Flood Early Warning System

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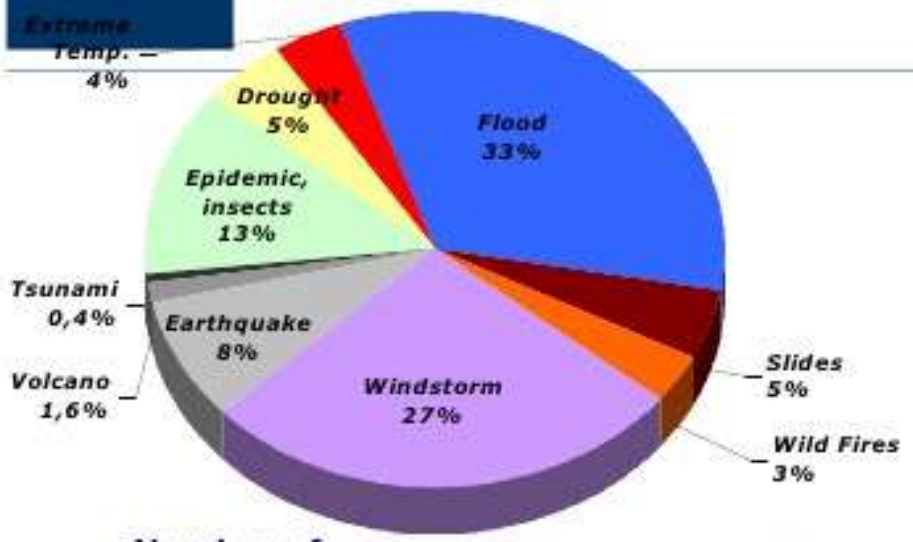
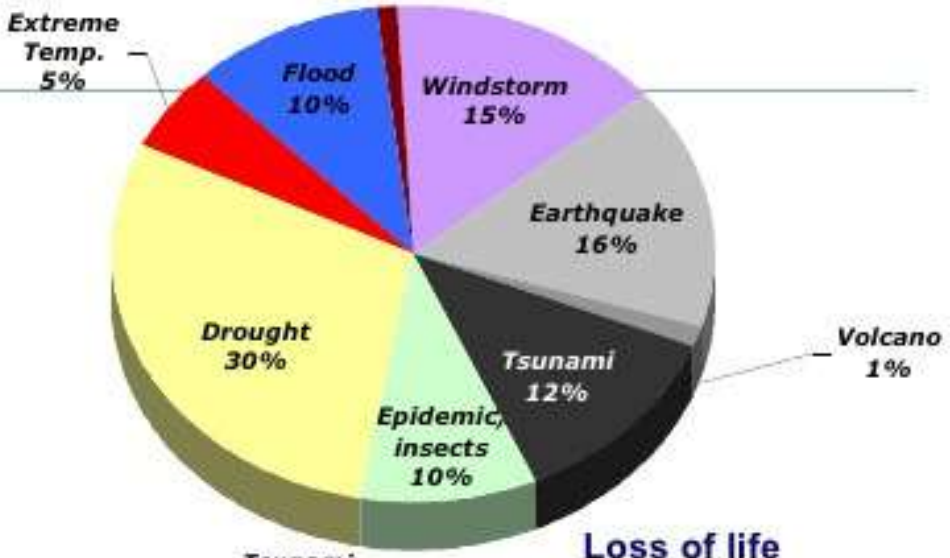
India Meteorological Department
Ministry of Earth Sciences (MoES)

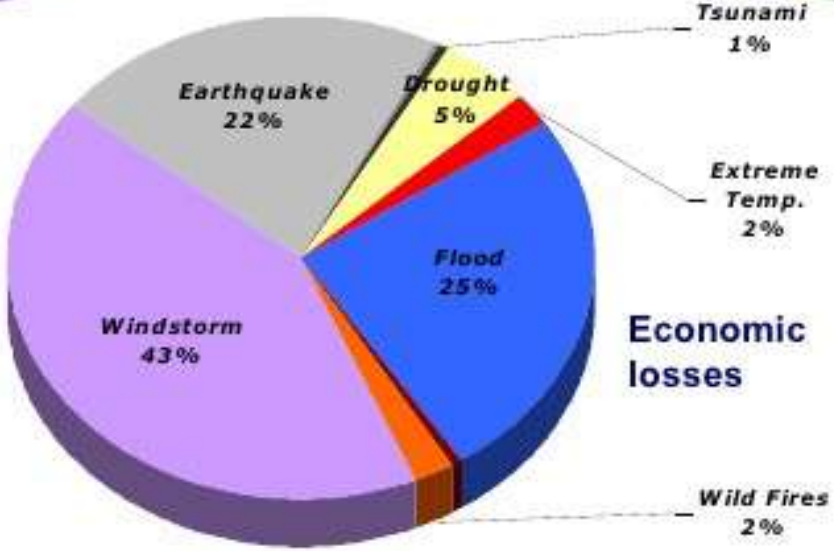
Global Distribution of Disasters Caused by Natural Hazards and their Impacts (1980-2007)



