

# Spatial Flood Early Warning

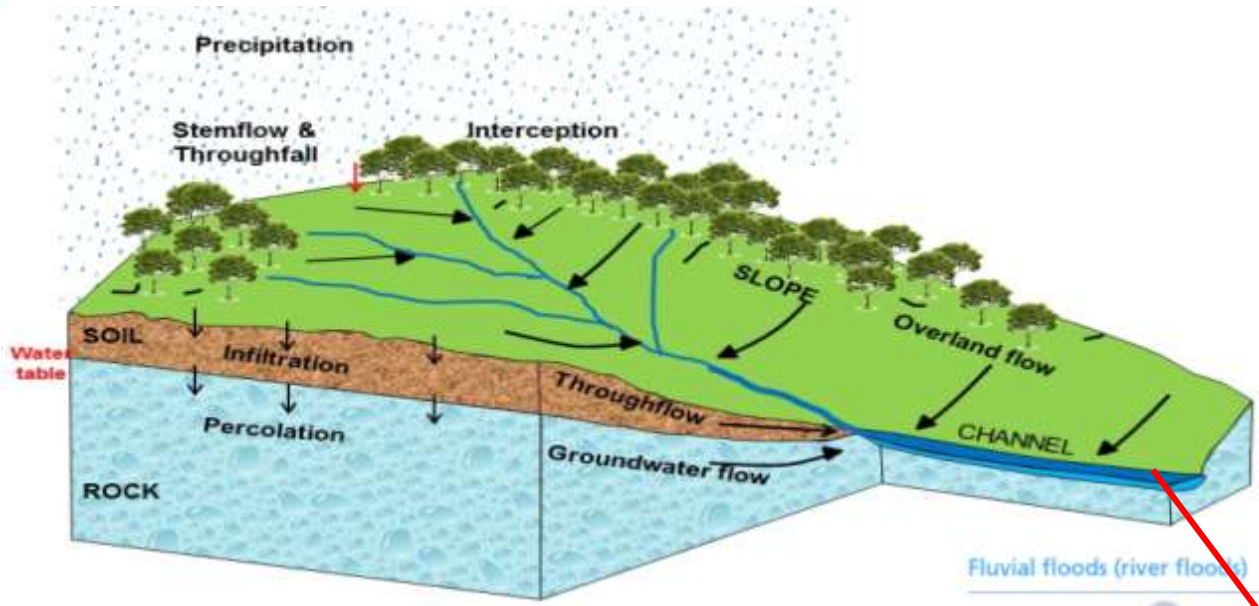


*nrsc*



**Disaster Management Support Group  
National Remote Sensing Centre  
Indian Space Research Organisation,  
Hyderabad, India**

Presented by  
**Amanpreet Singh**  
Scientist 'SE'  
NRSC/ISRO



**“Flood is an overflow of water onto land that is normally dry”**



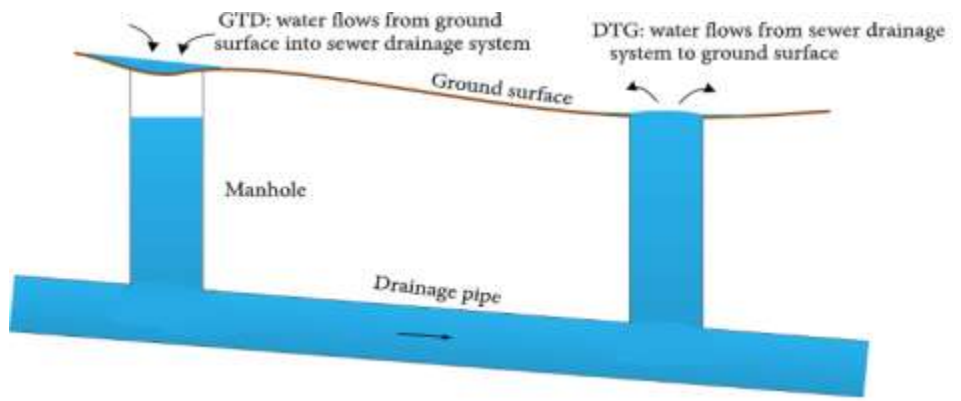
## River Flooding (Fluvial Flooding)

- A fluvial or river flood, occurs **when the water level in a river, lake or stream rises** and overflows onto the surrounding banks, shores and neighboring land.
- The water level rise could be due to excessive rain or snowmelt.



# Urban Flooding (Pluvial Flooding)

As per Federal Emergency Management Agency (FEMA), Urban Flooding is the inundation of property in a built environment, particularly in more densely populated areas, caused by rain falling on increased amounts of impervious surfaces and insufficient capacity of drainage systems.



## Storm surge

Cyclone winds can be deadly, but surging water levels can also threaten life

■ High winds push sea water towards the coast

■ The cyclone makes landfall, water has nowhere to go but inland



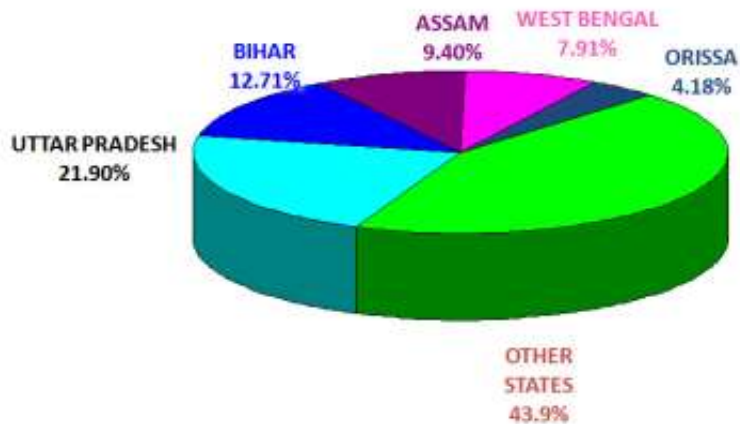
Source: NOAA, Met Office

© AFP

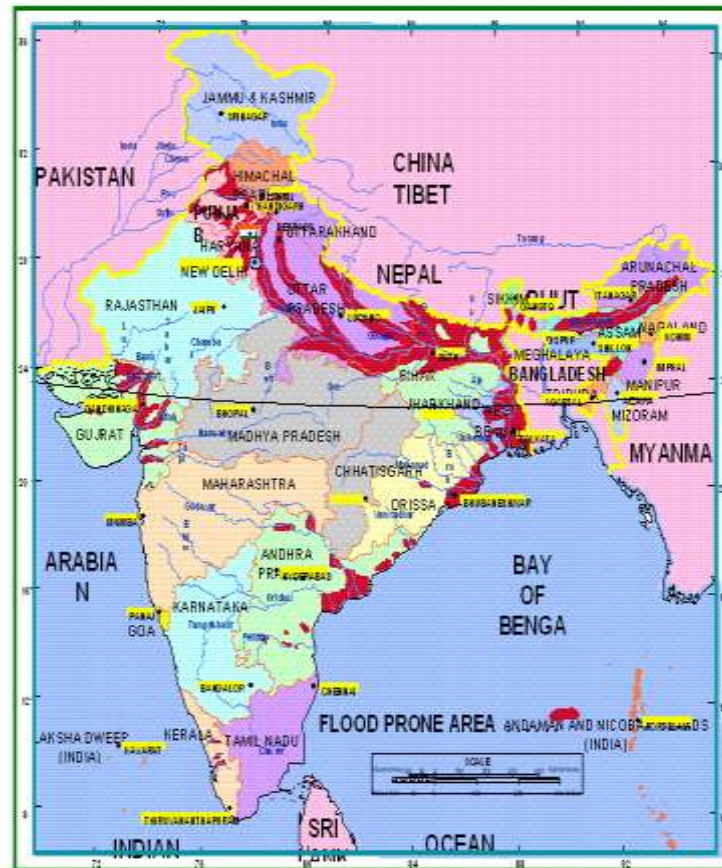


- Storm surge is an abnormal rise of water generated by a storm, over and above the normal tides.

- This rise in water level can cause extreme flooding in coastal areas



Geographical Area	329 mha
Total Flood Prone Area	40 mha
Major Flood Prone States	Assam, Bihar, West Bengal, UP, Orissa and A.P
Major Flood Prone Basins	Ganga, Brahmaputra, Mahanadi and Godavari River





- *UNDRR, 2009 defines EWS as “the set of capacities needed to generate and disseminate **timely and meaningful warning information** to enable individuals, communities and organizations threatened by a hazard to **prepare and to act appropriately and in sufficient time** to reduce the possibility of harm or loss.”*

## Flood Early Warning System

- Flood Early Warning System is a system by which **flood induced hazards** can be **minimized and prevented**.
- In a flood early warning system the most important input is **real time hydro-meteorological observations** such as **rainfall, water level or discharge** etc. **Weather forecasts** (Numerical Weather Prediction-NWP) are also playing an important role in providing input for hydrological models.
- LULC, Soil and DEM are important inputs for hydrological model and spatial flood inundation model.
- Besides having forecasts of the most important input (precipitation), a **model** needs to be selected that characterizes and simulates the **catchment responses** for flood early warning.
- **Flood early warning system** can provide essential help for the risk and disaster management by helping to **identify possible affected areas** as well as the potential impact and therefore giving more time to **prepare disaster relief efforts** and to **allocate resources**.



