Spatial Flood Early Warning

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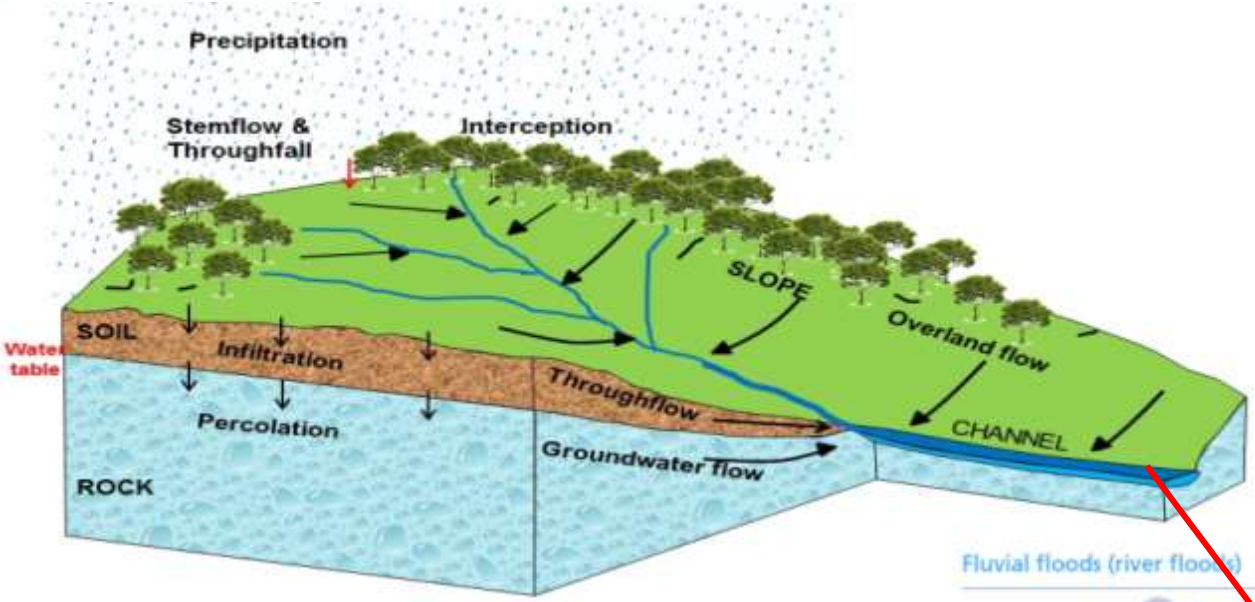
Drainage Basin Hydrological Cycle



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

Source: https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood

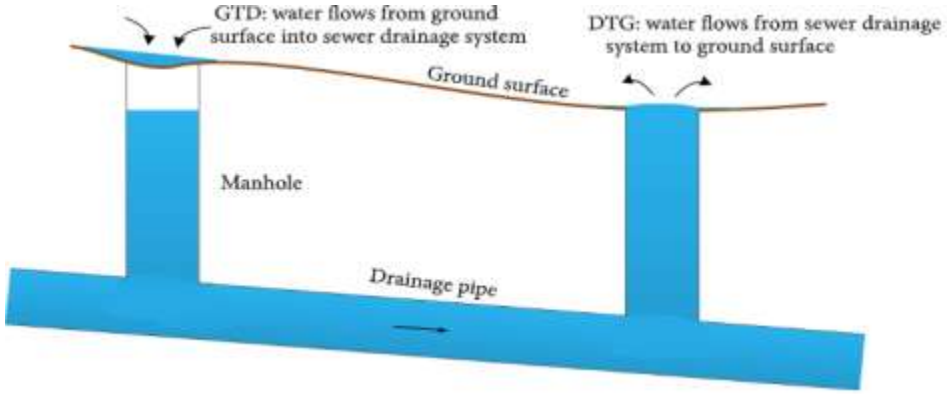
River Flooding (Fluvial Flooding)

- **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.



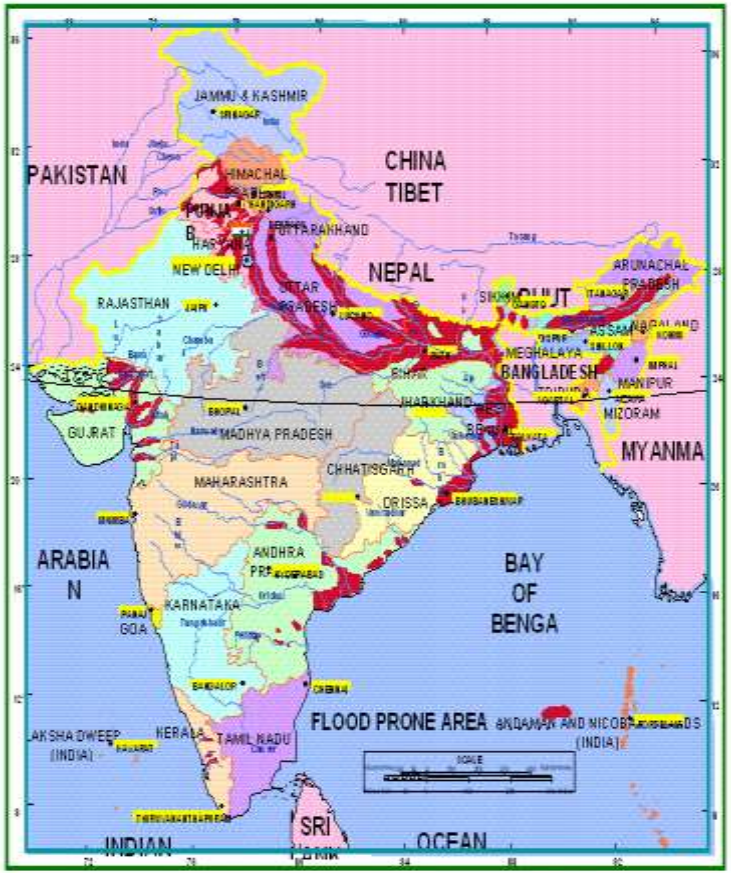
Coastal Flood

- **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**

Flood Problem (India)

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



Early Warning System

- ***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

- ✓ **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*.**

Categories of Flood Forecasting Techniques

- **Short Range Forecast**

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

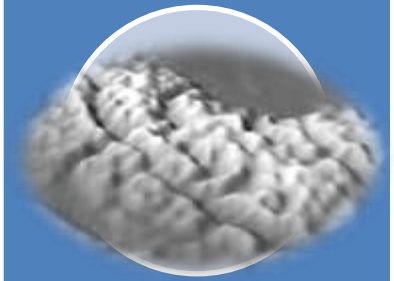
- **Medium Range Forecast**

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

- **Long Range Forecast**

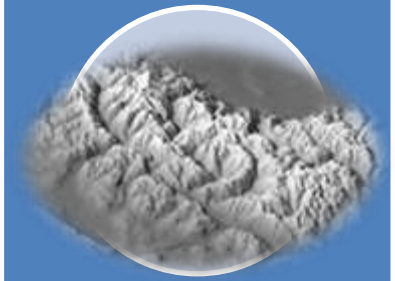
  This method can give advance warning of more than 5 days