Number of events



Loss of life

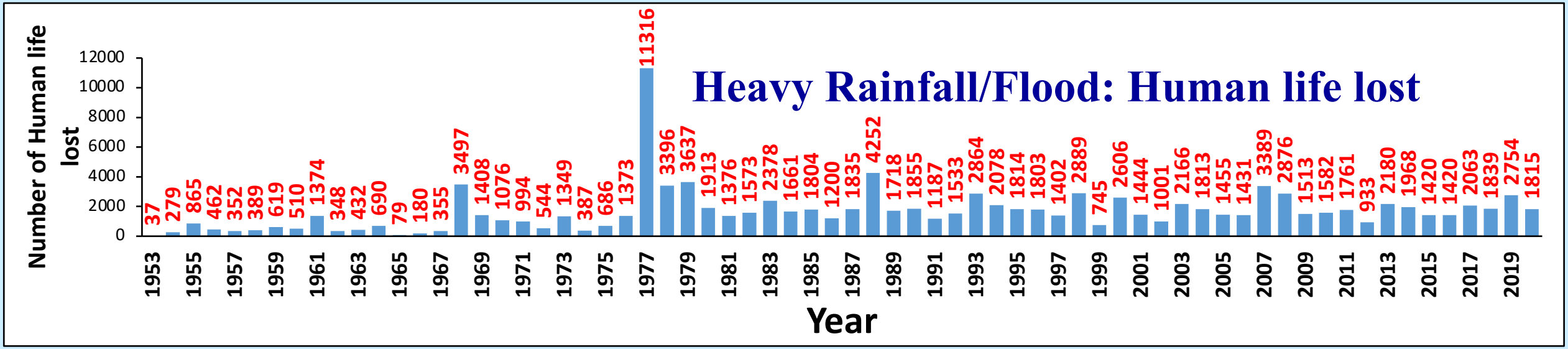


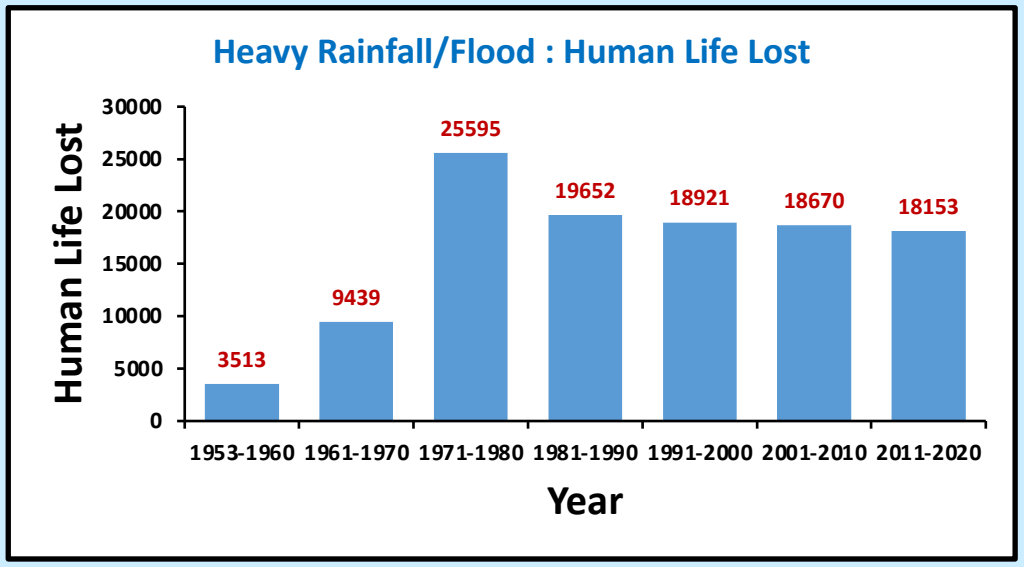
Economic losses

Source: EM-DAT: The OFDA/ CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels - Belgiumc

90% of events, **70%** of casualties and **75%** of economic losses are related to hydro-meteorological hazards.