## Flood Early Warning Models mainly consist of

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- ✓ Development of ***medium-range flood early warning models*** using space based inputs through hydrological modelling approach.
- ✓ Development of ***spatial flood inundation simulation models*** using high resolution DTM in the major floodplains of the rivers
- ✓ Development of ***web-enabled real-time spatial flood early warning system.***



- **Short Range Forecast**

This method can give advance warning of 12-40 hrs for flood

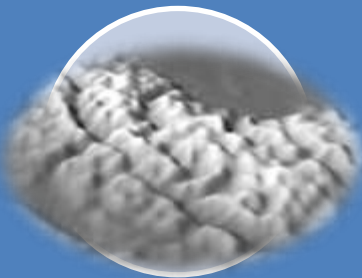
- **Medium Range Forecast**

This method can give advance warning of 2-5 days for flood

- **Long Range Forecast**

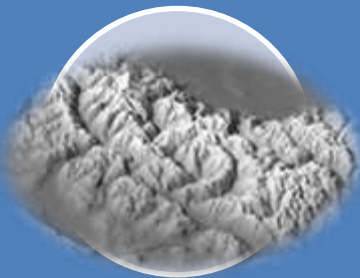
This method can give advance warning of more than 5 days

# Digital Elevation Models at National Level for Spatial Hydrological Modelling



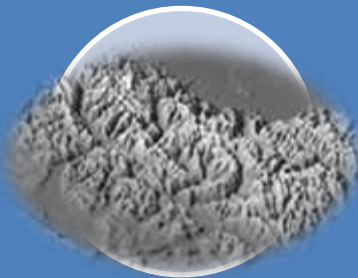
## Course Resolution DEMs

- Global DEM (1 km resolution)
- SRTM DEM (90 m resolution, Vertical Accuracy: < 16 m)



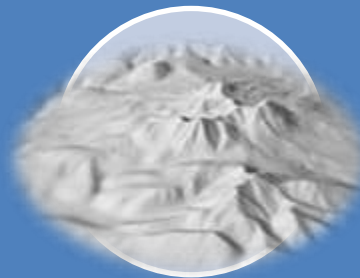
## Medium Resolution DEMs

- CARTO DEM (30m resolution, Vertical Accuracy: < 8 m)
- ASTER DEM (30m resolution)



## Fine Resolution DEMs

- CARTO DEM (10m resolution, Vertical Accuracy: < 8 m)
- ALOS (Advanced Land Observing Satellite, 5m resolution)



## Very Fine Resolution

- LiDAR DEM (1m resolution, Vertical Accuracy: ~50 cm)
- SAR DEM (<5m)





# Satellite Remote Sensing Based Flood Mapping VS Flood Inundation Simulation Based Flood Mapping

Satellite Remote Sensing	Flood inundation simulation
During or within a short time after a flood event	Before the event
Provides only Spatial Flood extent	Flood extent, water depth and velocity and other parameter
Time series of images are discontinuous	Time series of images are continuous
Represents actual observed flooded areas, therefore more realistic than inundation simulation	Results based upon the accuracy of input parameter
The time of acquisition of satellite data may not coincide with the time of flood peak	It covers entire range of flood progression, peak and recession

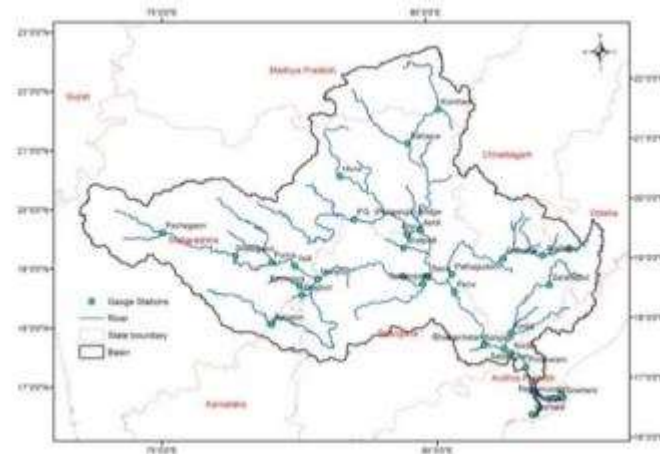
# Study Area

## Godavari Basin

- **Length of the Godavari river** is approximately around **1,465 km**. Basin Area is **312,812 km<sup>2</sup>**. It drains through six states.
- 2006, 2010, 2013, 2016, and 2020 are major floods year in the Godavari basin.
- **Reservoirs:** Jayakwadi, SRS, Gosi Kurd, Bailmela, Isapur etc

Year	Discharge (cumec)
1981	51496
1983	43879
1986	62889
1990	62800
1994	41042
1995	40205
2000	40942
2006	51916
2010	44200
2013	57244
2019	38070
2020	44988

## The Godavari Basin



Hydrological setting of Godavari basin

## Major floods (discharge at Perur, CWC)

Year	Discharge (cumec)
1944	33527
1945	28996
1949	23843
1959	36642
1968	44174
1998	19057
2006	25768
2012	9508
2013	12146

## Major floods at Surat (CWC)

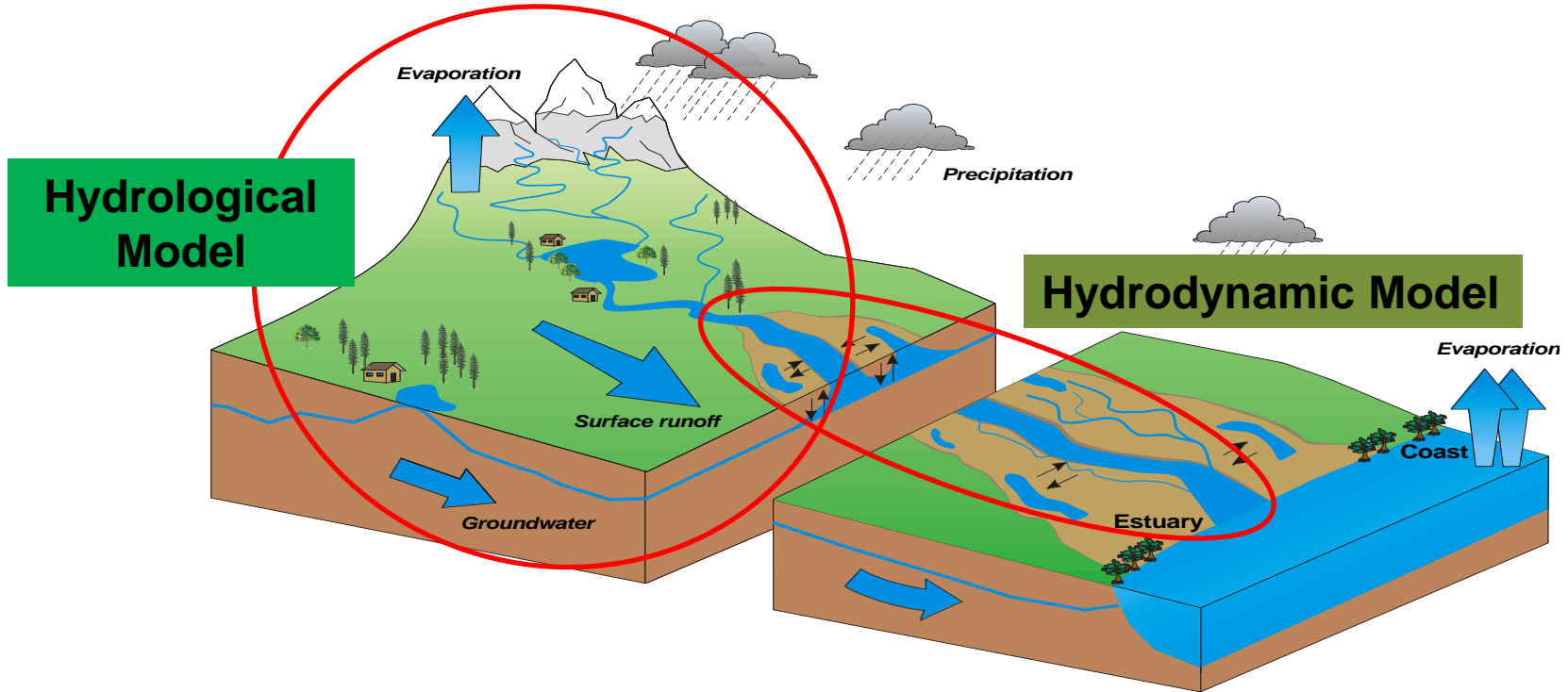
## Tapi Basin

- **Length of the Tapi river** is approximately around **724 km**. It drains through three states.
- 2006, 2012, 2013 are major floods year in the Tapi basin.
- **Reservoirs:** Hathnur, Ukai etc

