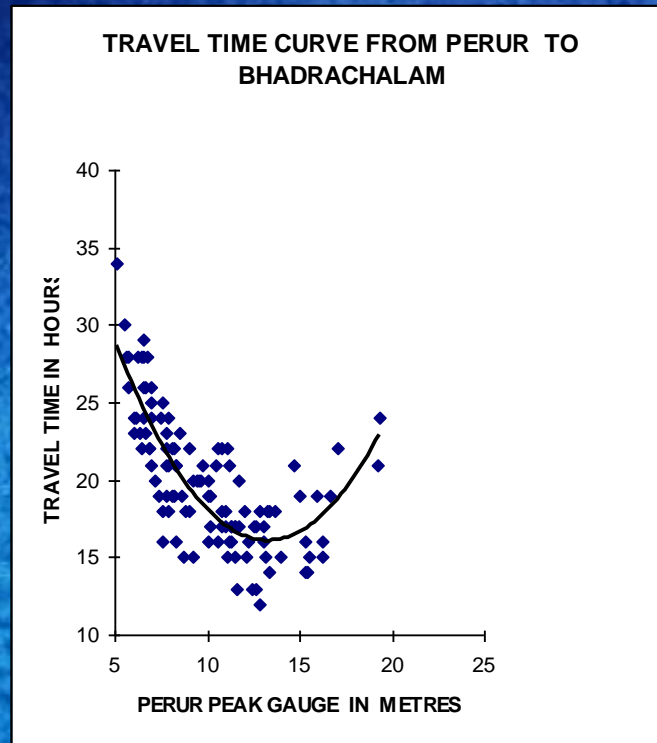
# Flood forecasting by Conventional Methods