Flood Damage Statistics: India



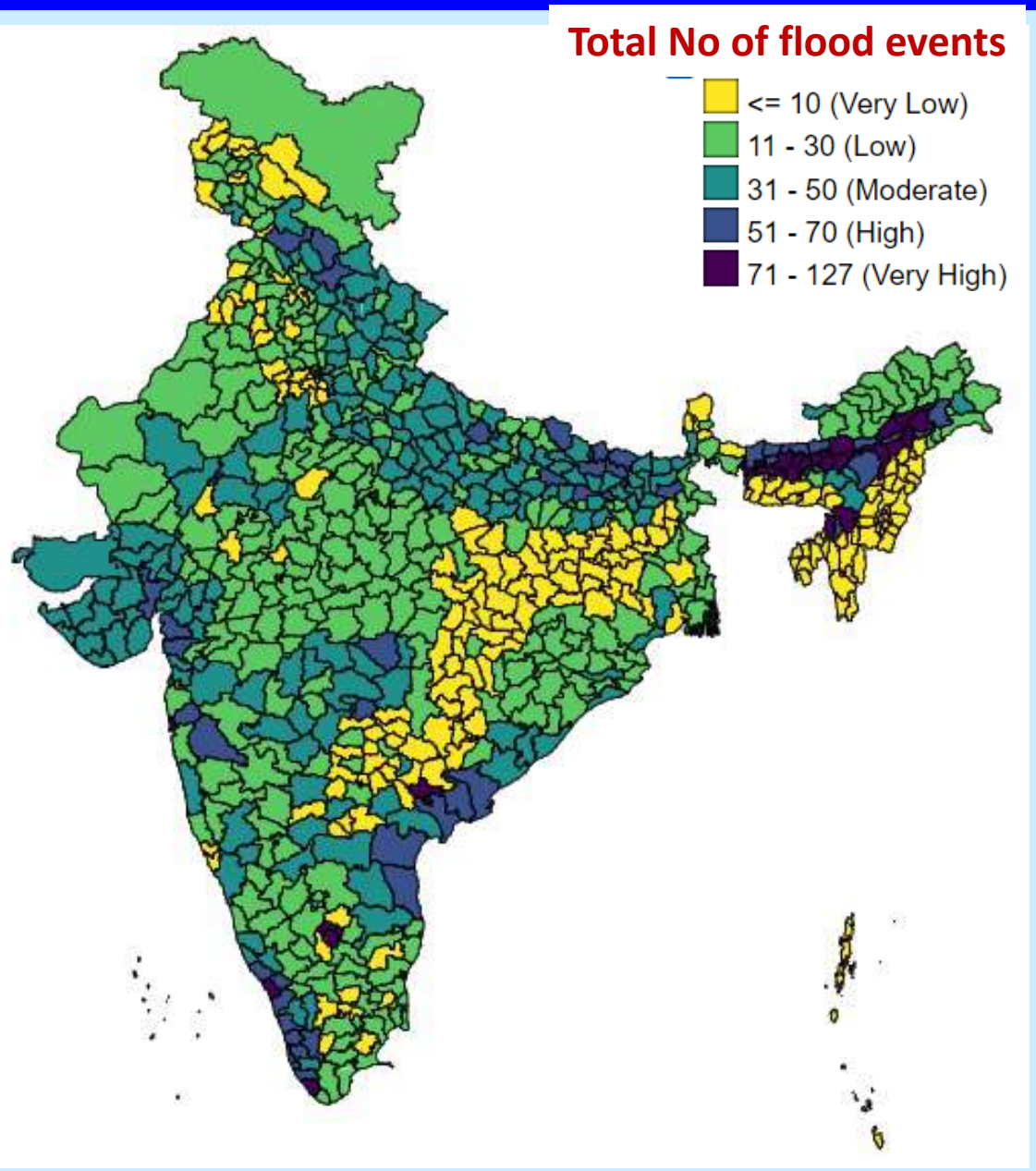


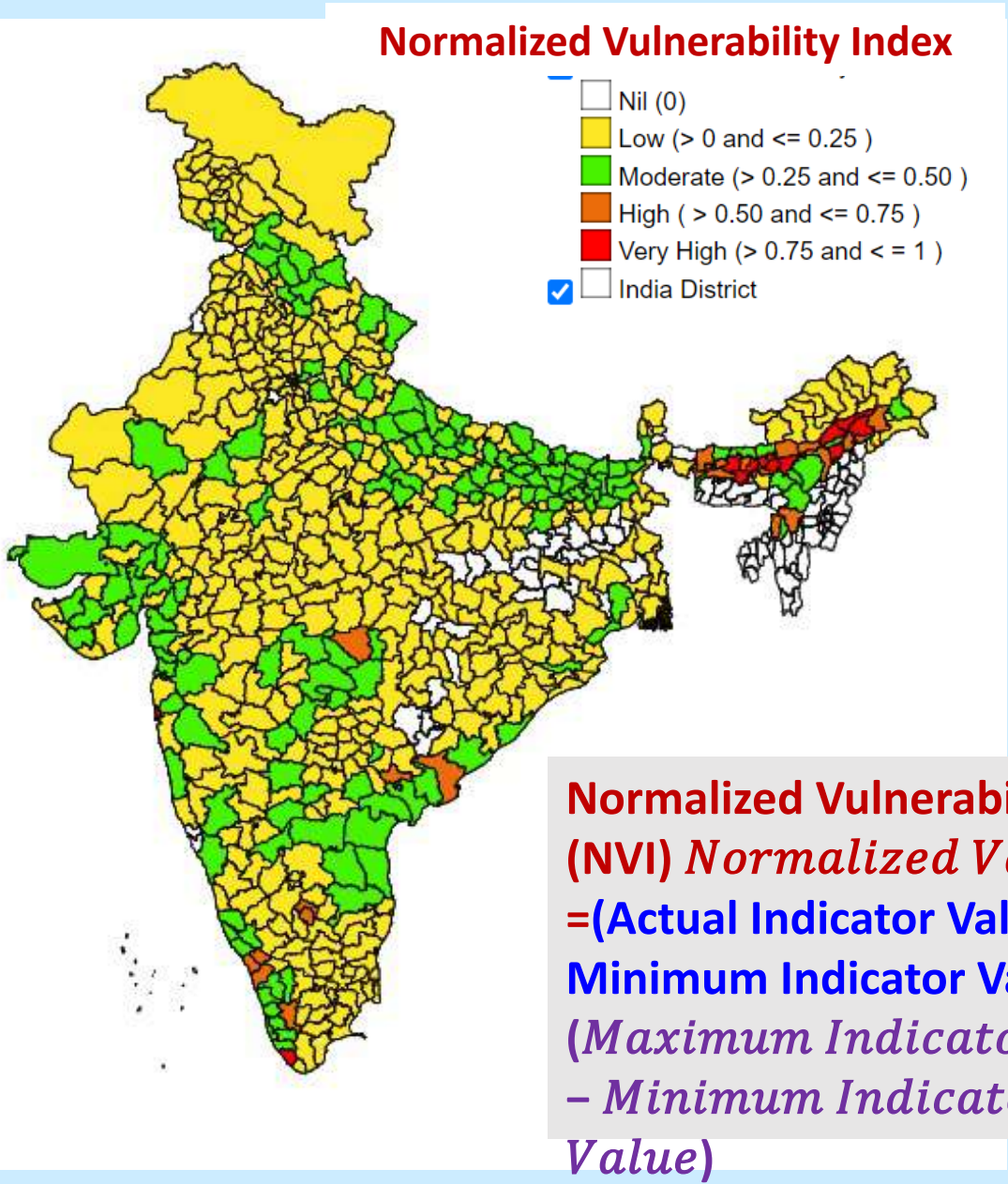
Flood Damage Statistics: India

0.04% of GDP

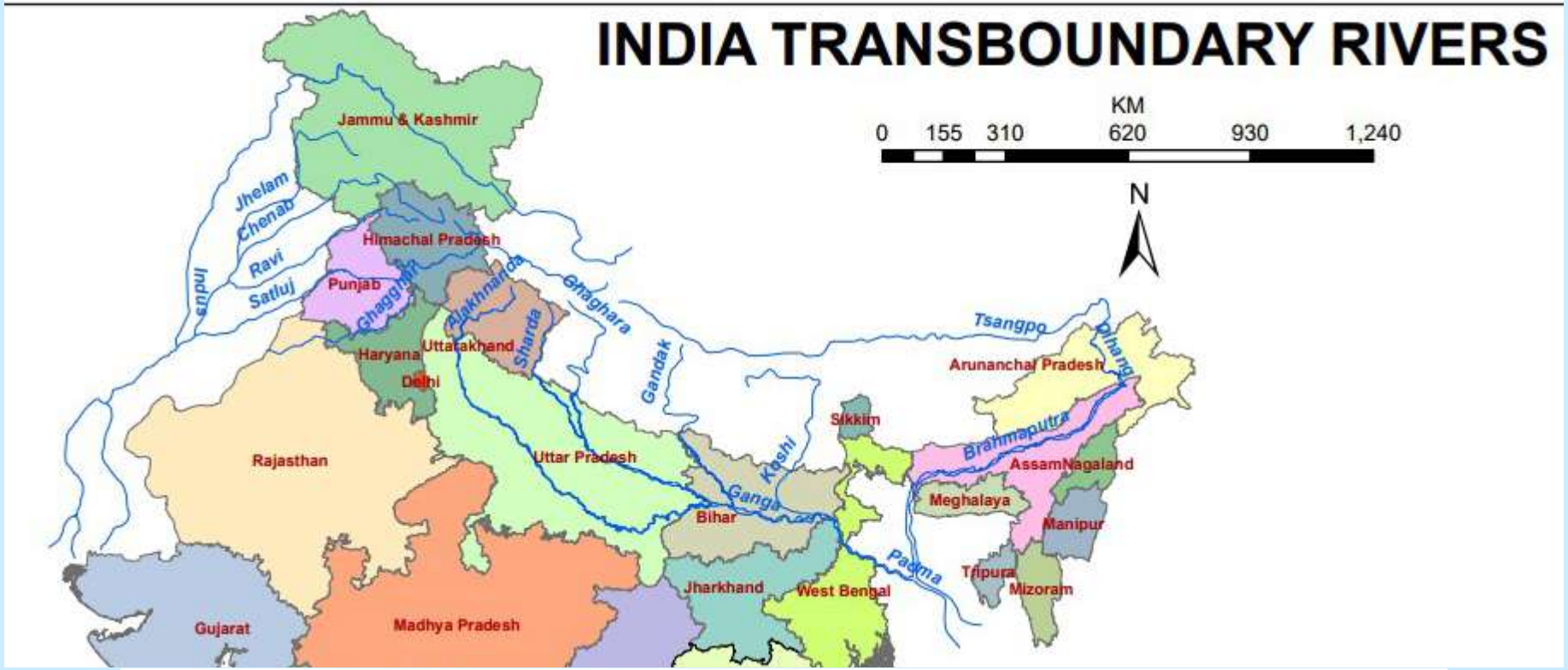
- Area affected 7.4 MHa (2.24%)
- Cropped Area affected 4.2 MHa (2%)
- Population affected 32.4 M (2.3%)
- Annual Avg Flood Damage (1953-2021)
- Human Lives lost (1671)
- Cattle Lives lost (90548)

NO. OF FLOOD EVENTS (1969 to 2019) AND NORMALIZED VULNERABILTY INDEX





Normalized Vulnerability index (NVI) $Normalized\ Value$ **=(Actual Indicator Value – Minimum Indicator Value) /** ($Maximum\ Indicator\ Value$ – $Minimum\ Indicator\ Value$)