## The Tapi Basin

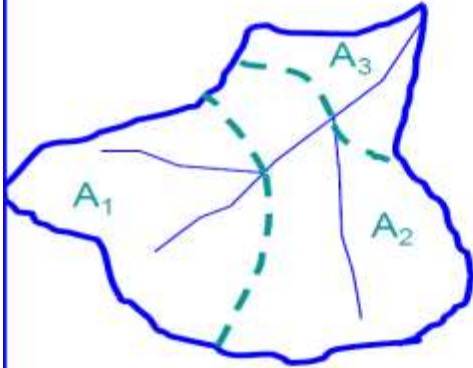


Hydrological setting of Tapi basin



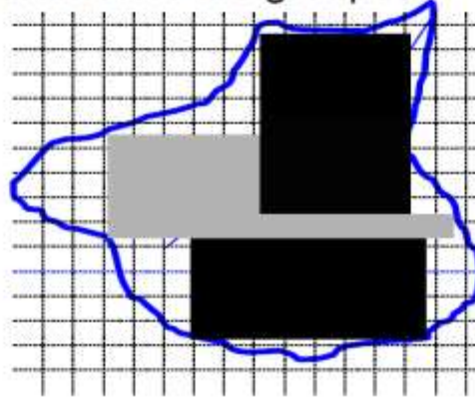
## Lumped

Parameters assigned to each sub-basin



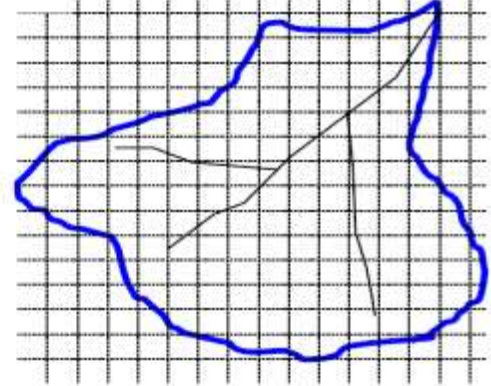
## Semi-Distributed

Parameters assigned to each grid cell, but cells with same parameters are grouped

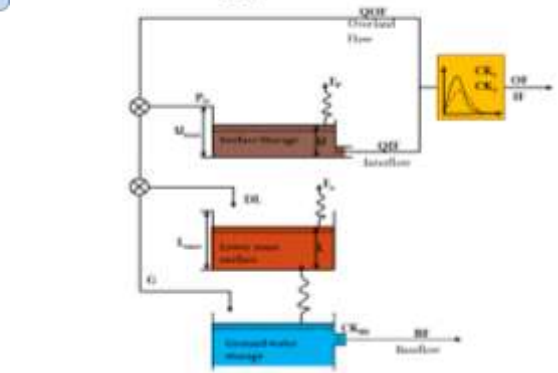
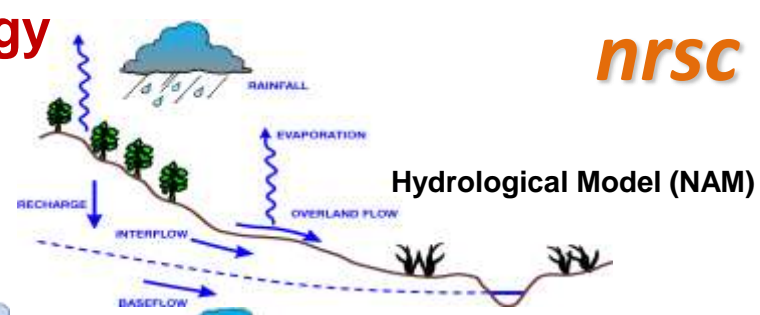
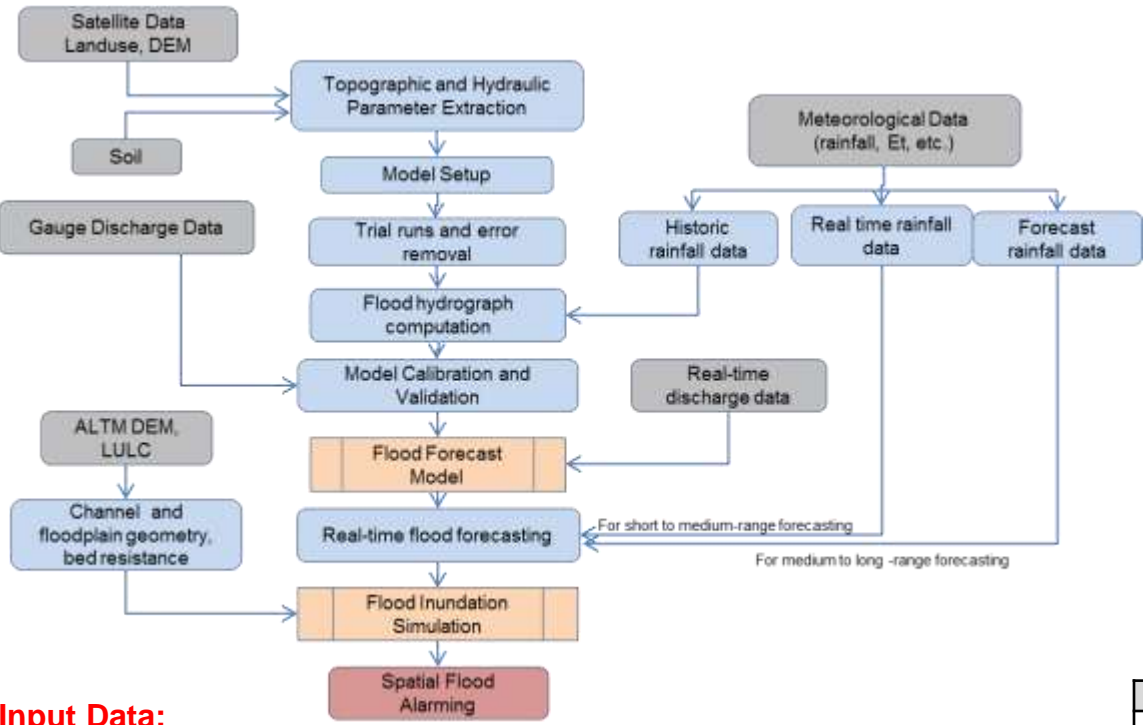


## Fully-Distributed

Parameters assigned to each grid cell



# The Broad Methodology



## Model Parameter:

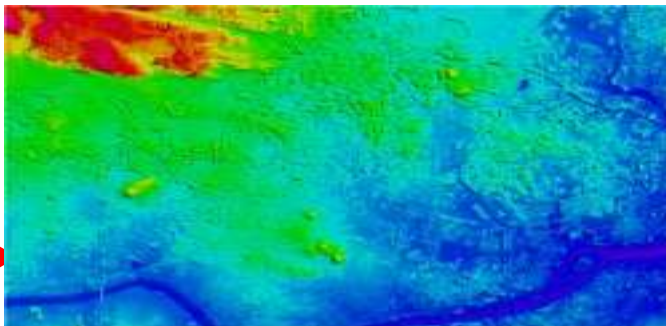
Parameter	Description	Unit
Umax (mm)	Maximum water content in surface storage	mm
Lmax (mm)	Maximum water content in root zone storage	mm
CQOF	Overland flow runoff coefficient	-
CKIF (h)	Time constant for interflow	h
TOF	Root zone threshold value for overland flow	-
CK1,2 (h)	Time constant for routing overland flow	H
TIF	Root zone threshold value for interflow	-
TG	Root zone threshold value for groundwater recharge	-
CKBF (h)	Time constant for routing base flow	h

## Input Data:

Data Requirement
<ul style="list-style-type: none"> <li>Meteorological data (rainfall and potential evaporation)</li> <li>Hydrological data (discharge at the outlet of the catchments for model calibration and validation)</li> <li>Model parameters (time constants and threshold values for routing surface storage, rootzone storage and groundwater storage)</li> </ul>

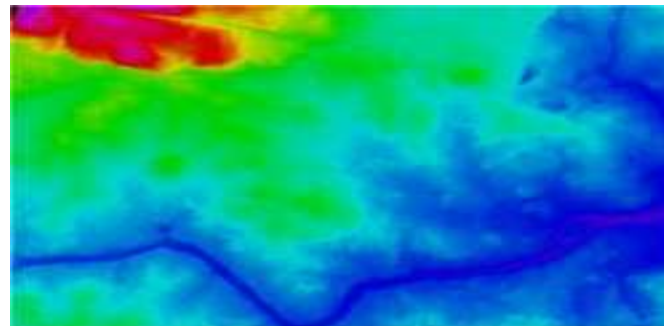
## Digital Surface Model (DSM)

represents the earth's surface and includes all objects on it.