## SIMPLE CORRELATION - EXAMPLE





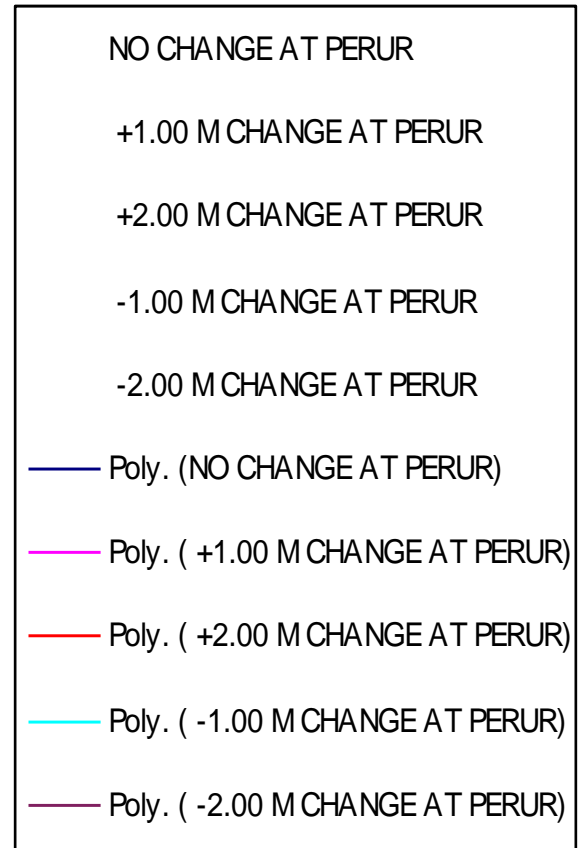
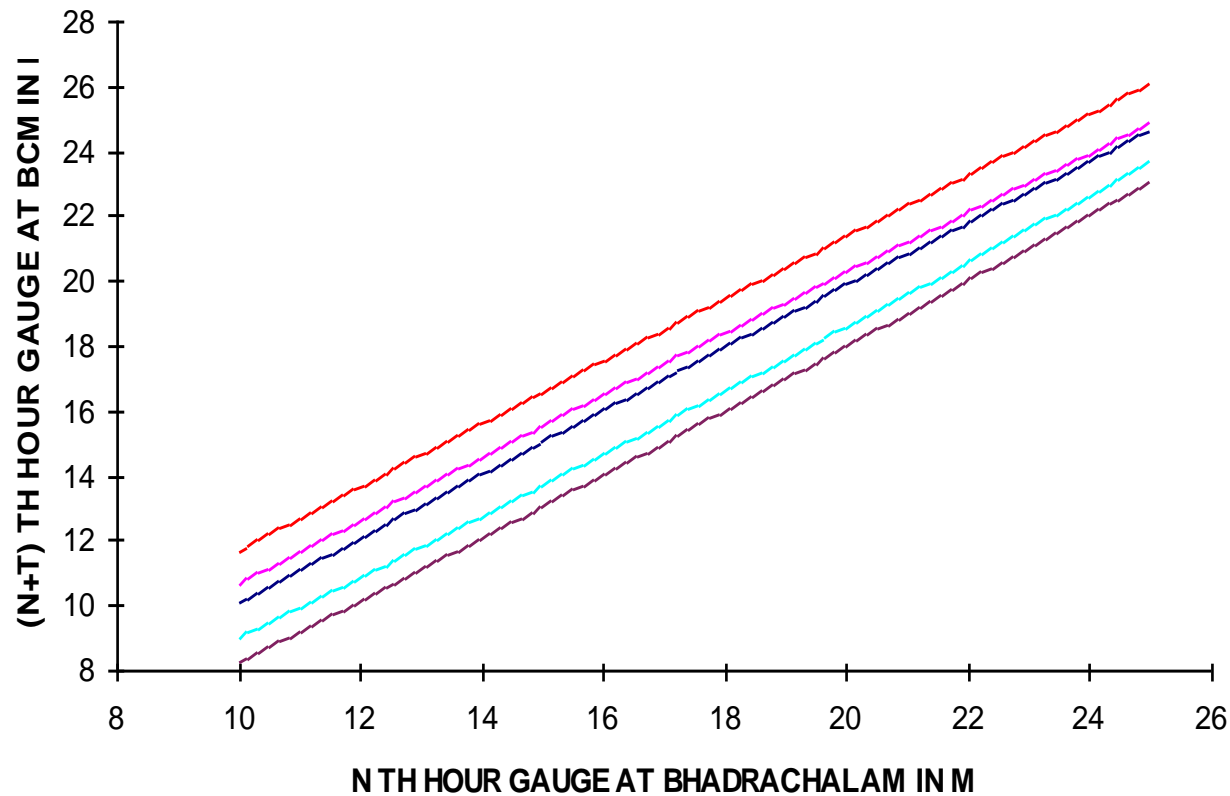
# Flood forecasting by Conventional Methods