Digital Elevation Models at National Level for Spatial Hydrological Modelling



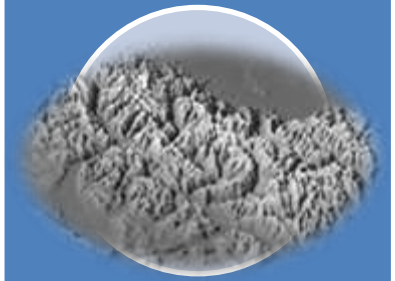
Course Resolution DEMs

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



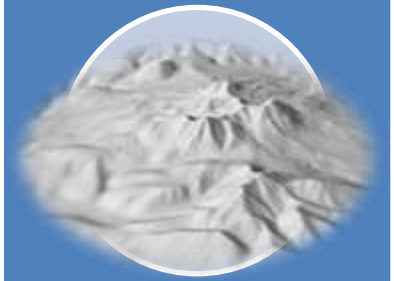
Medium Resolution DEMs

- 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

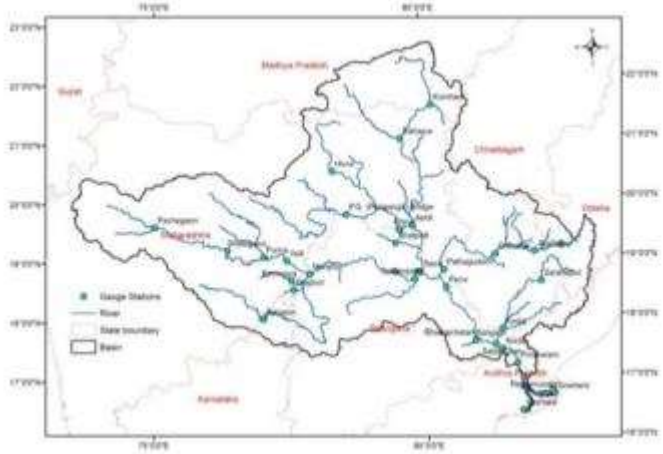
Godavari Basin

- **Length of the Godavari river** is approximately around **1,465 km**. Basin Area is **312,812 km²**. 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

Major floods (discharge at Perur, CWC)

The Godavari Basin



Hydrological setting of Godavari basin

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

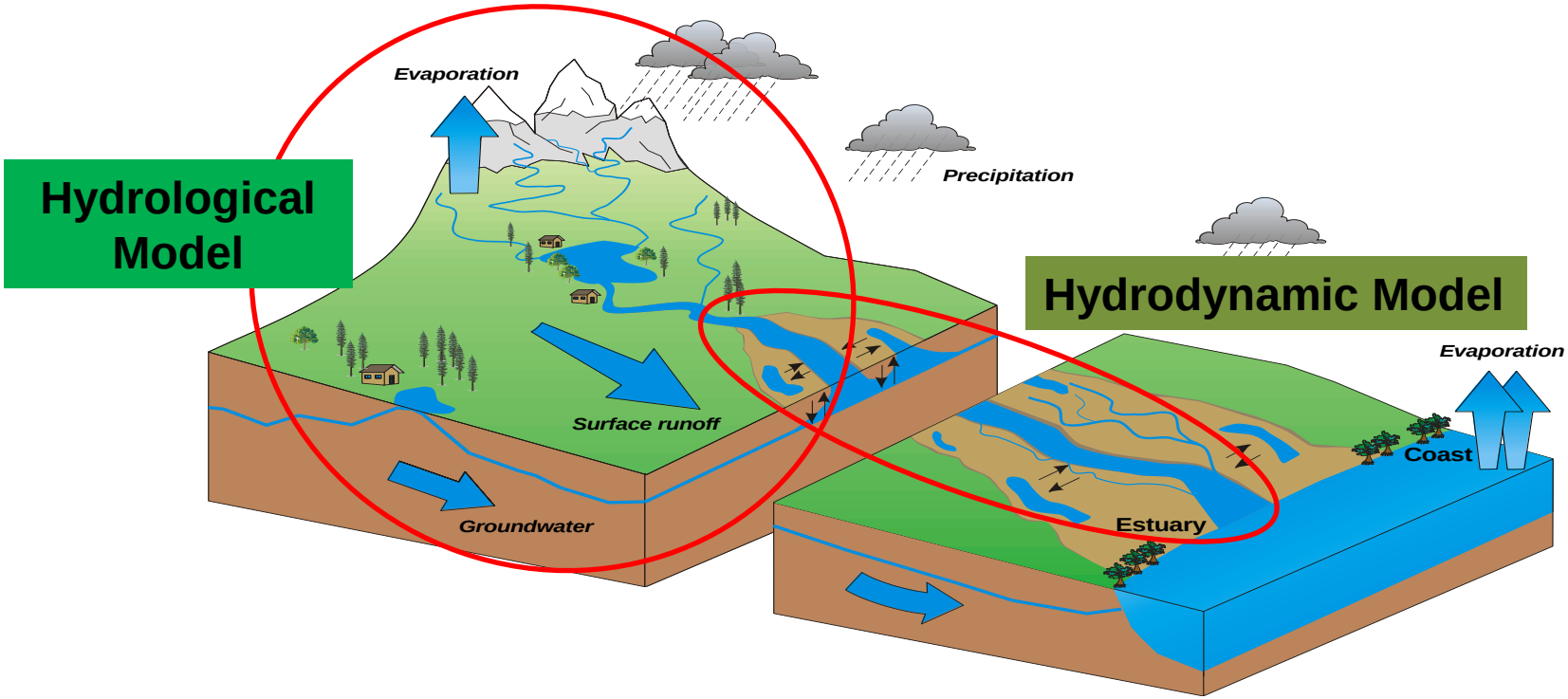
Year	Discharge (cumec)
1944	33527
1945	28996
1949	23843
1959	36642
1968	44174
1998	19057
2006	25768
2012	9508
2013	12146

Major floods at Surat (CWC)

The Tapi Basin

Hydrological setting of Tapi basin

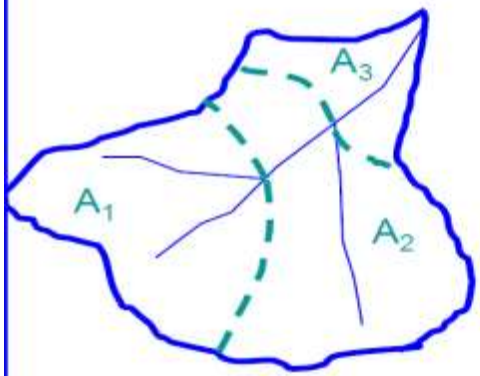
Hydrological Model and Hydrodynamic Model



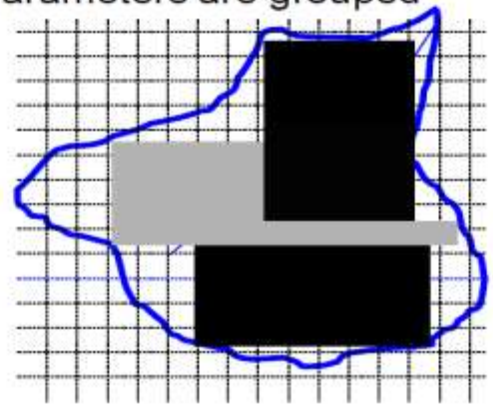
Source: https://publicwiki.deltares.nl/download/attachments/13402418/Flood%20forecasting%20using%20MIKE11.ppt?api=v2

Hydrological Model Classification

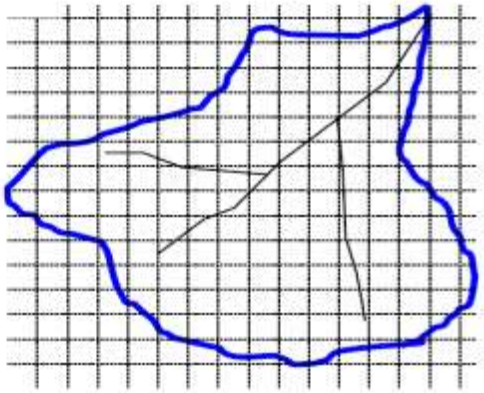
Lumped
Parameters assigned to each sub-basin