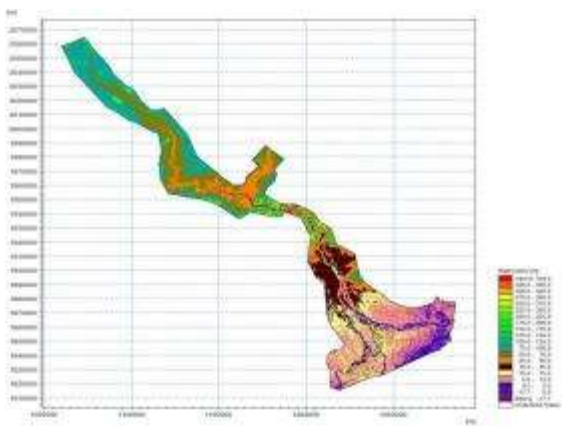
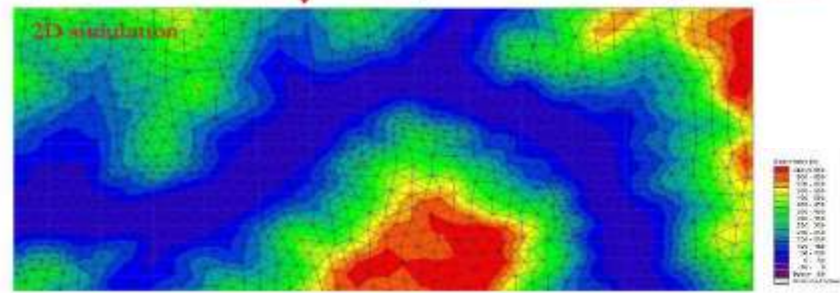
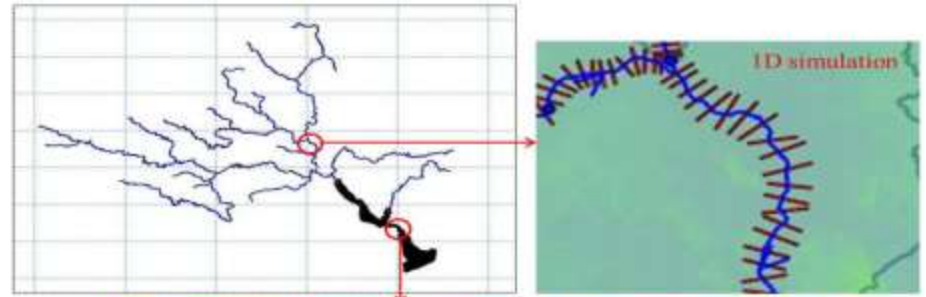
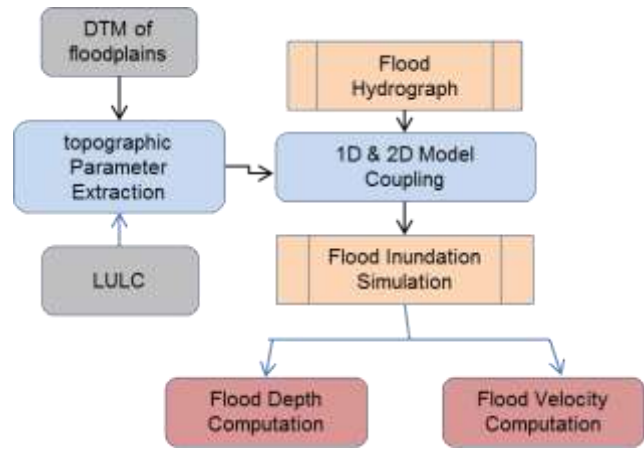
## Digital Terrain Model (DTM)

represents the bare ground surface without any objects like trees and buildings





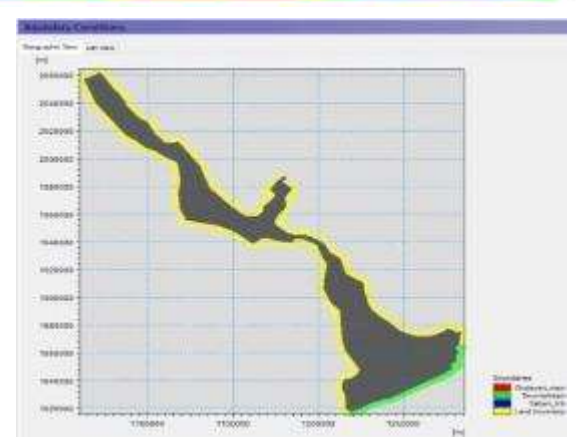
# Parameter Extraction and 1D-2D model coupling for flood inundation



Bathymetry



Bed resistance

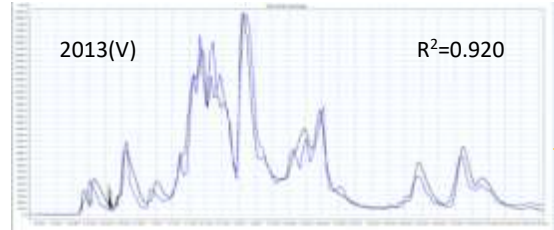
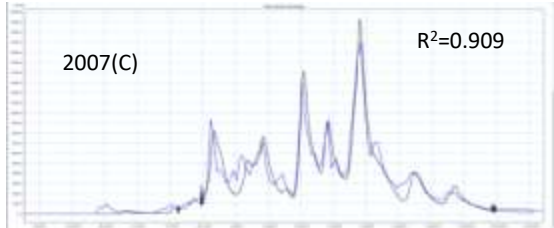


Boundary Conditions

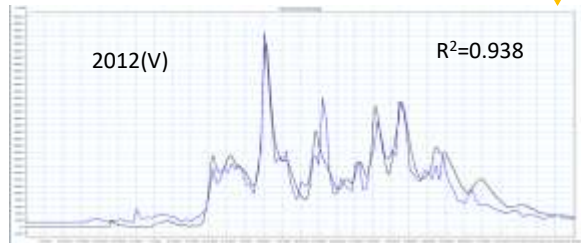
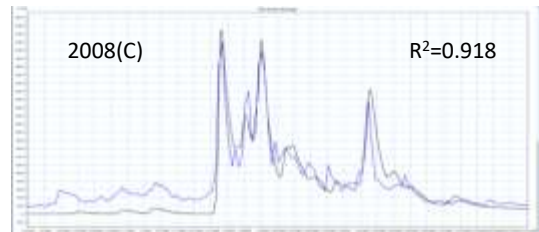
# Model Calibration & Validation

## - Godavari Basin

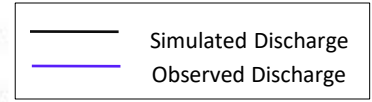
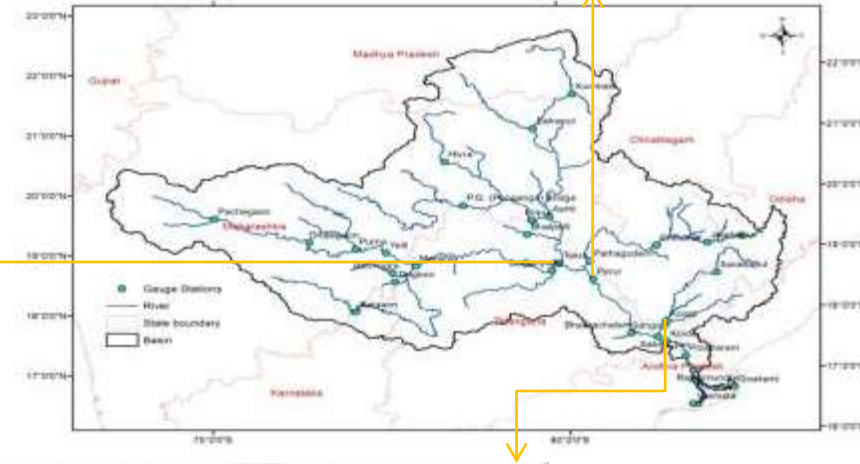
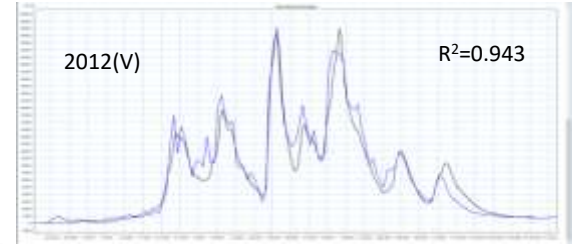
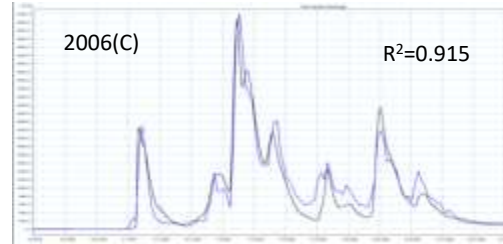
**Tekra**