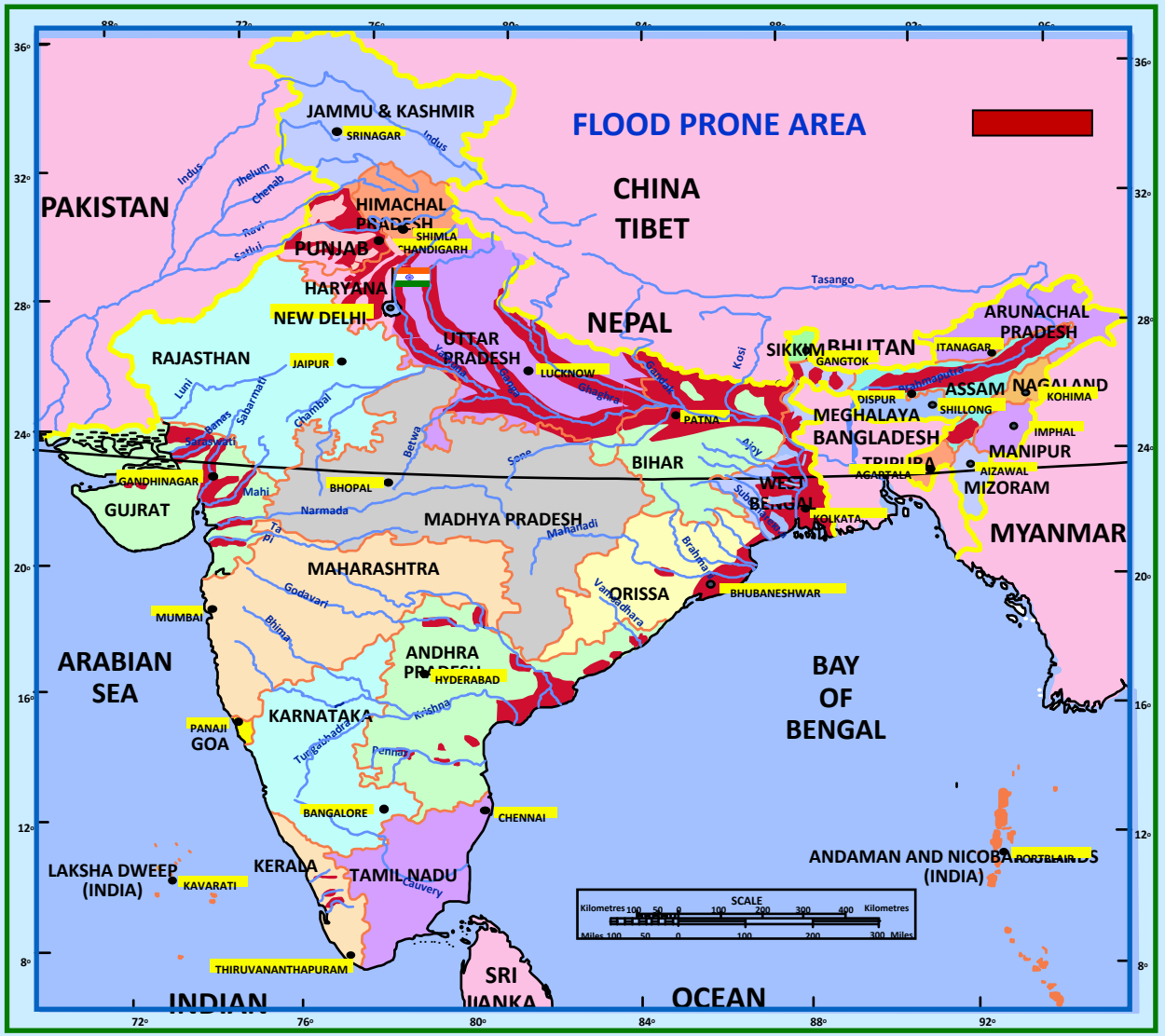


Name of rivers	Origin	En-routed countries	End
Indus	China	India, Pakistan	Arabian Sea
Jhelam	India	Pakistan	Chenab
Chenab	India	Pakistan	Indus
Ravi	India	Pakistan	Chenab
Satluj	India	Pakistan	Chenab
Ganga	India	Bangladesh(Padma)	Bay of Bengal
Sharda	India	Nepal	Ghaghra
Ghaghra	Nepal	India	Ganga, India
Gandak	Nepal	India	Ganga, India
Koshi	Nepal	India	Ganga, India
Brahmaputra(Tsangpo)	China	India	Padma, Bangladesh

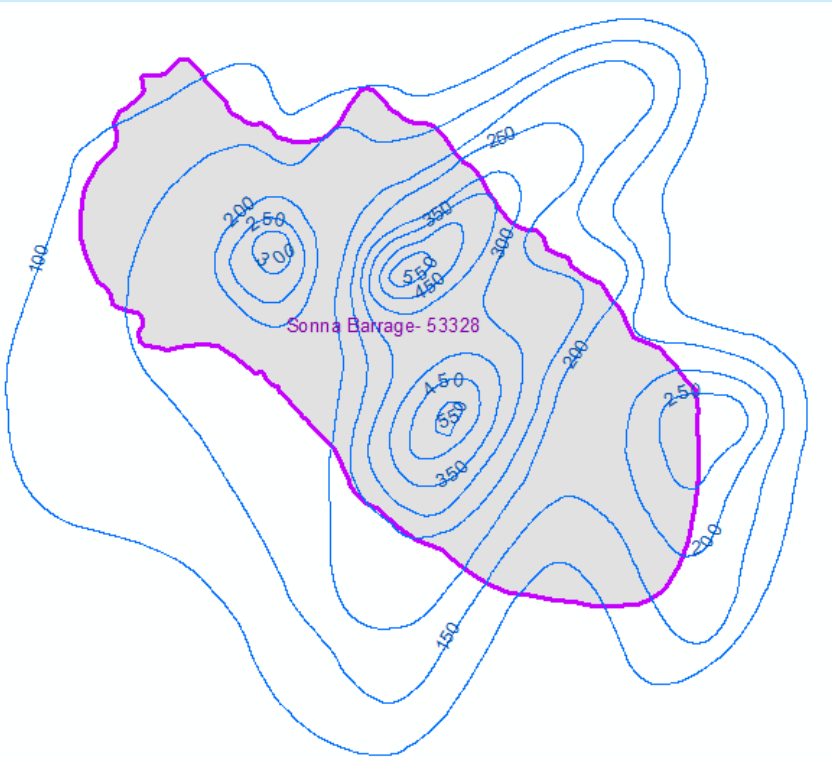
- ✓ **Major Flood Prone States:** Assam, Bihar, West Bengal, UP,
- ✓ Odisha & Andhra Pradesh

- ✓ **Major Flood Prone Basins:** Ganga, Brahmaputra & Mahanadi, Godavari.

Flood Prone areas in India ~ 40 million Ha (RBA,1980)



Rain Storm Analysis



S.No	Isohyetal Range mm From	Isohyetal Range mm To	Mean	Area (Sq Km.)	Cumulative Area	Volume of Rainfall	Cumulative Volume of R/F	Average Depth of Rainfall(mm.)
1	596	550	573	170.4288	170.429	97655.709	97655.709	573.0
2	550	450	500	983.8081	1154.237	491904.073	589559.782	510.8
3	550	550	550	258.728	1412.965	142300.384	731860.165	518.0
4	550	450	500	814.0424	2227.007	407021.217	1138881.383	511.4
5	450	350	400	1825.613	4052.621	730245.339	1869126.722	461.2
6	450	350	400	1383.17	5435.791	553268.147	2422394.869	445.6
7	350	300	325	5034.281	10470.072	1636141.227	4058536.095	387.6
8	300	300	300	361.7861	10831.858	108535.835	4167071.930	384.7
9	300	250	275	979.465	11811.323	269352.875	4436424.805	375.6
10	300	250	275	5865.699	17677.022	1613067.250	6049492.055	342.2
11	250	250	250	660.1752	18337.197	165043.800	6214535.855	338.9
12	250	200	225	1756.345	20093.542	395177.634	6609713.490	328.9
13	250	200	225	1493.878	21587.421	336122.650	6945836.140	321.8
14	250	200	225	4330.625	25918.045	974390.515	7920226.655	305.6
15	200	150	175	17548.93	43466.970	3071061.891	10991288.546	252.9
16	150	100	125	8585.366	52052.336	1073170.748	12064459.294	231.8

Causes of Floods

CAUSES OF FLOODS

I METEOROLOGICAL FACTORS

(a) Heavy rainfall
(b) Cyclones, thunderstorms, cloud bursts
(c) Sudden melting of snow / ice
(d) Storm surges

II GEOGRAPHICAL FACTORS

(a) Earth quakes
(b) Land slides etc
(c) Glacial out burst

III MAN MADE FACTORS

a) Failure of dams and other control works like reservoirs
b) Encroachment in flood plain areas