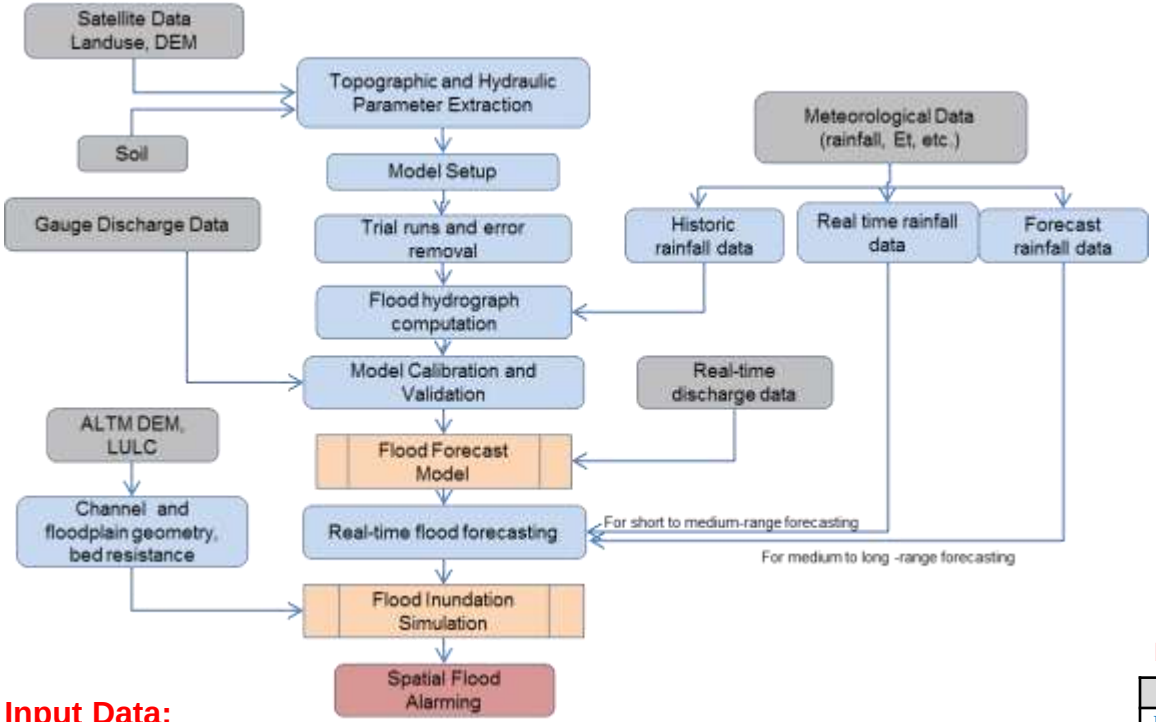
Semi-Distributed
Parameters assigned to each grid cell, but cells with same parameters are grouped

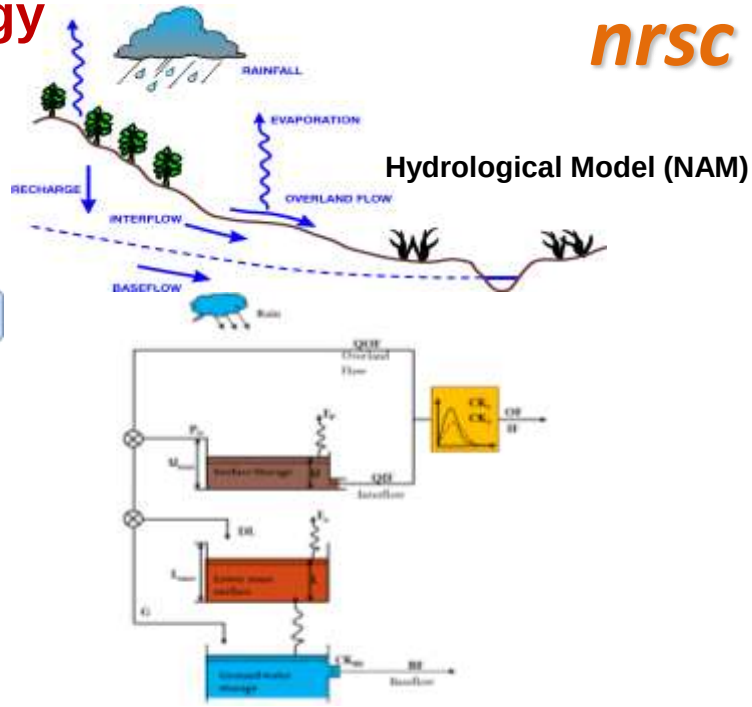


Fully-Distributed
Parameters assigned to each grid cell



The Broad Methodology





Hydrological Model (NAM)

Input Data:

Data Requirement
• Meteorological data (rainfall and potential evaporation)
• Hydrological data (discharge at the outlet of the catchments for model calibration and validation)
• Model parameters (time constants and threshold values for routing surface storage, rootzone storage and groundwater storage)

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

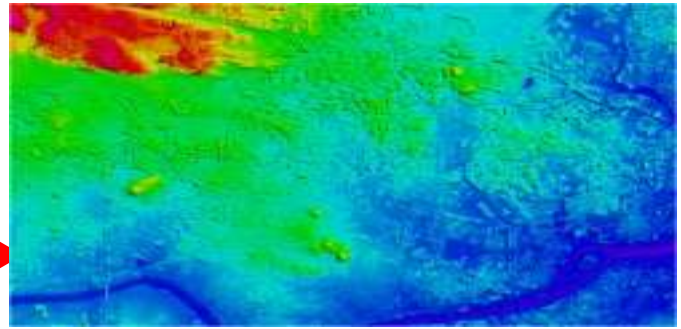
DSM and DTM

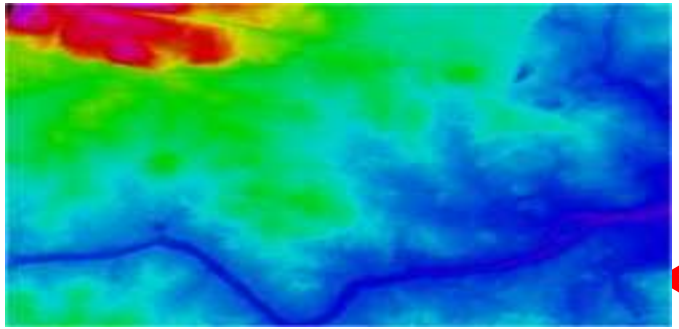
Digital Surface Model (DSM)

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

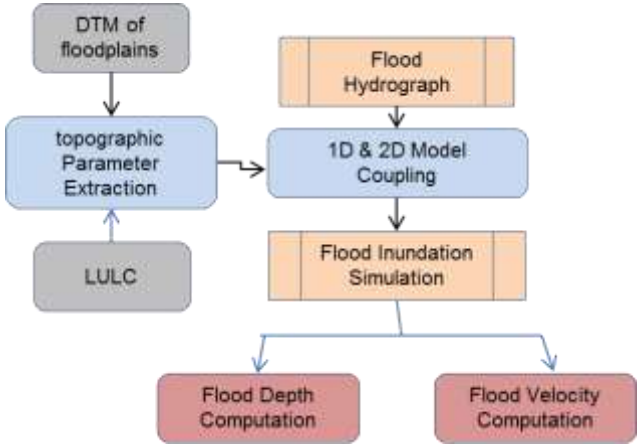
Digital Terrain Model(DTM)

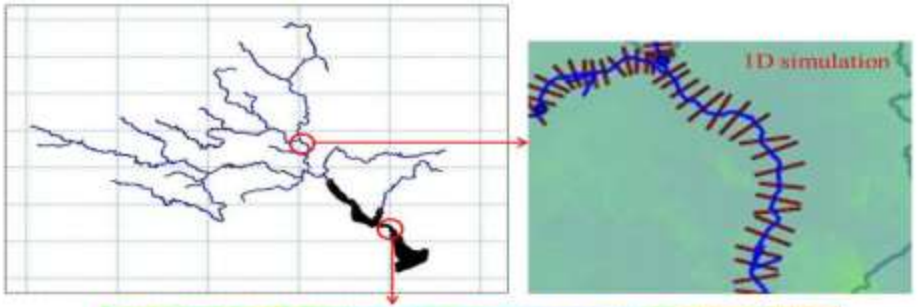
represents the bare ground surface without any objects like trees and buildings