**Konta**

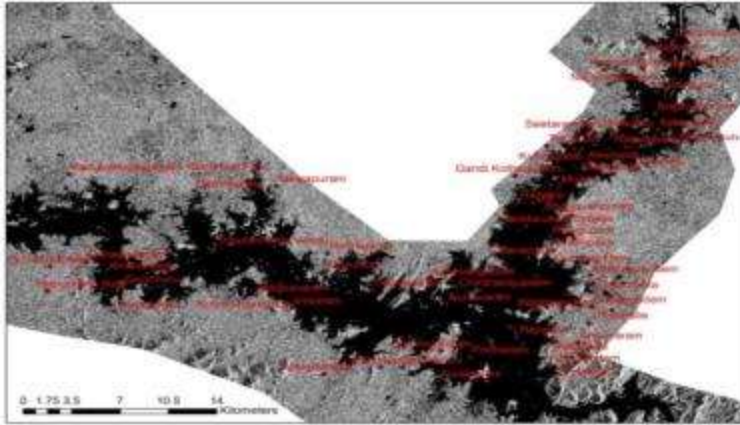


**Perur**

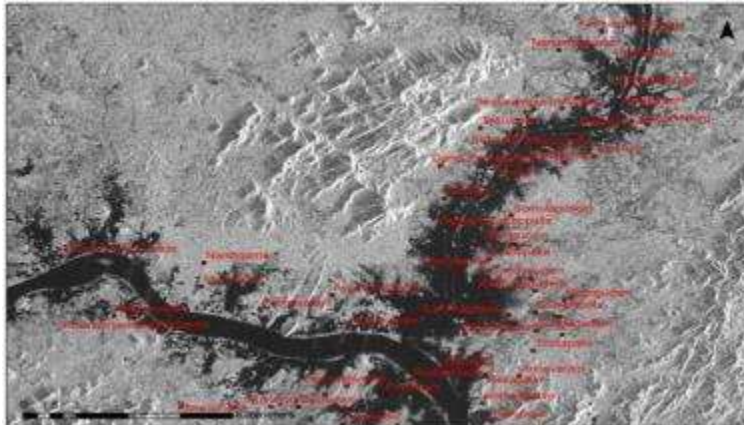
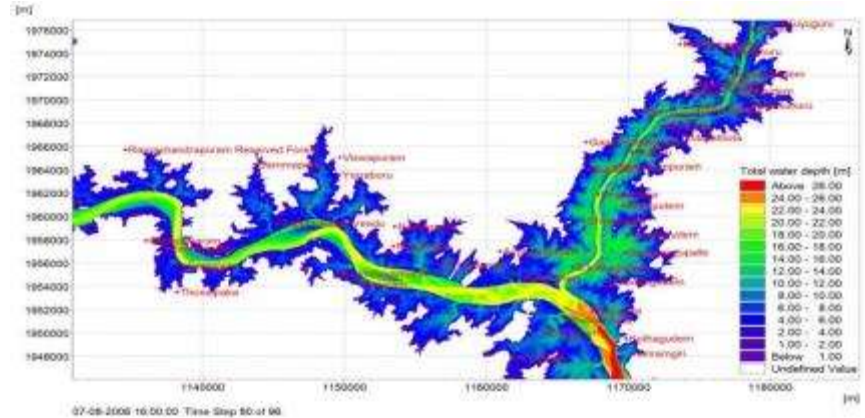


Calibration:(2006-2010)  
Validation:(2011-2013)

# Spatial Flood Inundation Simulations (Observed Vs Simulated) (Godavari Floodplains)



Simulated flood inundation during 2006 flood at Sabari confluence (calibrated)



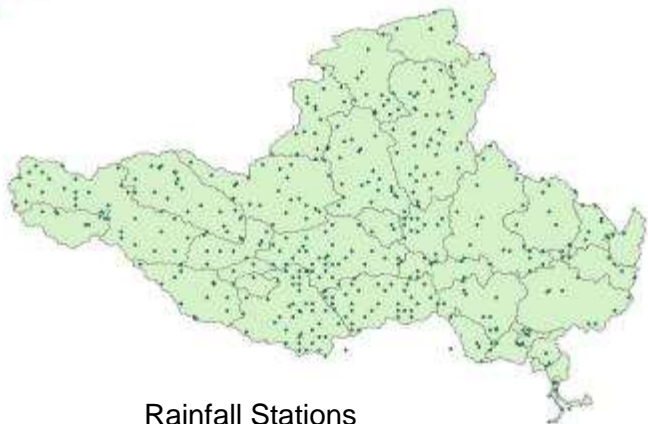
Simulated flood inundation during 2020 flood at Sabari confluence



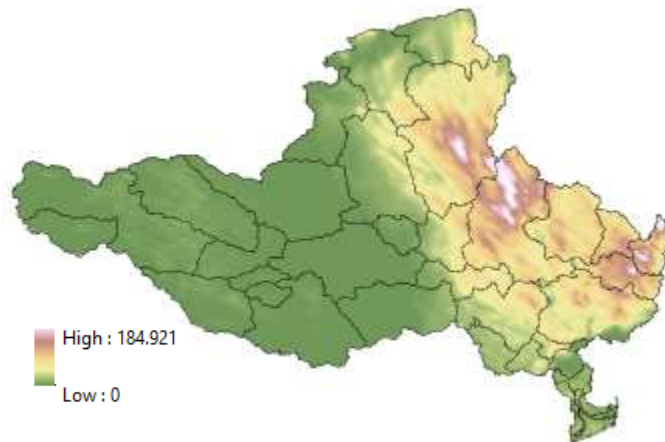


# Advantages of Flood Inundation Simulation

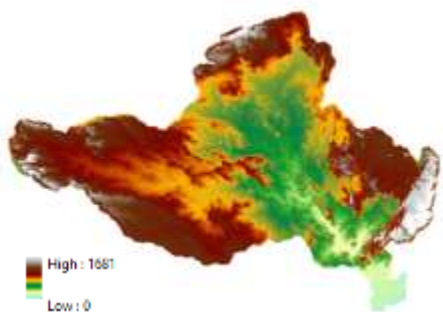
- Flood inundation simulation helps in many of these, such as
  - ❖ **Planning Rescue and Relief**
  - ❖ **Damage Assessment**
  - ❖ **Flood Risk Assessment**
  - ❖ **Design of structure**
  - ❖ **Zoning the floodplain to guide appropriate development**
  - ❖ **Flood mapping to raise community awareness**
  - ❖ **Assess benefits of natural flood management options**