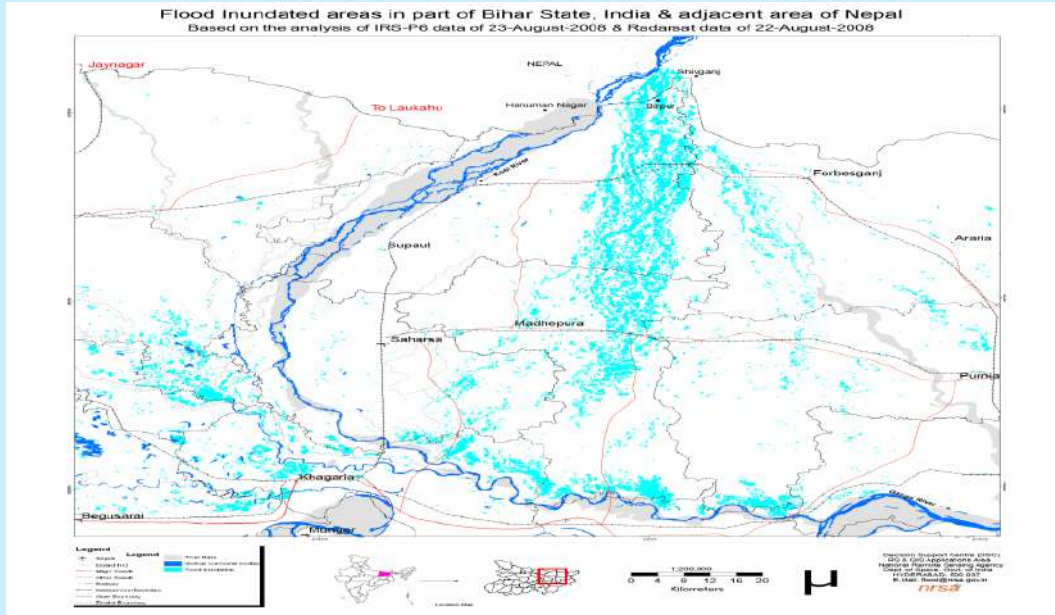
IV. OTHER FACTORS (LOCAL SCALE)

(a) Debris flow
(b) Back water
(c) Change in river course

However majority of floods occur due to Heavy rains in a wide areal extend with extended time period. Hence accurate QPF is a prime factor of reasonable Flood forecasting and warning.

ENCROACHMENT IN FLOOD PLAIN AREAS

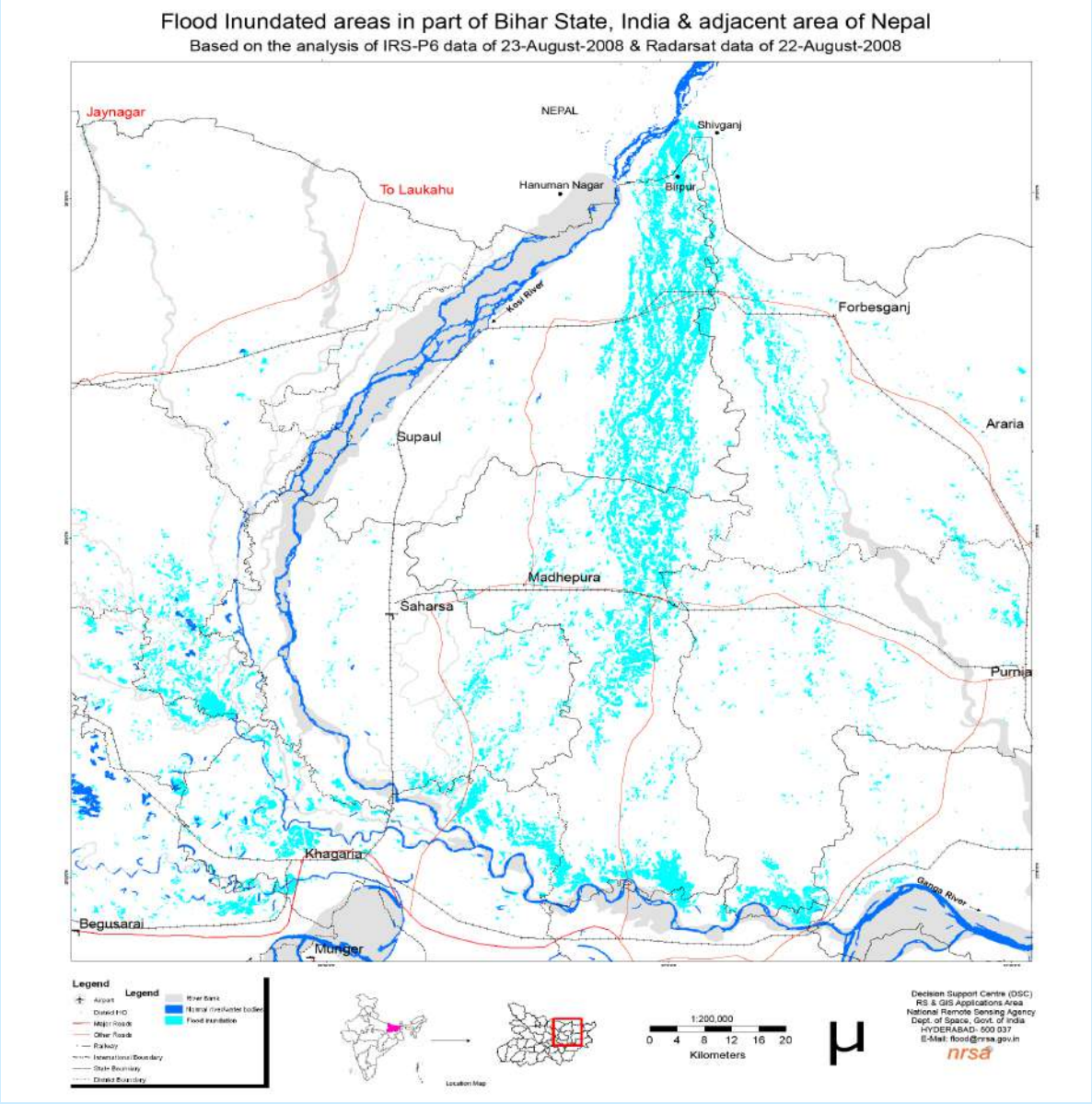
BREACH IN KOSI BARRAGE IN AUGUST 2008



CAUSES OF FLOOD

ENCROACHMENT IN FLOOD PLAIN AREAS

BREACH IN KOSI BARRAGE IN AUGUST 2008



HYDROMETEOROLOGICAL HAZARD: FLOOD

A flood is an overflow of water that submerges land which is usually dry

Various types of floods:

- Riverine flood (fluvial flood)
- Flash flood
- Coastal flood (storm surge)
- Urban flood
- Ponding or pluvial flood
- Glacial lake outburst flood (GLOF)

VARIOUS TYPE OF FLOOD

1. RIVERINE/FLUVIAL FLOOD

- Rainfall over an extended period and an extended area can cause major rivers to overflow their banks.
- Downstream areas may be affected, even when they didn't receive much rainfall.
- With large rivers the process is relatively slow. The rain water enters the river in many ways.
- A lot of rain water will run off the surface when the soil is saturated or hard.
- It flows to small rivers and then small rivers to larger rivers and these rivers flow into even larger rivers.
- In this way all the rain that fell in a large area (catchment area) comes together to a very large river.

VARIOUS TYPE OF FLOOD

2. FLASH FLOOD

- Short duration < 6 hr with relatively high peak discharge between the occurrence of the rainfall and peak flood
- In areas with steep slopes, heavy rain can cause a riverbed that held very little or no water at first, to suddenly brim with fast flowing water.
- The rain water is collected on the slopes, then flows downhill gathering speed and all the water comes together in the river bed. The water level rises fast.

- It all happens fast, if it rains heavily. The water flows at high speed. Because of this speed it has the strength to carry away heavy objects.
- The area covered by water in a flash flood is relatively small compared to other types of floods, but is so concentrated on a small area that it can rise very high.
- Because of the sudden onset and the high travelling speed of the water, flash floods can be very dangerous. The water can transport large objects like rocks, trees and cars.