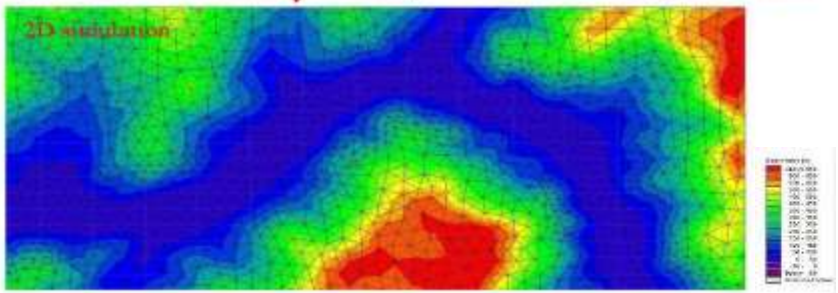


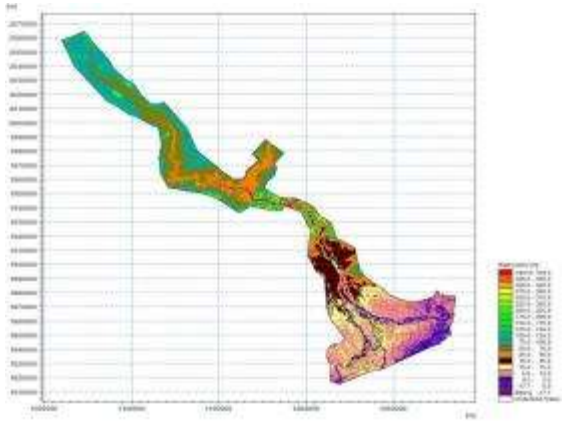


Parameter Extraction and 1D-2D model coupling for flood inundation



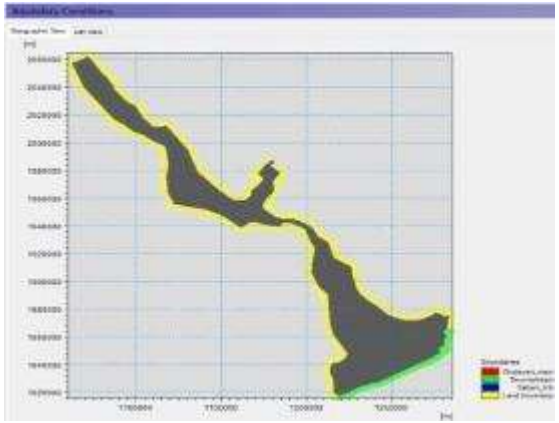






Bathymetry

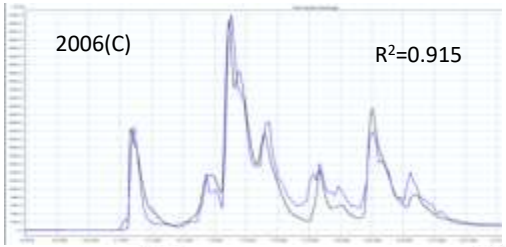
Bed resistance

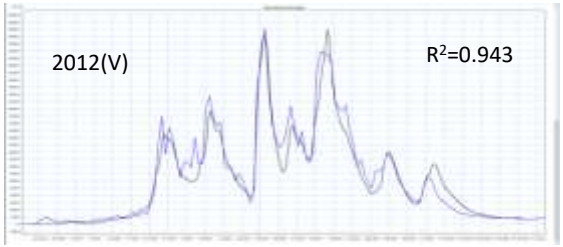


Boundary Conditions

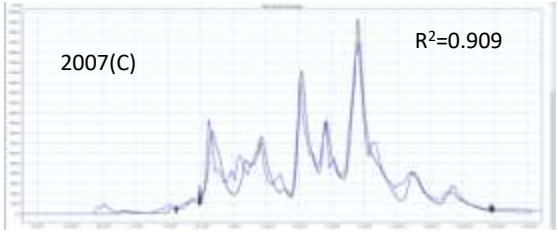
Model Calibration & Validation - Godavari Basin