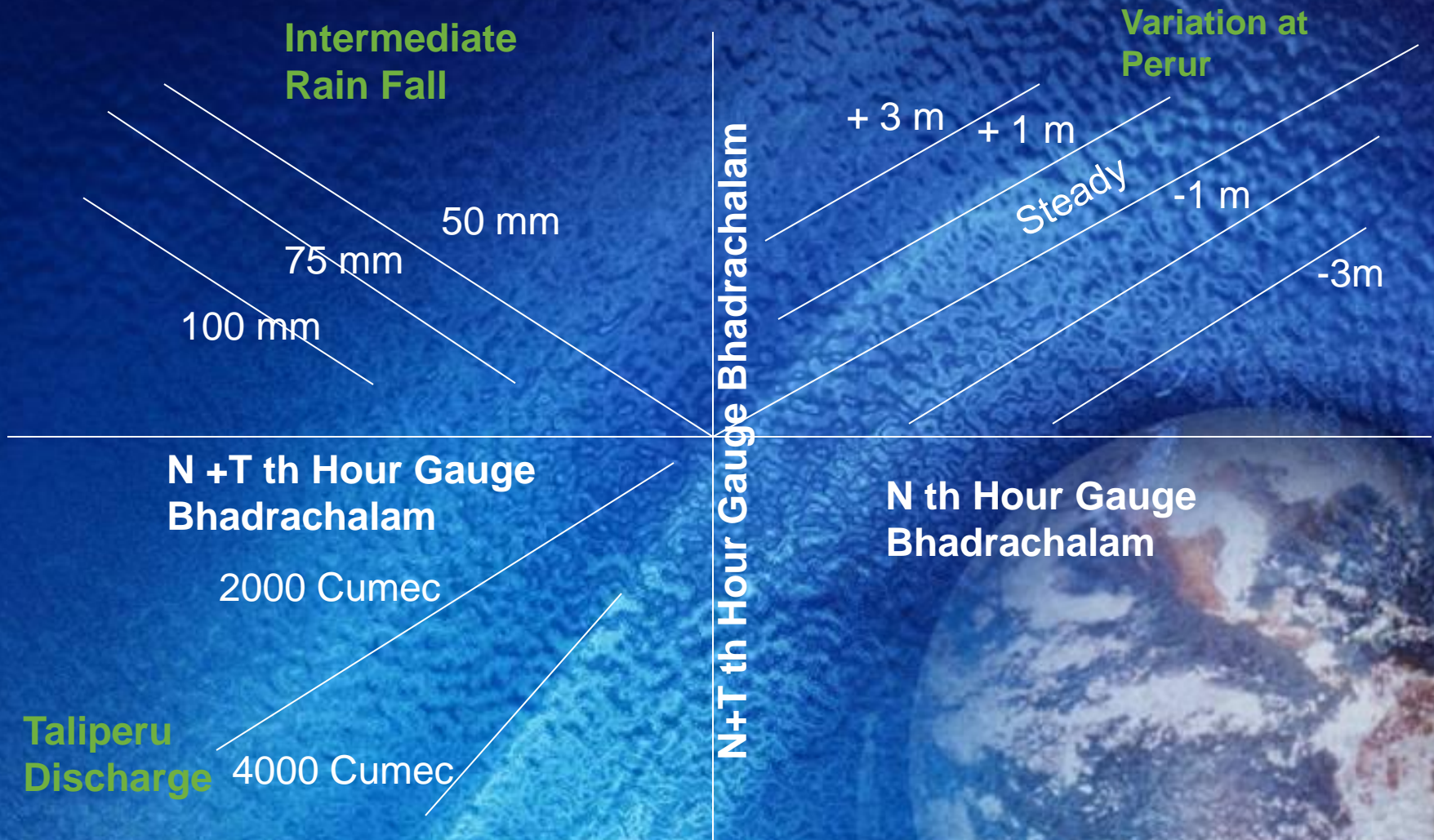


# Flood forecasting by Conventional Methods

CORRELATION DIAGRAM FOR BHADRACHALAM



# Multiple Correlations - Example

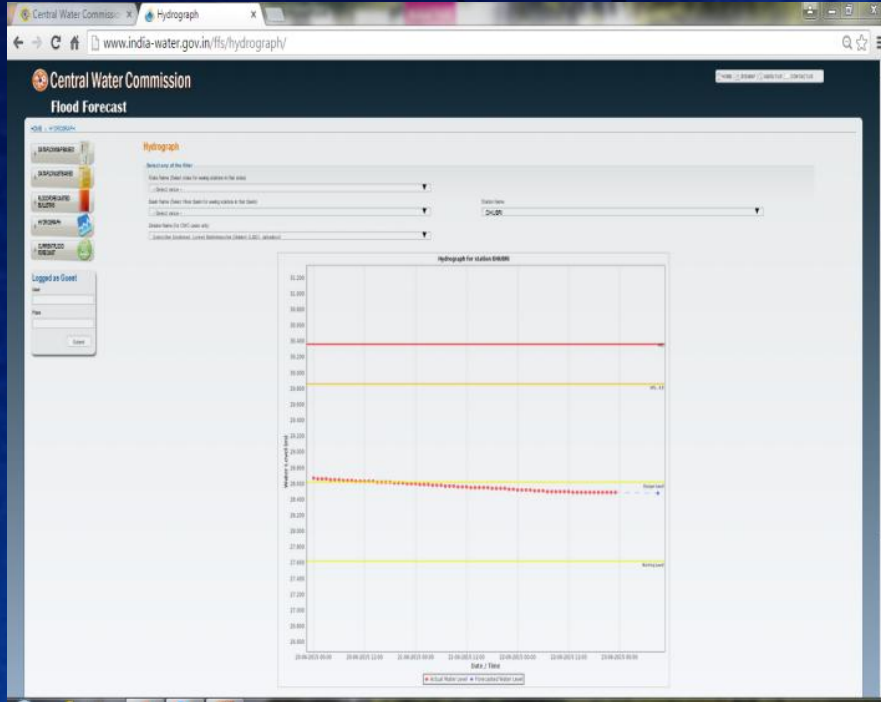




# Flood Bulletin Colour Codes

<b>Flood Category</b>	<b>Description</b>	<b>Forecast Bulletin Colour</b>
<b>IV</b>	<b>Low Flood (Water Level between Warning Level and Danger Level)</b>	<b>Yellow</b>
<b>III</b>	<b>Moderate Flood (Water Level below 0.50 m less than HFL and above Danger Level)</b>	<b>Yellow</b>
<b>II</b>	<b>High Flood (water level less than Highest Flood Level but still within 0.50 m of the HFL)</b>	<b>Orange</b>
<b>I</b>	<b>Unprecedented Flood (Water Level equal and above Highest Flood Level (HFL))</b>	<b>Red</b>

# Forecast Dissemination through Website(<http://india-water.gov.in/ffs>)



Central Water Commission Flood Forecast

Tools: Navigation, Table of contents, Legend and Tools are available inside Tools

Logged as Guest

User:

Pass:

Submit

Current Flood Forecast

LEVEL FORECASTING SITES

S. NO.:	Site Name:	State:	Basin:
1	Badatighat	Assam	BRAHMAPUTRA
2	Bassu	Bihar	GANGA
3	Beki Road bridge	Assam	BRAHMAPUTRA
4	DHUBRI	Assam	BRAHMAPUTRA
5	Dibrugarh	Assam	BRAHMAPUTRA
6	Goalpara	Assam	BRAHMAPUTRA
7	NT Road Crossing Jia-Bharati	Assam	BRAHMAPUTRA
8	Neamatighat	Assam	BRAHMAPUTRA
9	Tezpur	Assam	BRAHMAPUTRA