VARIOUS TYPE OF FLOOD

3. COASTAL FLOOD (Storm Surge)

- Coastal flood is occurred when the coast is flooded by the sea.
- The cause of such a surge is a severe storm. The storm wind pushes the water up and creates high waves.
- A storm is formed in a low pressure area. Beneath a low pressure area the sea level is higher. This contributes to the high sea level, but the wind can have a larger effect.

Coastal Flood

- A flood starts when waves move inland on an undefended coast or overtop or breach the coastal defence works.
- characteristic of a coastal flood is that the water level drops and rises with the tide. At high tide the water may flow in and at low tide it may recede again.

VARIOUS TYPE OF FLOOD

4. URBAN FLOOD

- Urban flooding is specific in the fact that the cause is a lack of drainage system in urban areas.
- As there is little open soil that can be used for water storage nearly all the precipitation needs to be transport to surface water or the sewage system.

Urban *flooding*

- High intensity rainfall can cause flooding when the city sewage system and draining canals do not have the necessary capacity to drain away the amounts of rain that are falling.
- Water may even enter the sewage system in one place and then get deposited somewhere else in the city on the streets.

VARIOUS TYPE OF FLOOD

V. PONDING (OR PLUVIAL FLOODING)

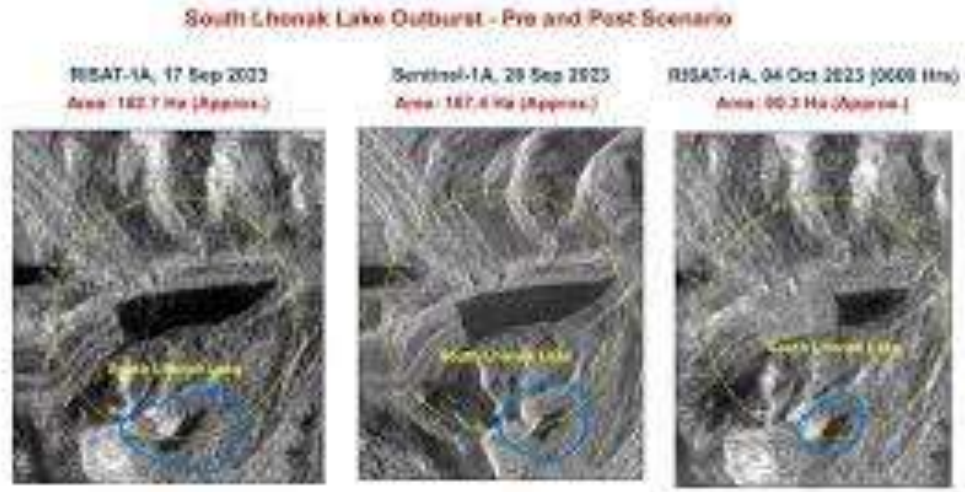
- Ponding is a type of flooding that can happen in relatively flat areas.
- Rain water falling in an area is normally stored in the ground, in canals or lakes, or is drained away, or pumped out.
- When more rainwater enters a water system that can be stored, or can leave the system, flooding occurs.
- Rain is the source of the flood: not water coming from a river, but water on its way to the river. That's why it is also called "pluvial flood".

- **It is like urban flooding, but without the sewage systems and in more rural areas.**

VARIOUS TYPE OF FLOOD

5. Glacial Lake Outburst Flood (GLOF)

- A Glacial Lake Outburst Flood (GLOF) is a type of outburst flood occurring when water dammed by a glacier or a moraine is released.
- Many of the big glaciers which have melted rapidly and gave birth to the origin of a large number of glacier lakes.
- Due to the faster rate of ice and snow melting, the accumulation of water in these lakes has been increasing rapidly and resulting sudden discharge of large volumes of water and debris and causing flooding in the downstream.



South Lhonak Lake burst due to incessant rains

EXPERTS OPINION

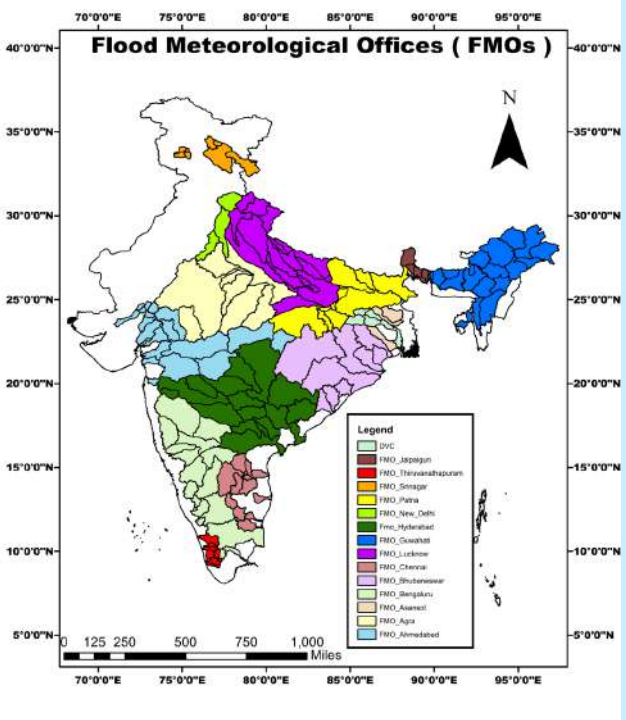
Though total immunity from floods is not feasible, the losses particularly of lives and movable property can be minimized by

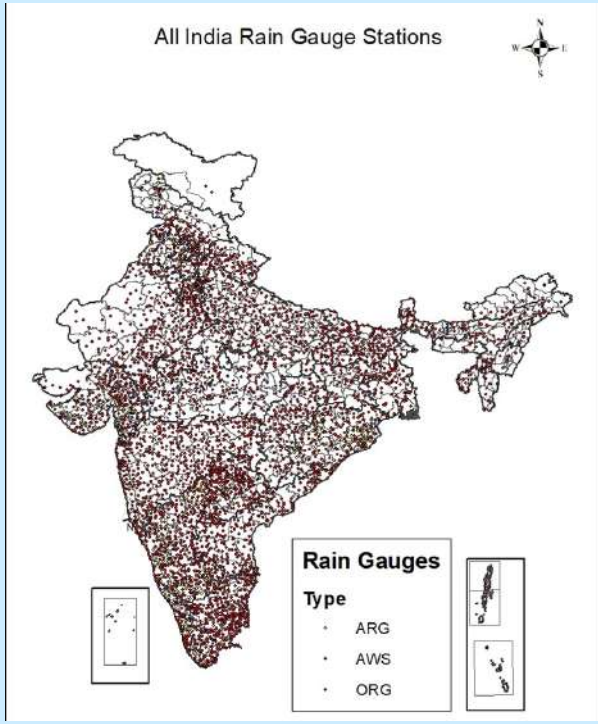
- Structural Measures
- Non Structural Measures

Structural	Non Structural
Construction of Dams, Embankments etc	Flood Warnings Flood plain zoning etc
Costly	Relatively less costly
Saves both movable and immovable property	Saves only movable property.