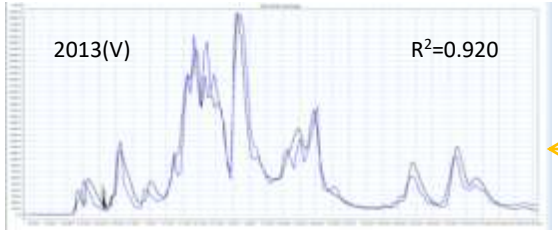
Perur

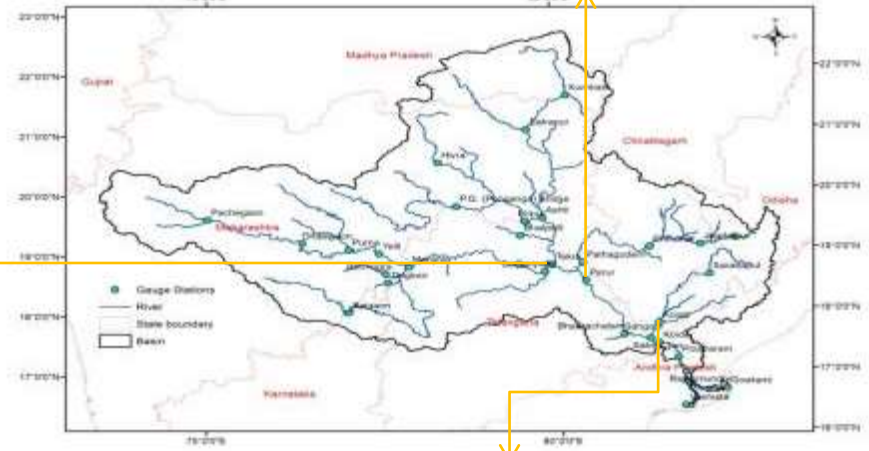




Tekra

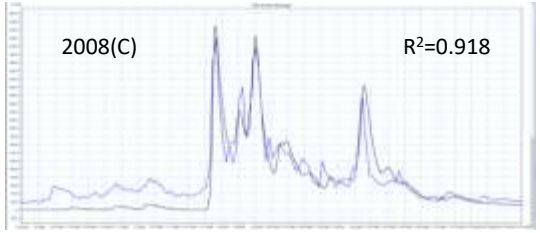


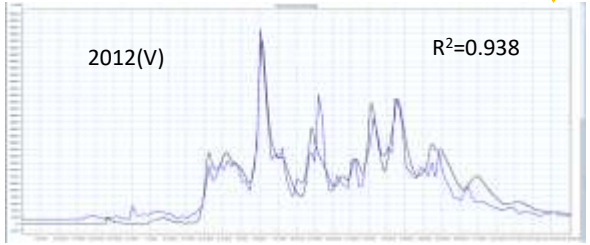




Simulated Discharge
Observed Discharge

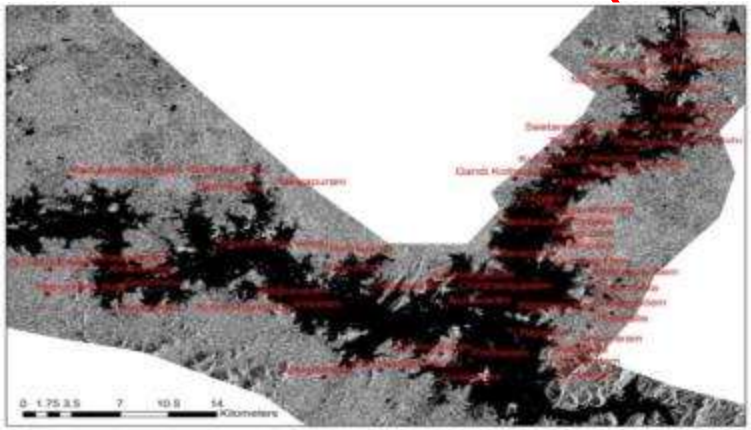
Konta

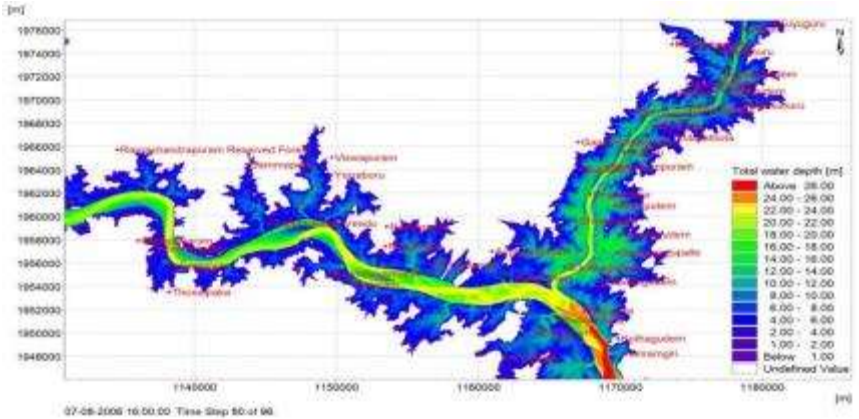




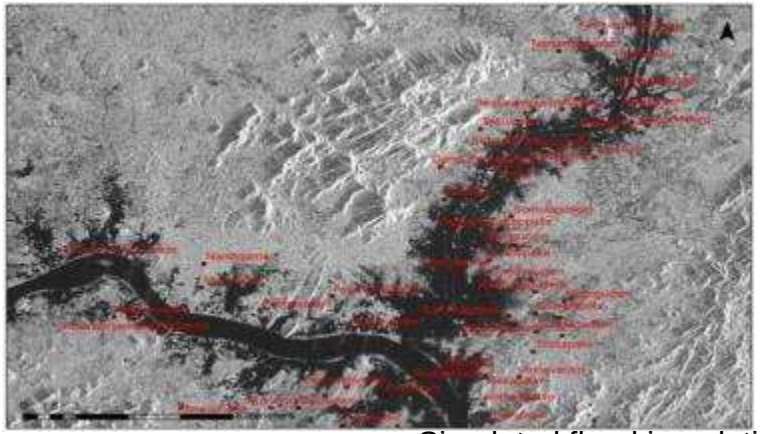
Calibration:(2006-2010)
Validation:(2011-2013)

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





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



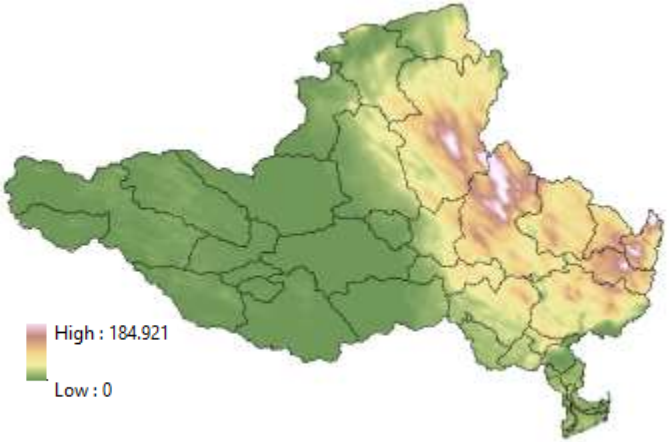
Simulated flood inundation during 2020 flood at Sabari confluence

Advantages of Flood Inundation Simulation

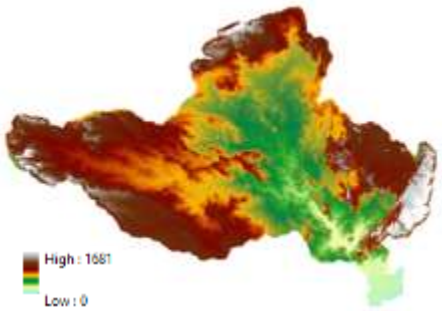
- Flood inundation simulation helps in many of these, such as
  - ❖ **Planning Rescue and Relief**
  - ❖ **Damage Assessment**
  - ❖ **Flood Risk Assessment**
  - ❖ **Design of structure**
  - ❖ **Zoning the floodplain to guide appropriate development**
  - ❖ **Flood mapping to raise community awareness**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