INFLOW FORECASTING SITES

S. NO.:	Site Name:	State:	Basin:
1	Prakasam Barrage	Andhra Pradesh	Krishna



# Preparation and Advance Warning

➤ Real time satellite based data transmission for flood wave simulation

➤ Assessment of Impounded water volume behind natural dams and glacial lakes

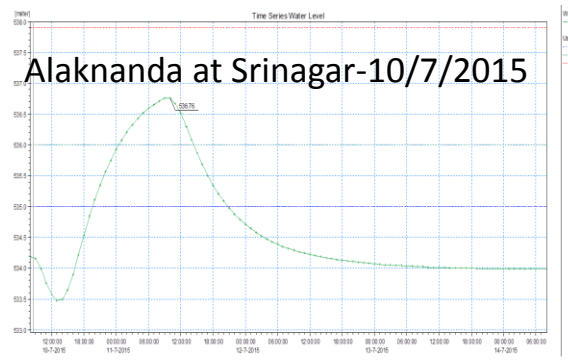
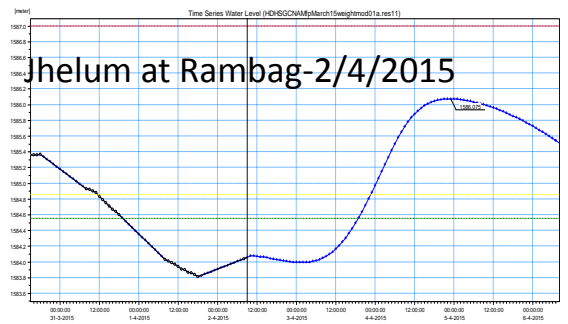
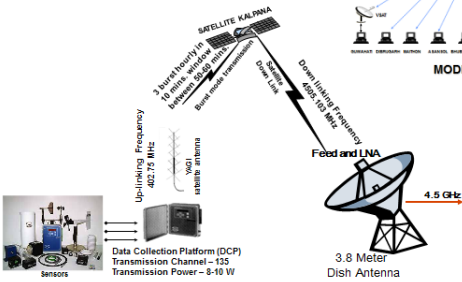
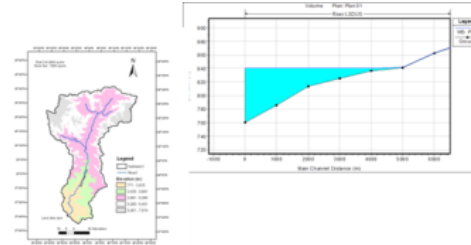
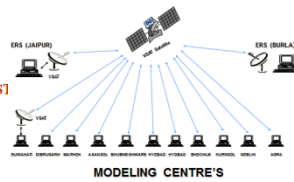
➤ Simulation of the flood wave propagation using remote sensed DEMs in hilly and inaccessible regions for Glacial lakes and landslide dams

➤ Setting up of inflow forecasting for safety of dams and reservoirs

➤ Assessment of reservoir storage situation for drought vulnerability

➤ System for telemetry based monitoring of 120 reservoirs

SATELLITE BASED TELEMETRYSYS1

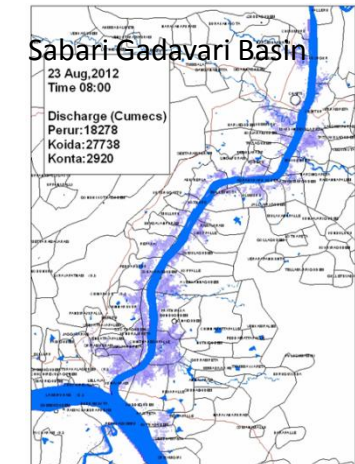


# New Initiatives

- Extended network of forecasting in unrepresented sub-basins/basin based on satellite based communication



Ganga at Rishikesh-10/7/2015



- Extended Hydrological Prediction Modeling to increase warning time upto 3 days using QPF by IMD

- Flood Inundation Modelling for generating spatial extent of flooding in advance using DEM from NRSC

- MOUs with Global agencies to ToT for 2D inundation modeling

ing of Flood Management Works using high resolution satellite imageries

- DSS for reservoir operation to minimise downstream flooding



# Glacial Lake Outburst Flood(GLOF)

- Flash floods caused by the outburst of glacial lakes, called as Glacial Lake Outburst Flood(GLOF), are well known in Himalaya where such lakes has been formed by landslides.
- Incidents of outburst of Glacial Lakes/Water bodies in Himalayan region are increasing which have potential of flooding in downstream areas.