Hydrometeorological Support for Flood Forecasting

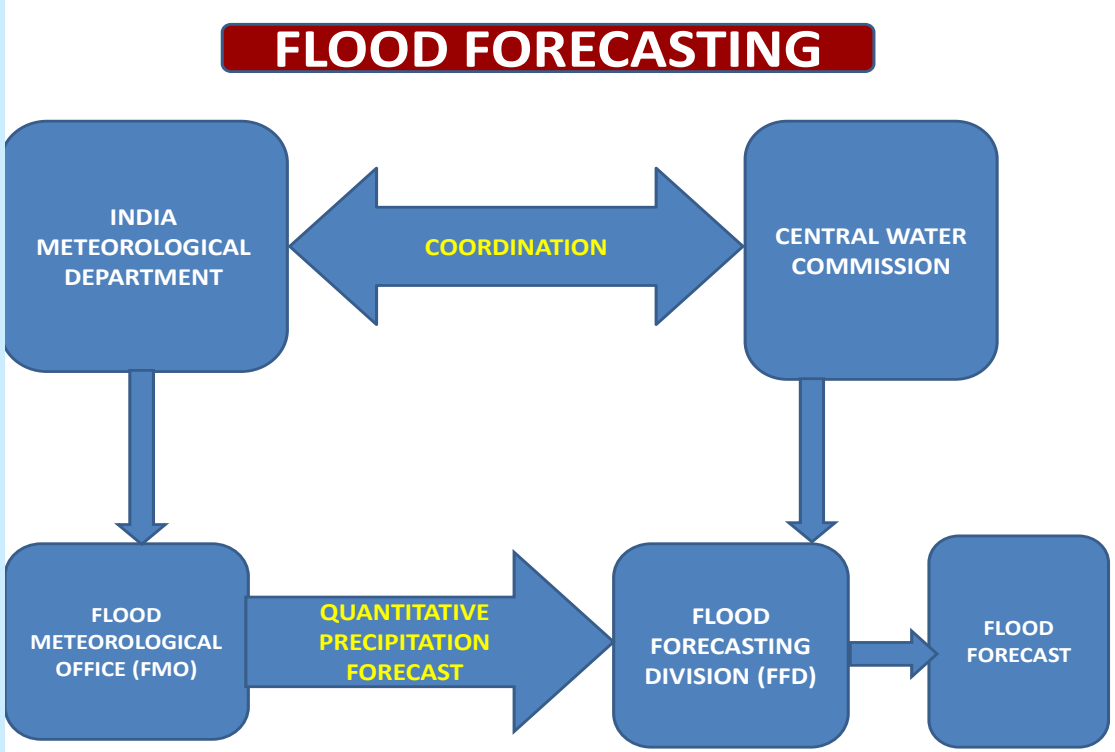
- Flood Forecasting in India: CWC + IMD
- IMD provides observed rainfall and Quantitative Precipitation Forecast (QPF) for 156 river sub-basins for flood forecast (Level Forecast) by CWC.
- Joint advisories on Flood Status of the country is issued by IMD, CWC and NDRF





Flood Meteorological Offices : 15

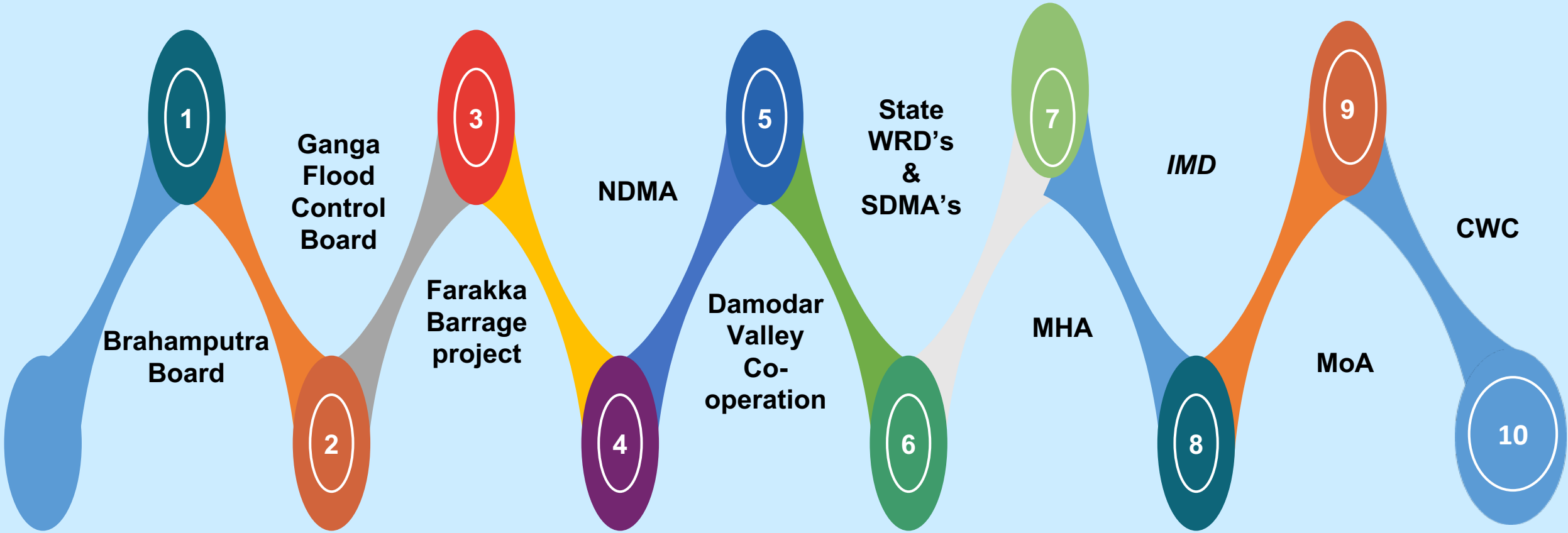
Total No of sub basin: 156



No. of Raingauge Stations under DRMS : 5896

- AWS: 532
- ARG: 574
- ORG: 4790

ORAGANISATIONS DEALING FLOODS



Quantitative Precipitation Forecast (to support riverine flood forecasting)

Sub basin wise QPF and Probabilistic QPF (PQPF) in different ranges for the next seven days are issued through Flood Meteorological Offices of IMD

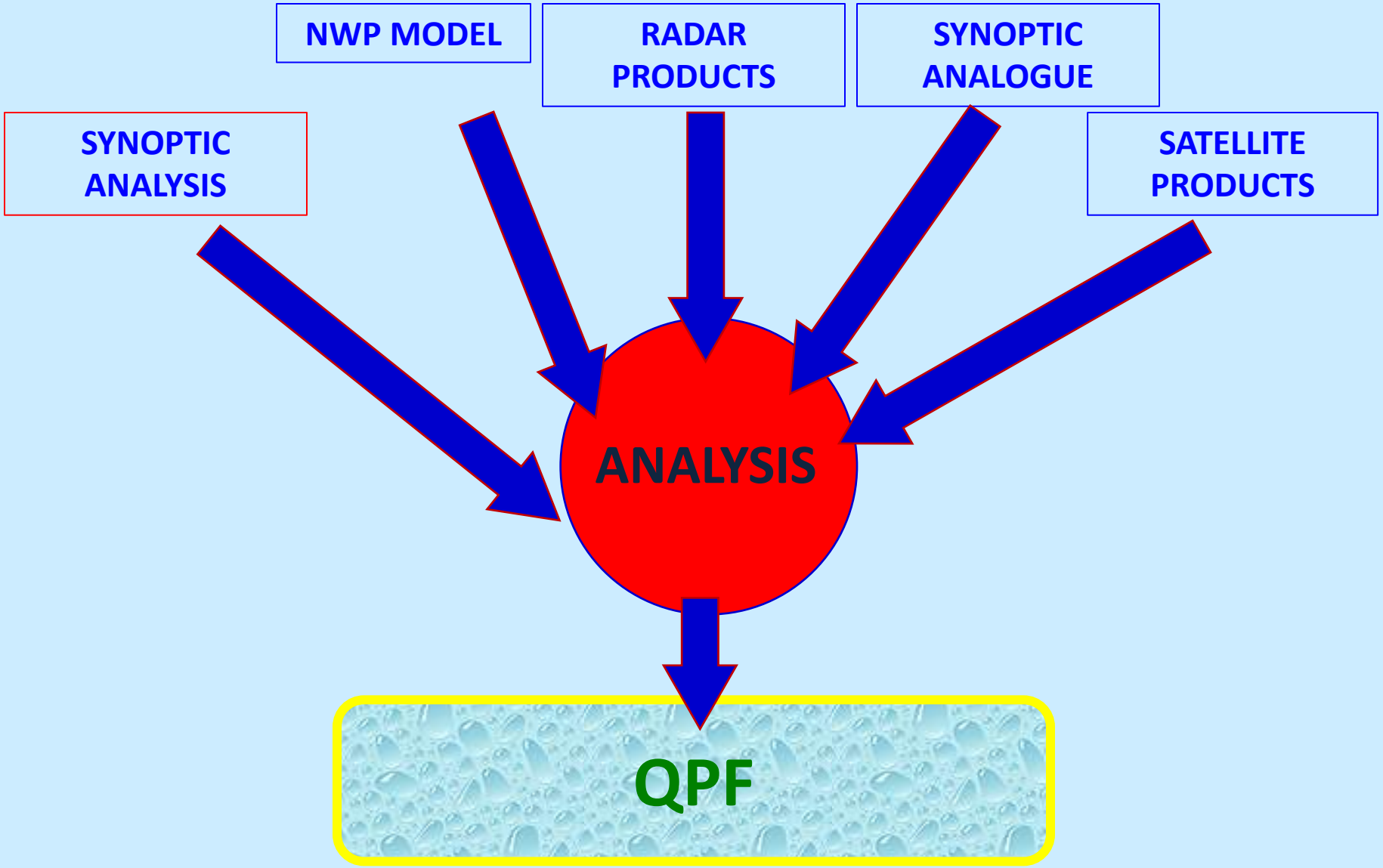
QPF categories (mm)	Colour Code
0	
0.1-10	
11-25	
26-50	
51-100	
>100	