Real time point rainfall and WRF meteorological data

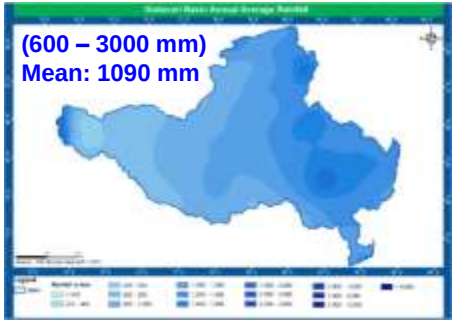
Rainfall Stations



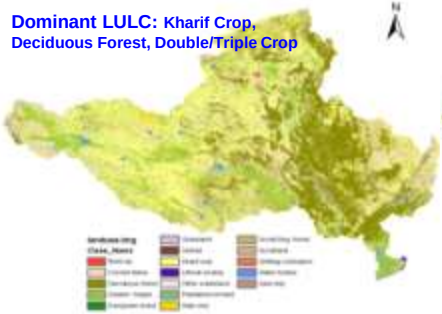
Topographic data



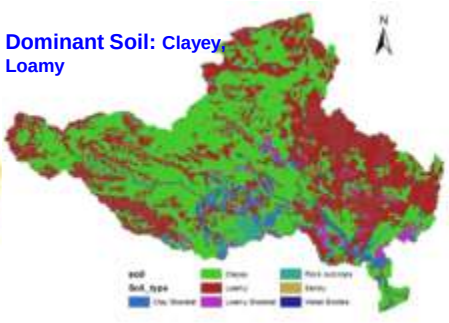
Digital Elevation Model



Rainfall

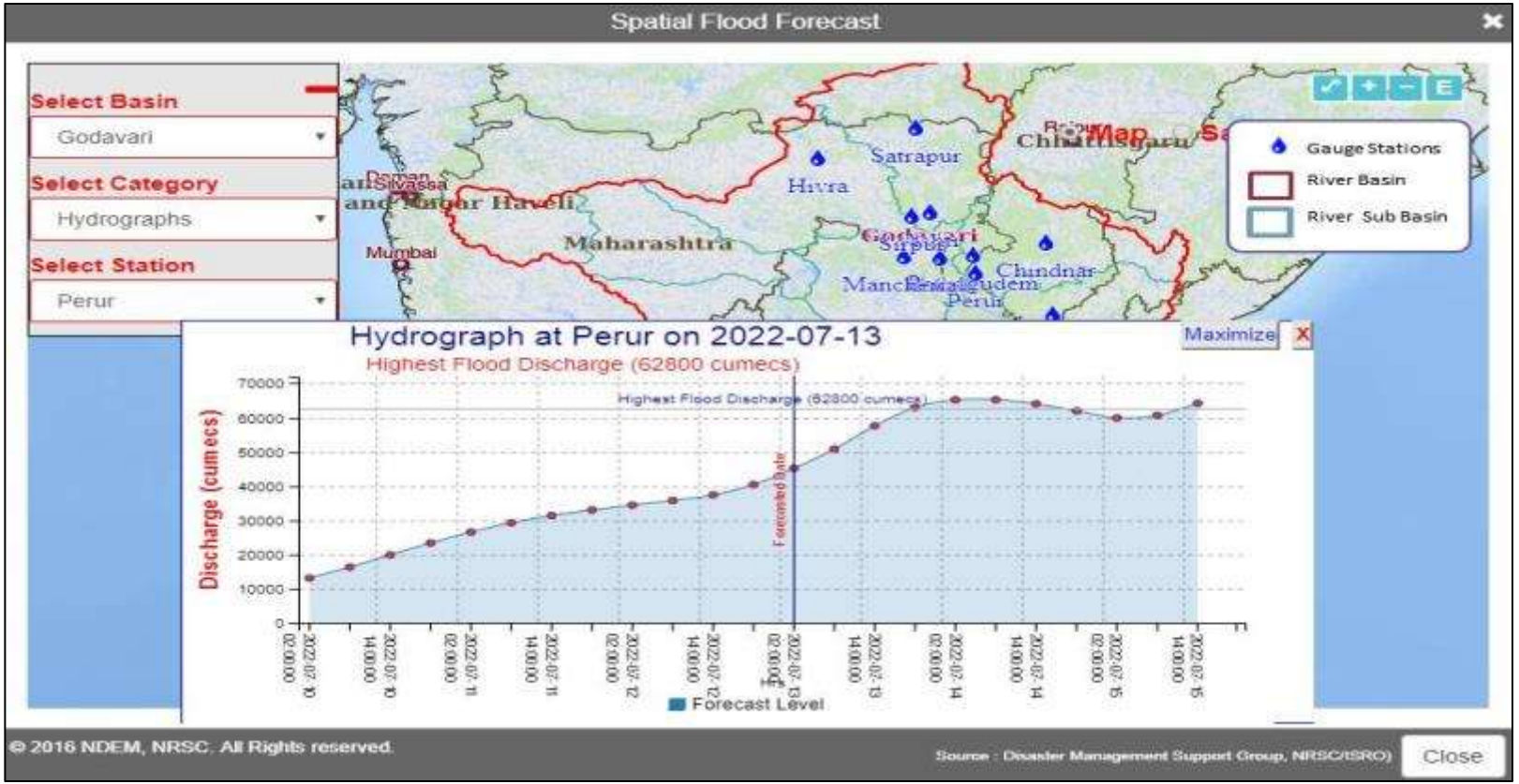


Landuse/Landcover



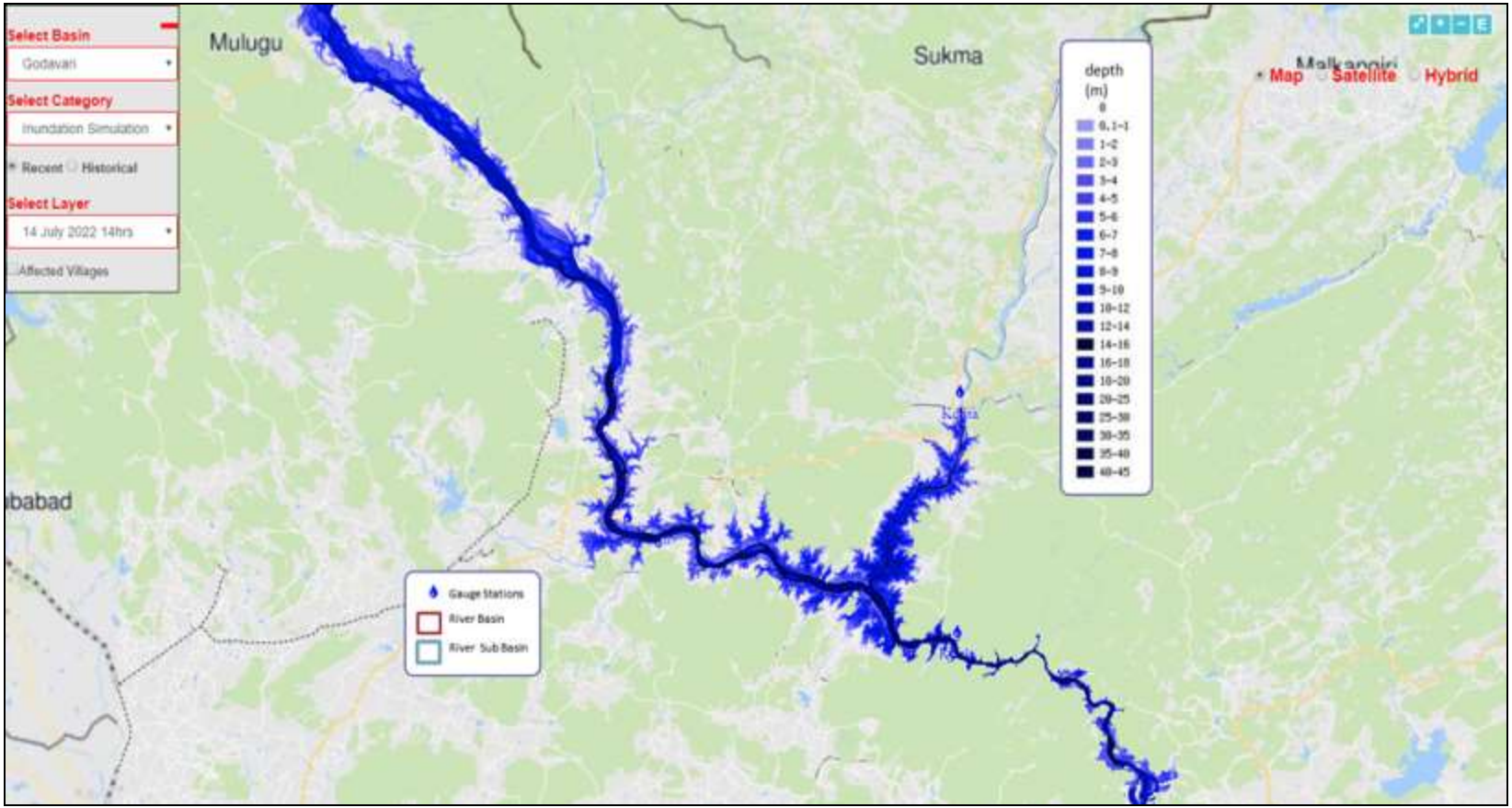
Soil Texture (NBSS & LUP)