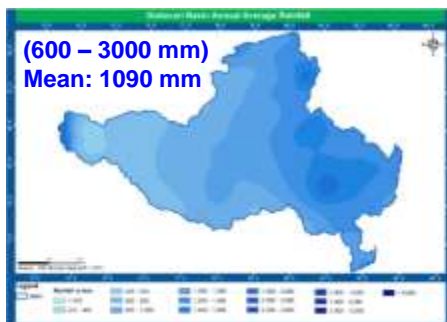
Rainfall Stations



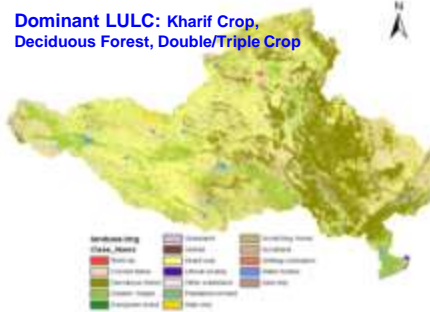
## Topographic data



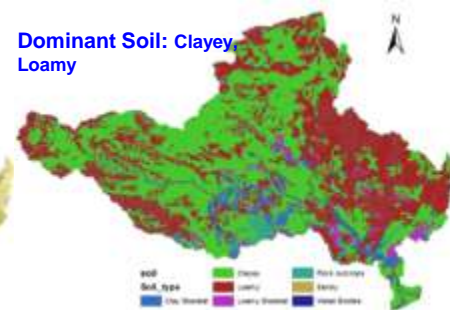
Digital Elevation Model



Rainfall

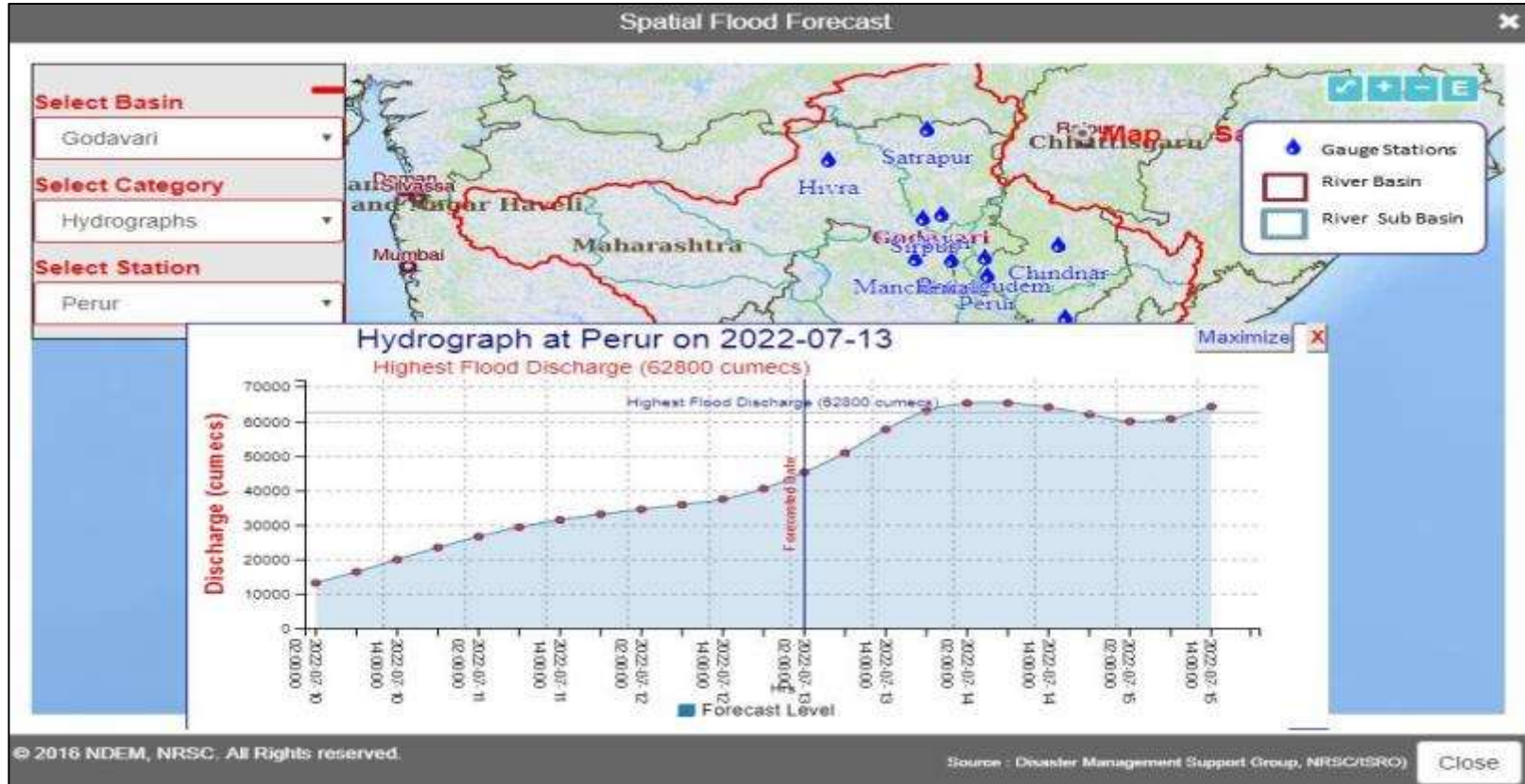


Landuse/Landcover



Soil Texture (NBSS & LUP)

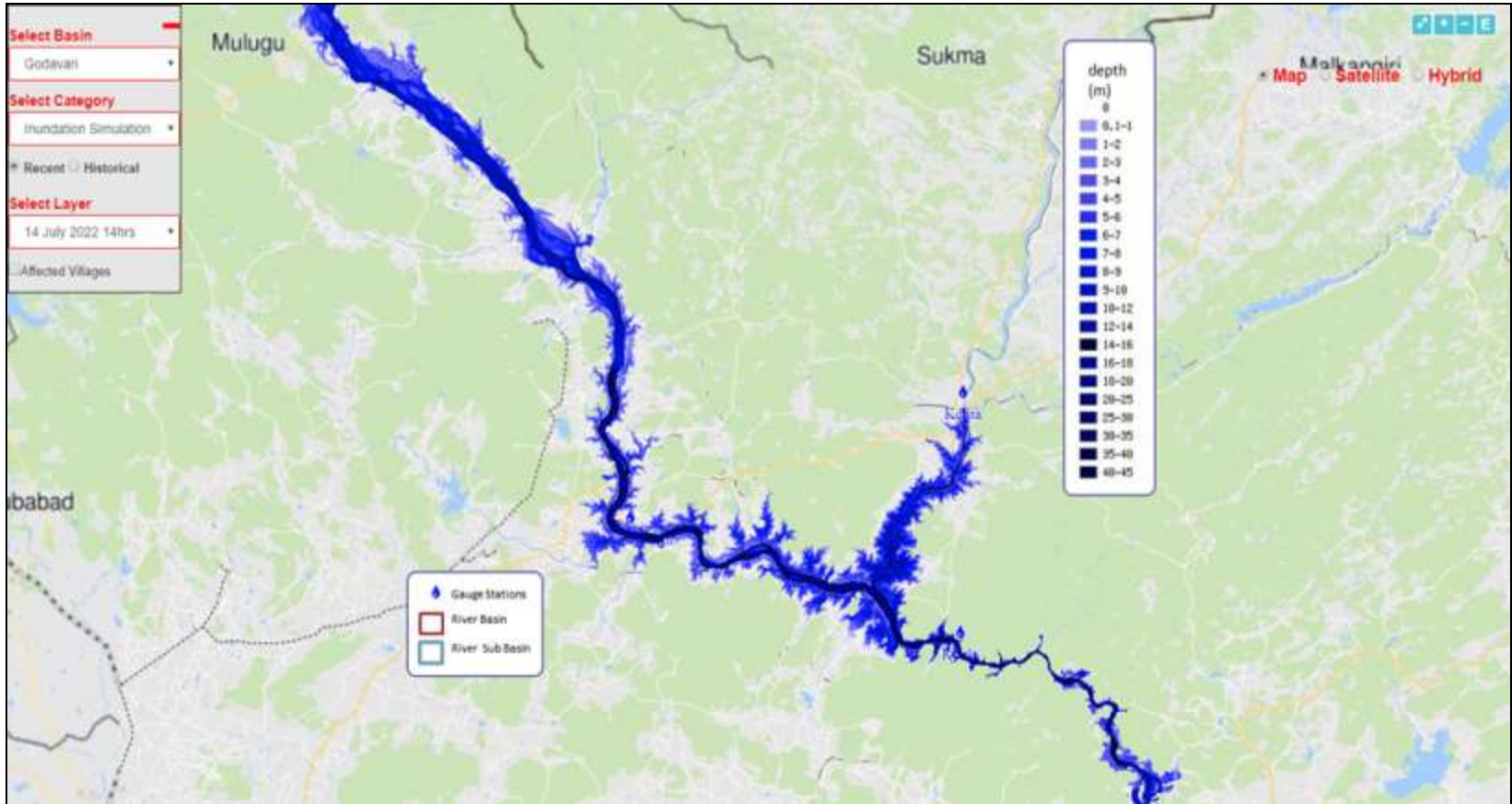
# Spatial Flood Early Warning Systems - Godavari and Tapi Rivers (2022)