## **ACTIVITIES/STUDIES CARRIED OUT BY CWC**

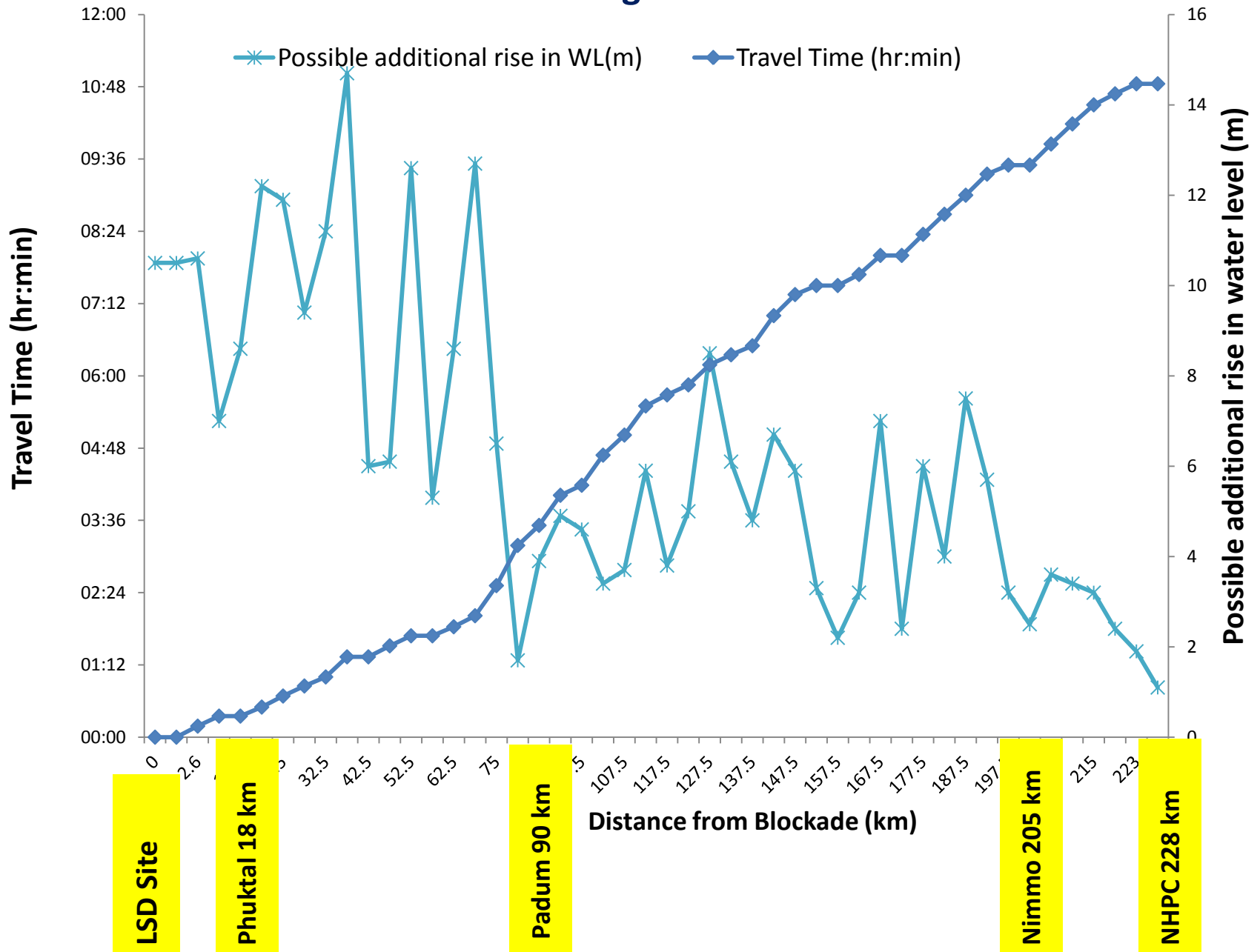
- **Inventory of Glacial Lakes > 10 ha.**
- **Monitoring of Glacial Lakes > 50 ha.**
- **Prioritization of Glacial Lakes with area > 50 ha. inside Indian Boundary for Glacial Lake Outburst Flood (GLOF) study. 16 number of Glacial Lakes indentified.**



# Flood -2014

- **Landslide in Koshi Basin in Nepal**
  - Dam break study for flood propagation upto Indo Nepal border
  - Officers from CWC were part of Expert team visiting dam site for for assessment of situation and mitigating measures
- **Landslide in Zaskar Valley in Laddakh region of J&K**
  - CWC carried out Dam break study for flood propagation upto Nimmo Bazgo HEP
  - Officers from CWC were part of the NDMA team for assessment of situation and mitigating measures
  - CWC Installed Automatic Water Level Recorder for monitoring & warning

# Travel Time & Possible Rise in Water Level vs Distance from Blockage Site







**THANK YOU FOR A PATIENT HEARING**