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



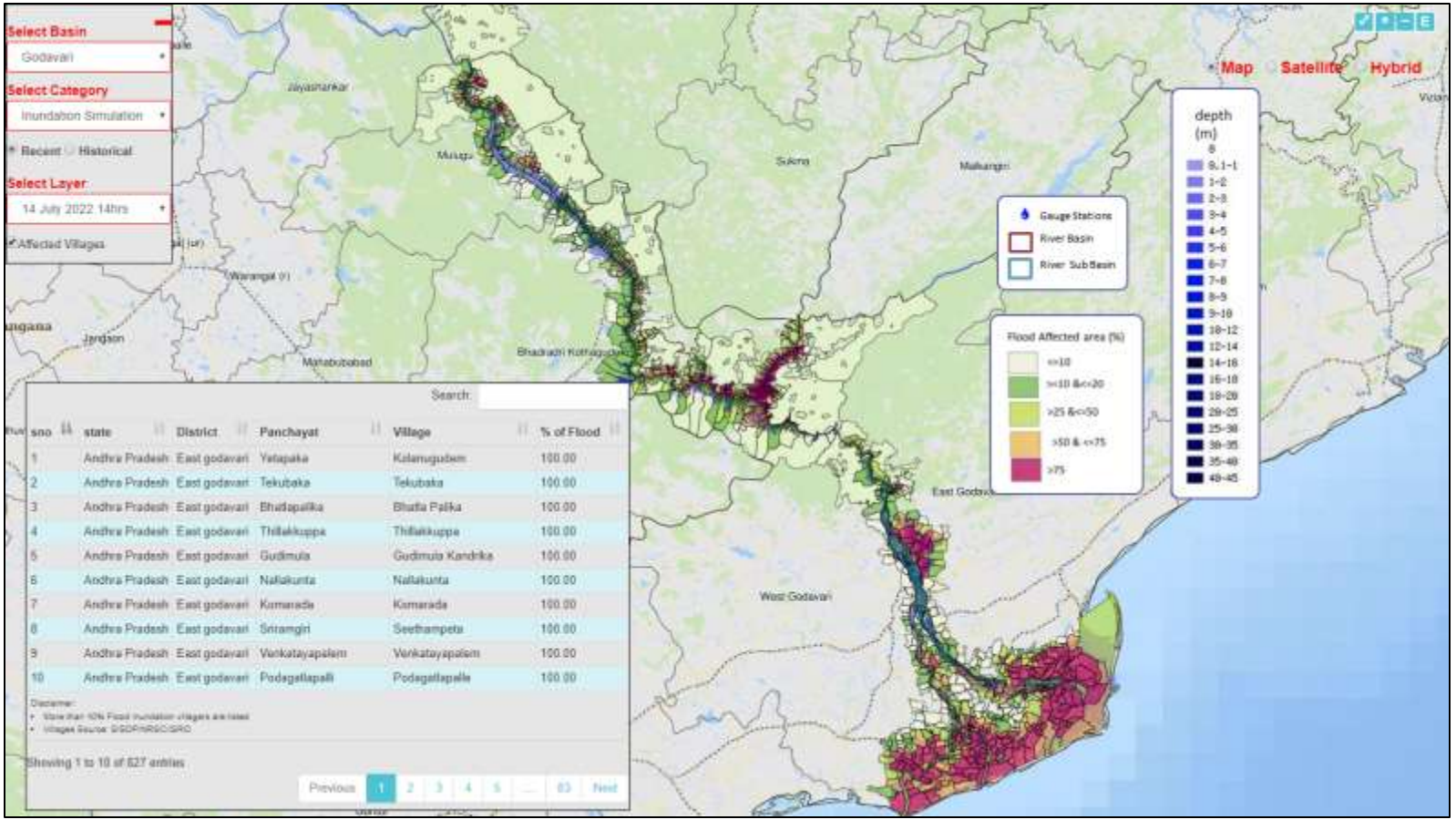
Godavari Flood Early Warning-2022

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



Inundation July 2022 flood event in Godavari River

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

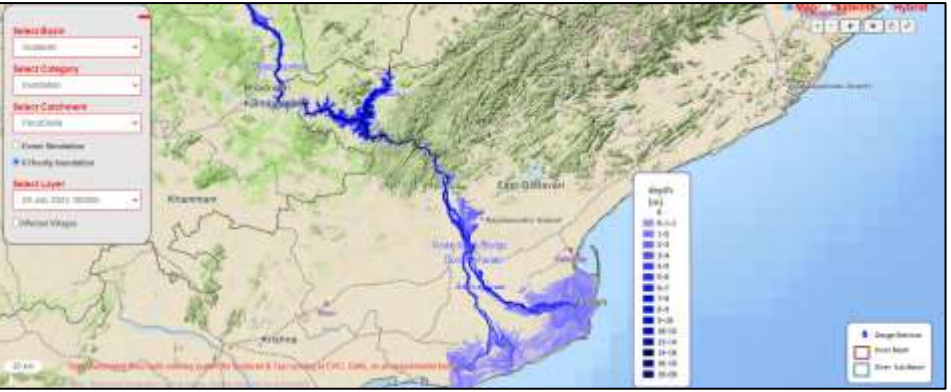


Village Affected

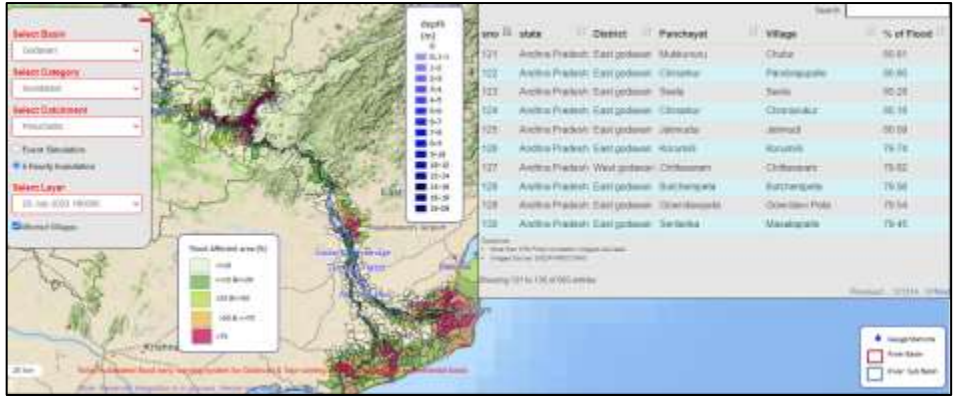
Spatial Flood Early Warning Systems - Godavari and Tapi Rivers (2023)

Flood Hydrograph at Bhadrachalam in Godavari River

Flood Hydrograph at Sarangkheda in Tapi River

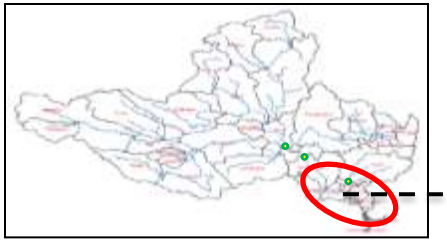


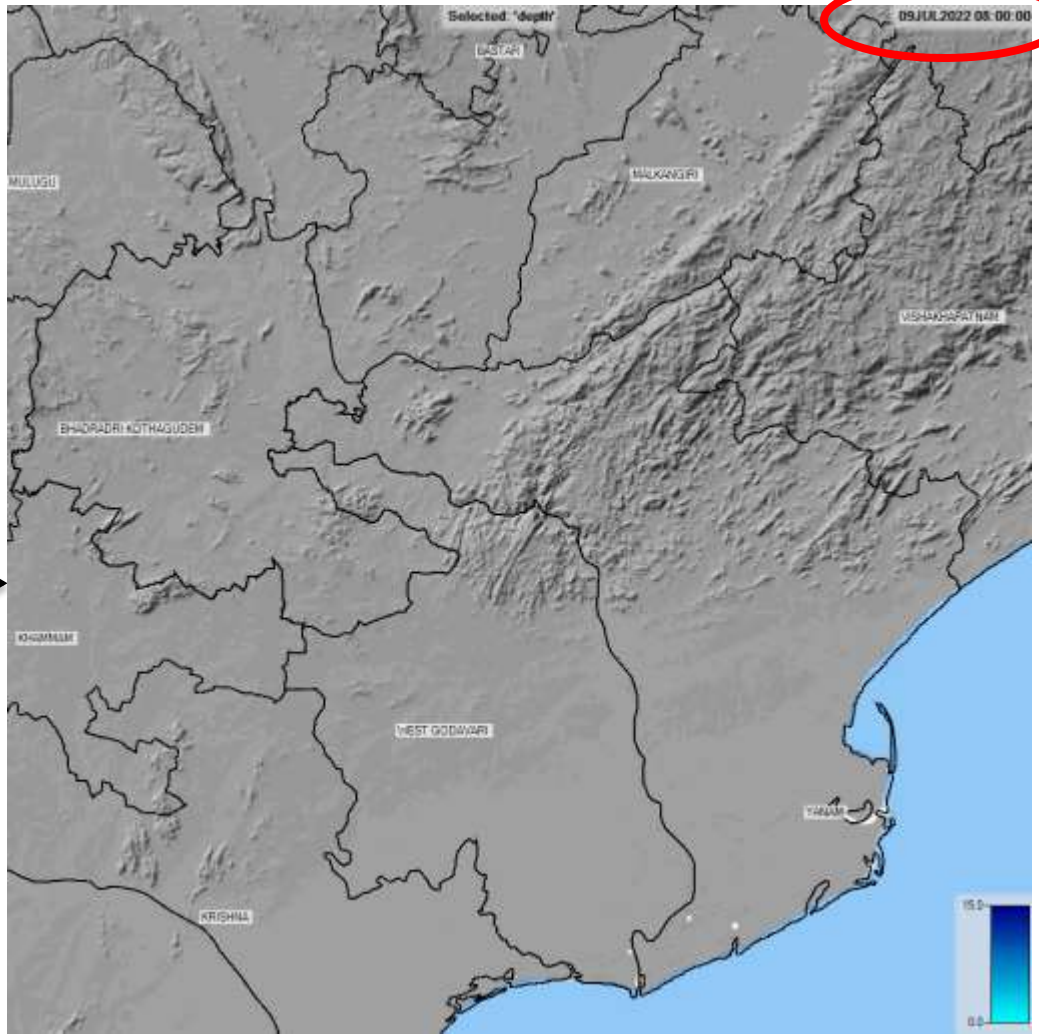
Spatial flood inundation simulation (29 Jul 2023)