Godavari Flood Early Warning-2022

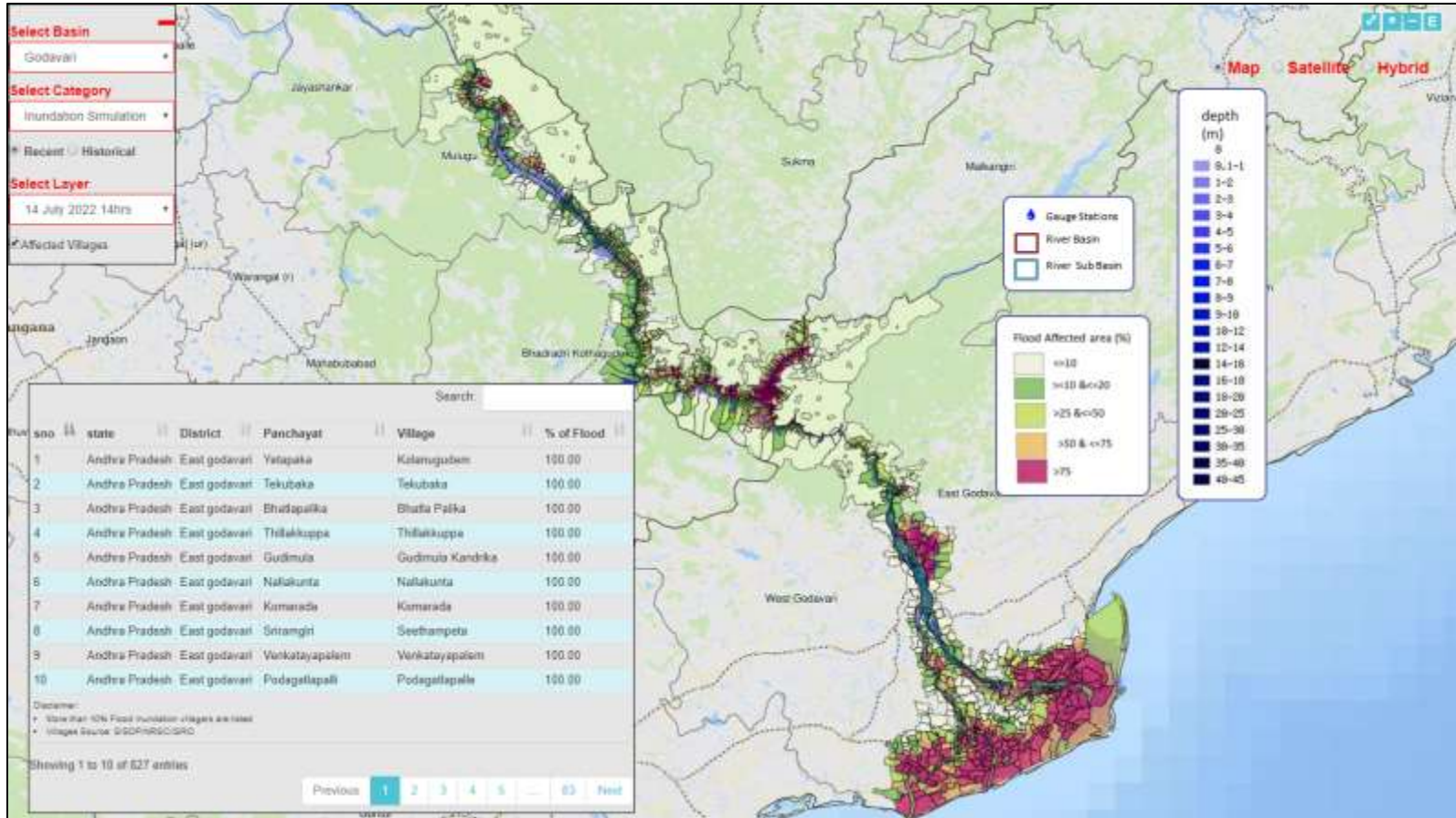
# Spatial Flood Early Warning Systems - Godavari and Tapi Rivers (2022)

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Inundation July 2022 flood event in Godavari River

# Spatial Flood Early Warning Systems - Godavari and Tapi Rivers (2022)



**Village Affected**



# Spatial Flood Early Warning Systems - Godavari and Tapi Rivers (2023)



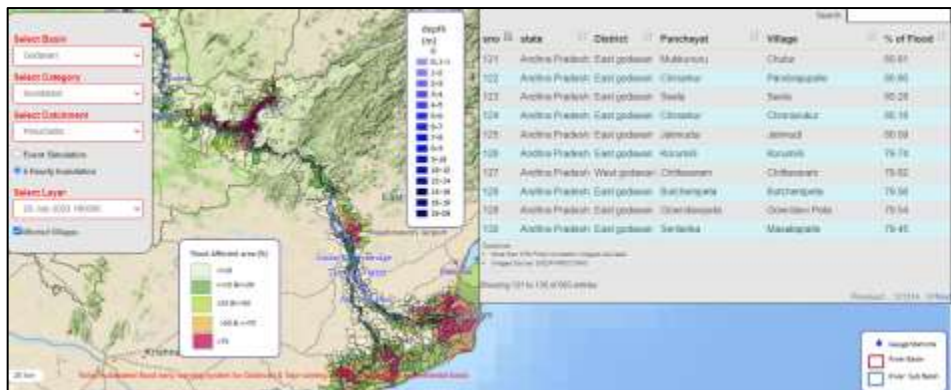
Flood Hydrograph at Bhadrachalam in Godavari River



Flood Hydrograph at Sarangkhedha in Tapi River

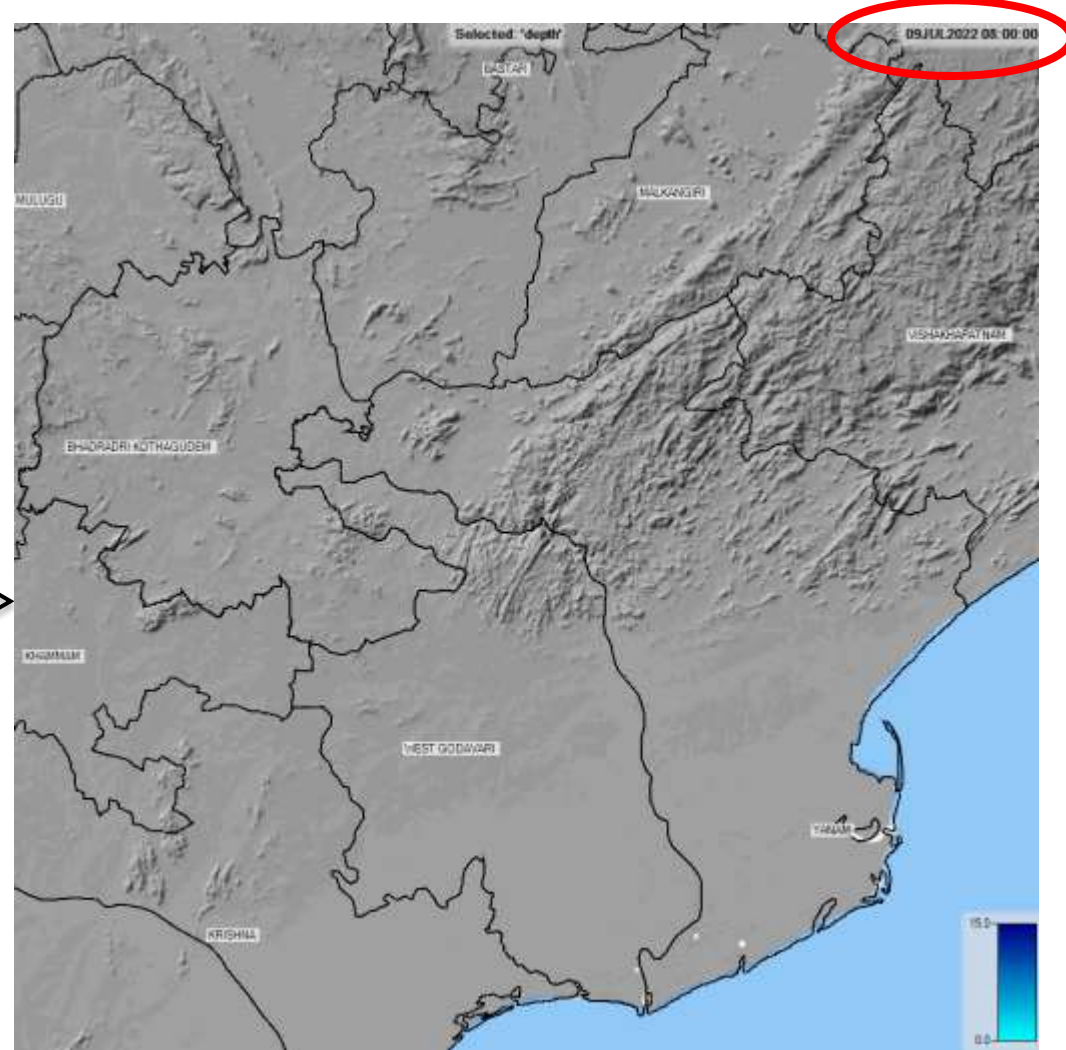
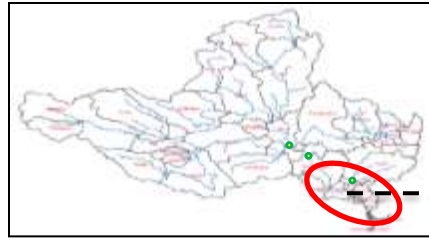


Spatial flood inundation simulation (29 Jul 2023)