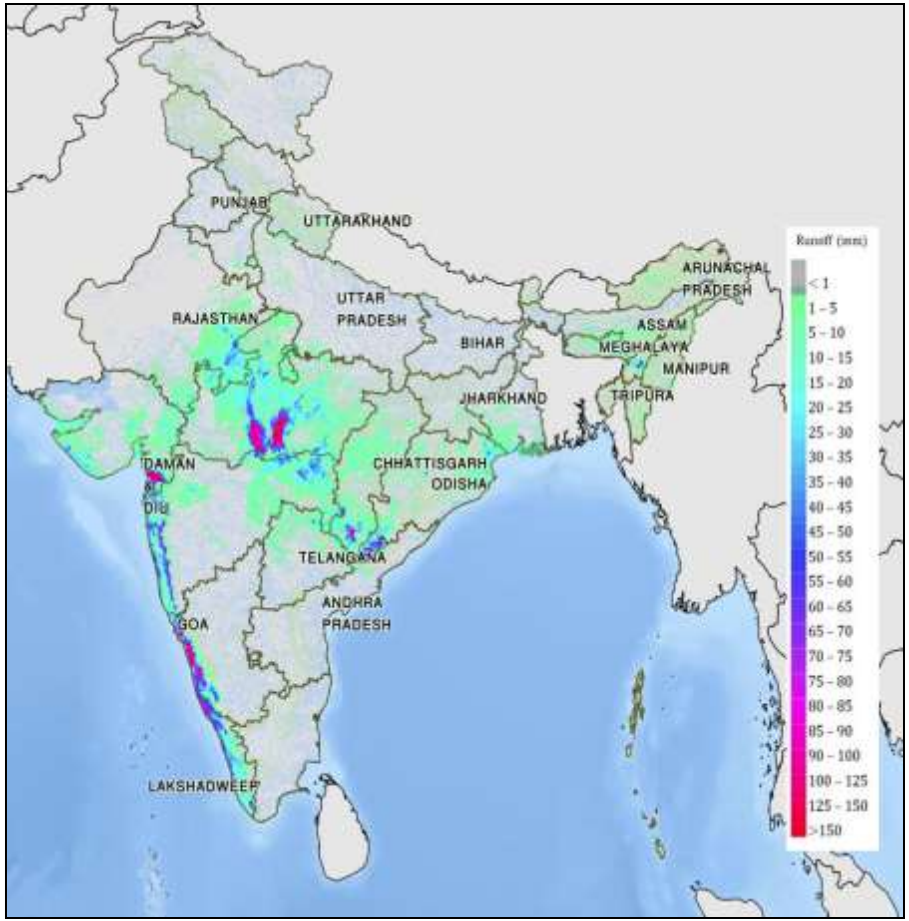
Spatial flood early warning and villages affected (29 Jul 2023)

Flood Inundation Simulations for Godavari Basin - 2022

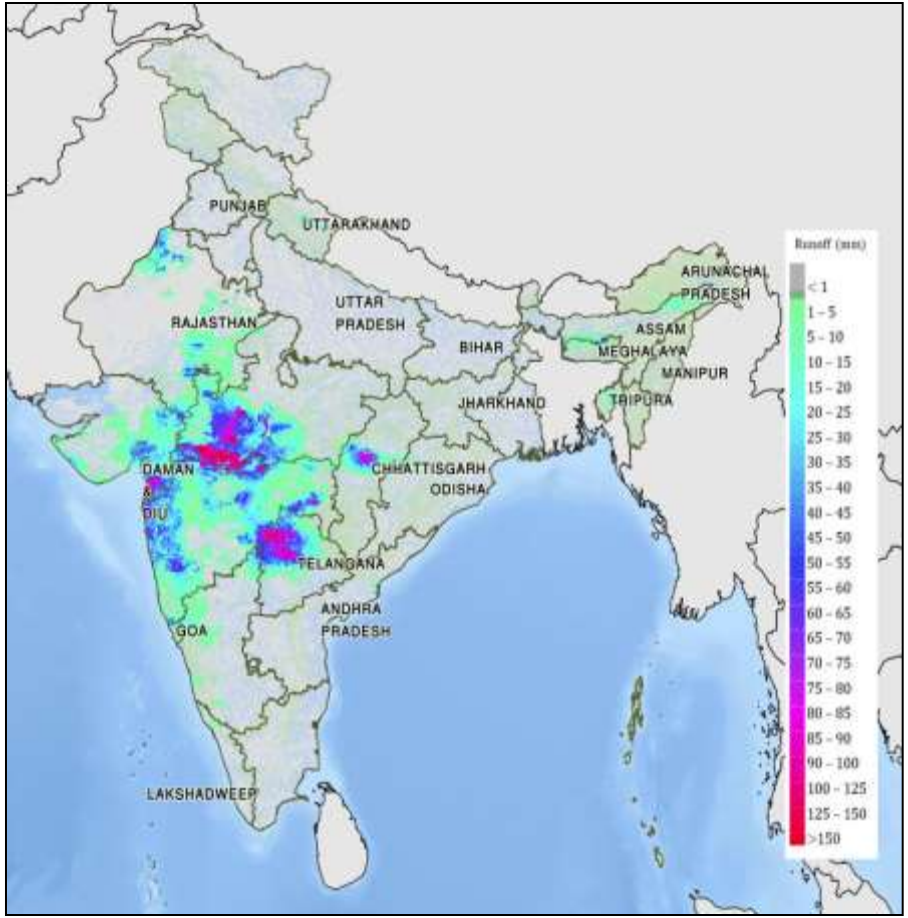




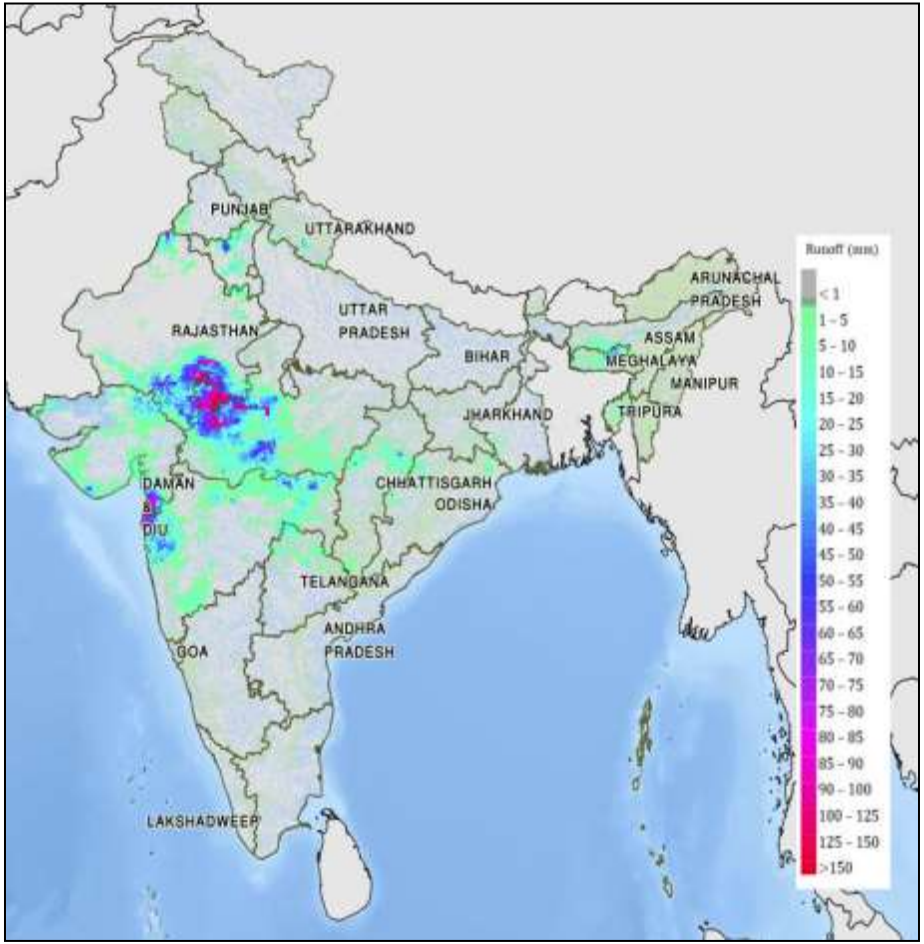
PAN INDIA RUNOFF (14 July 2022)



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

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