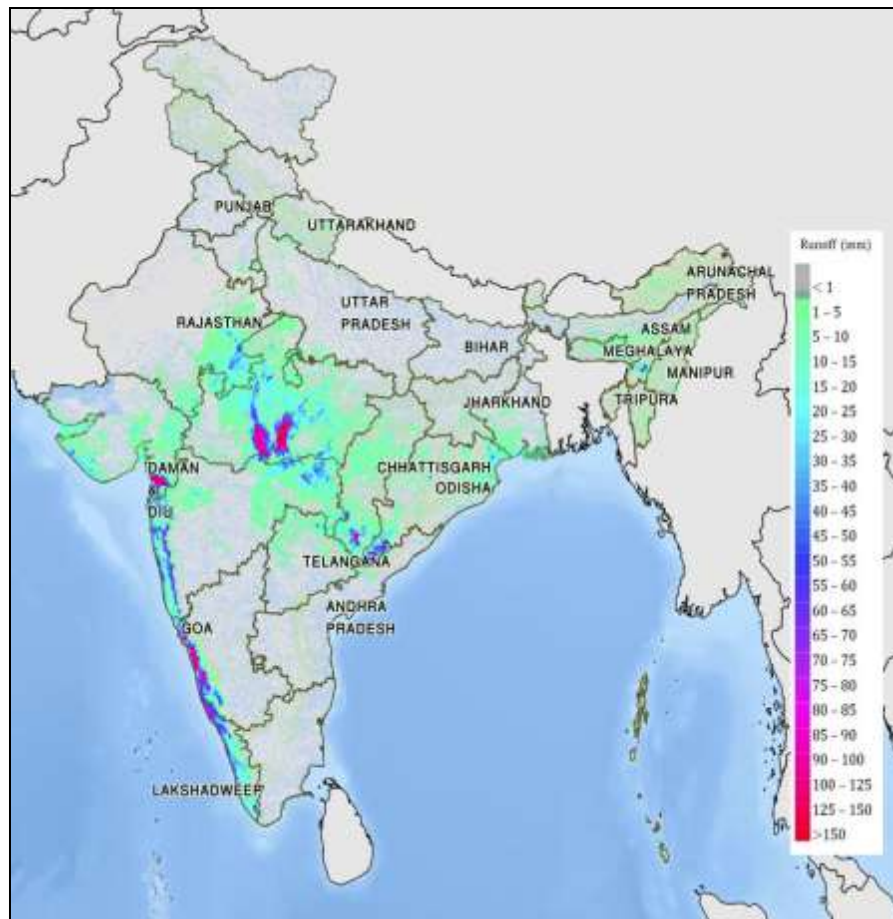


Spatial flood early warning and villages affected (29 Jul 2023)

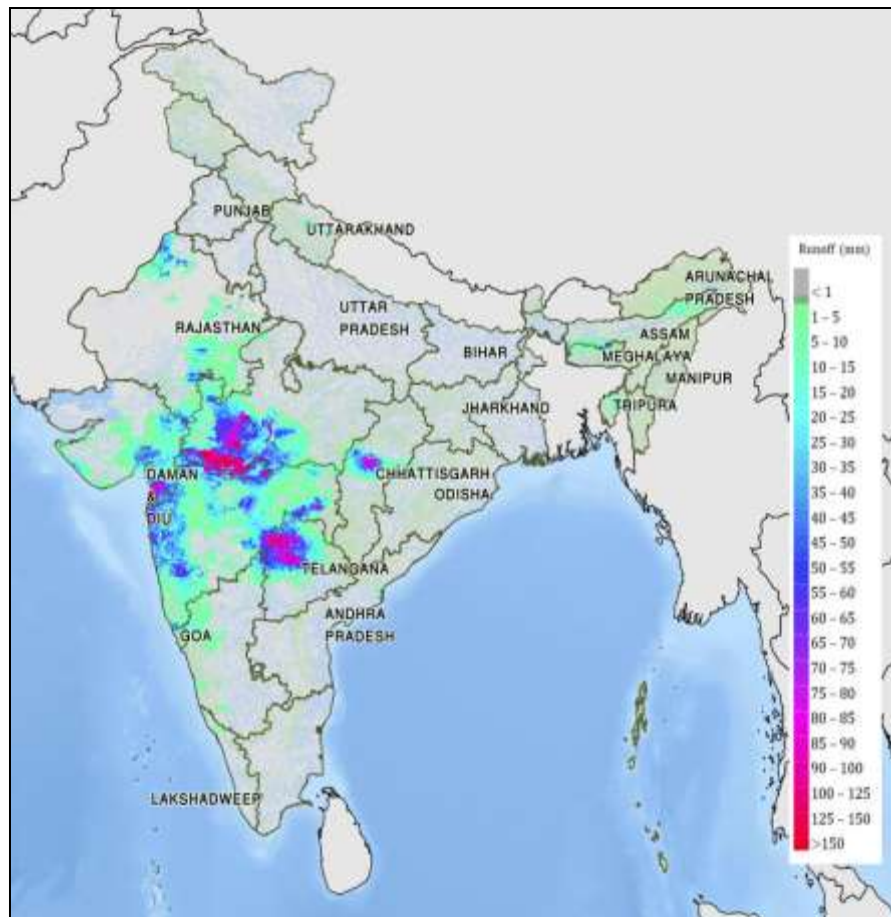
# Flood Inundation Simulations for Godavari Basin - 2022



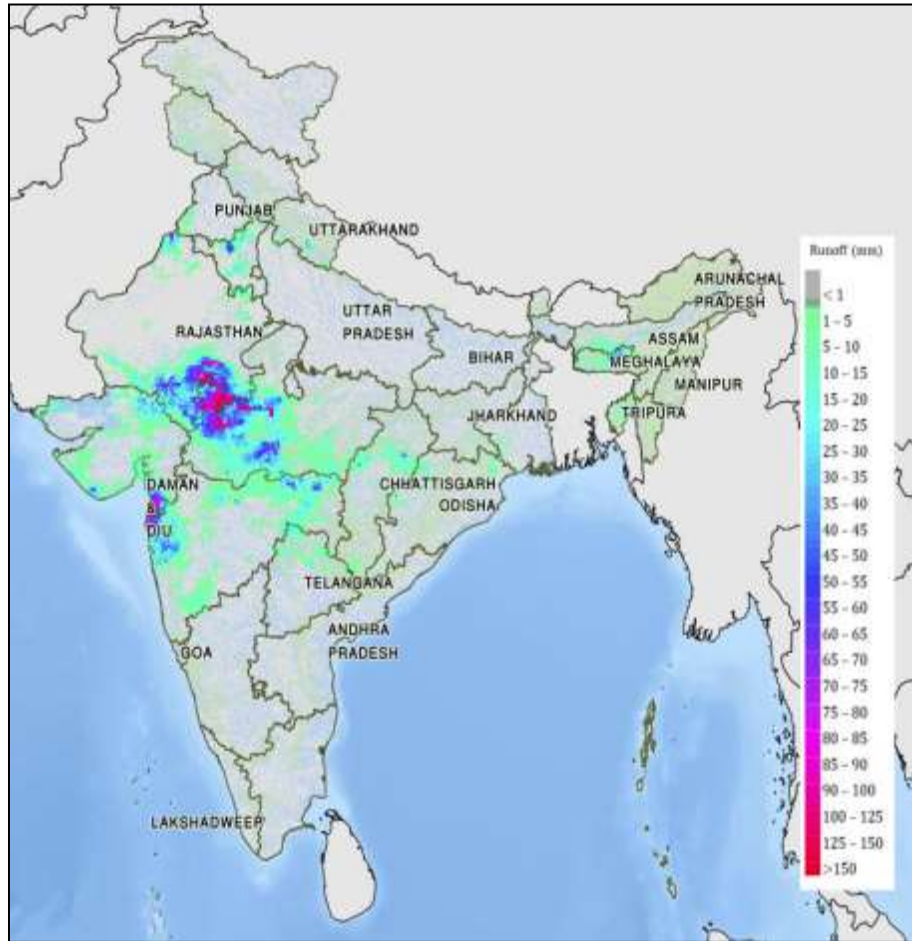
# PAN INDIA RUNOFF (14 July 2022)



# PAN INDIA RUNOFF (15 July 2022)



# PAN INDIA RUNOFF (16 July 2022)



# Major Highlights & End use

## Accuracy

Flood discharge computation accuracy is  $> 85\%$  with Improved Forecast lead time (36 to 50 hours) at multiple locations.

## Application

Spatial flood advisories on flood extent & depth to all the stake holders through automated sms services.

## End use

Vital input in relief & rescue operations, and in preparing Basin level DM plans for DRR.  
Scientific assessment of flood-prone area in the Basins



For details, please contact at  
[durgarao\\_khv@nrsc.gov.in](mailto:durgarao_khv@nrsc.gov.in)