Probability of Occurrence (%)	Colour Code
0-5	
5-25	
25-50	
50-75	
75-100	

HYDROMET BULLETINS by FMOs (Forecasts and Observations):

- Sub Basin wise QPF In various categories for seven Days
- Probability of occurrence of QPF In different categories
- Heavy Rainfall Warning for Next Five Days
- Area Averaged Rainfall During Past 24-hours
- Station wise Significant Rainfall During The Past 24-hours (≥ 5cm)

Inputs for issuing of QPF



DSS for Quantitative Precipitation Forecast

Monitoring: 1. Rainfall Monitoring 2. Synoptic Analysis 3. Isohyetal Analysis 3. QPE/AAP computation using GIS 4. Evaporation/Soil moisture 5. Cumulative Rainfall

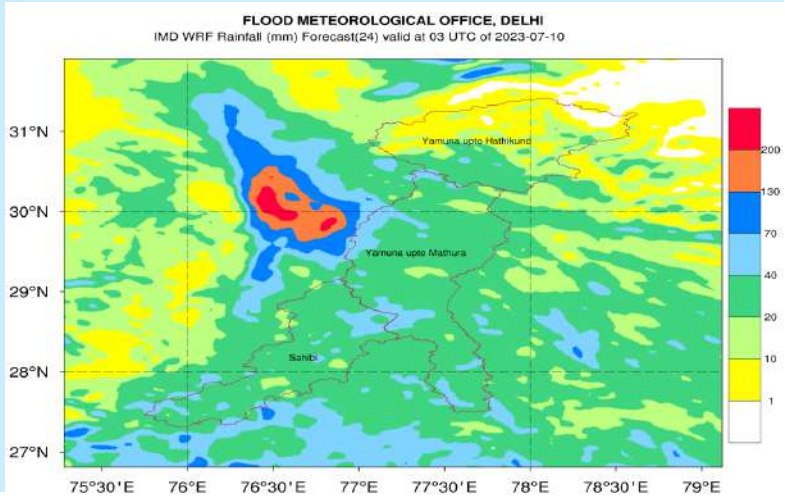
Model Forecast: i. WRF ii. NCUM-R iii. GFS iv. GEFS v. NCUM-G vi. ECMWF vii. NCEP viii. JMA ix. MME

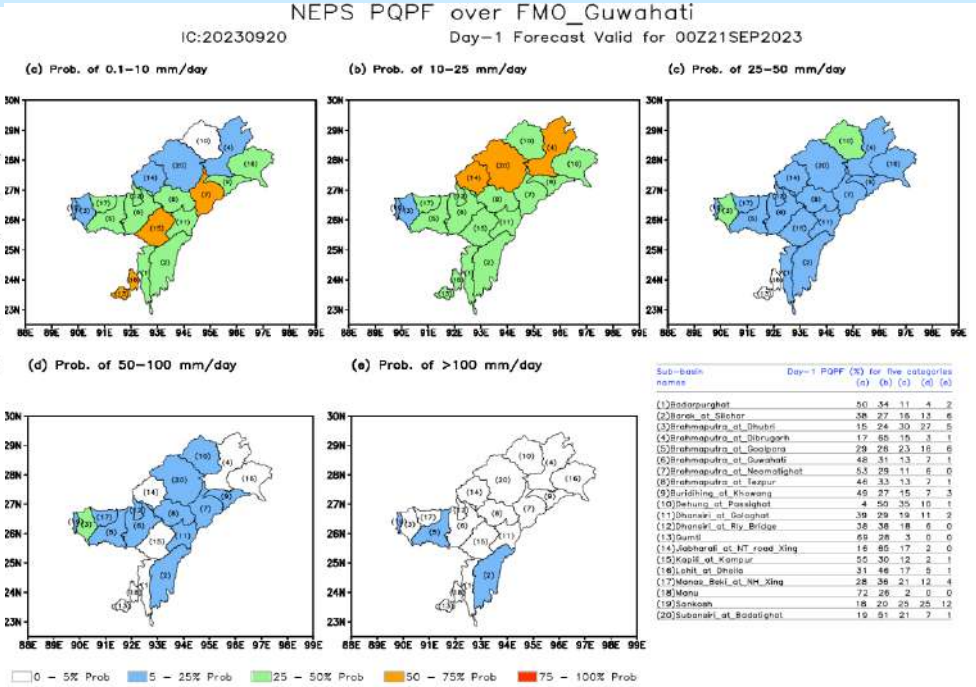
Methods: 1. Synoptic 2. Satellite 3. Radar 4. Synoptic analysis 5. Climatology 6. Model

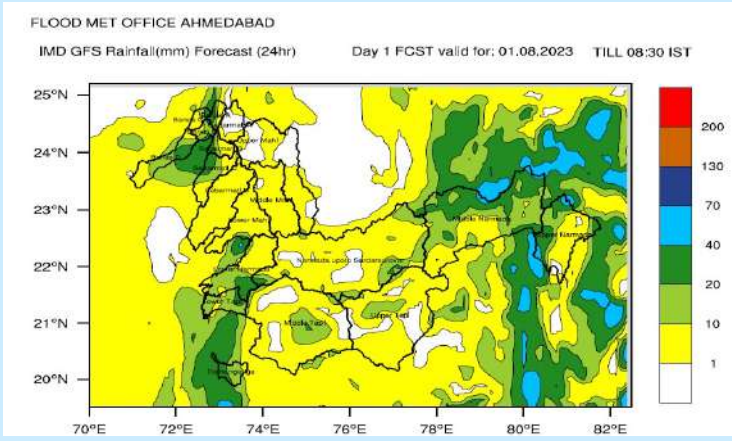
V.C. for Consensus

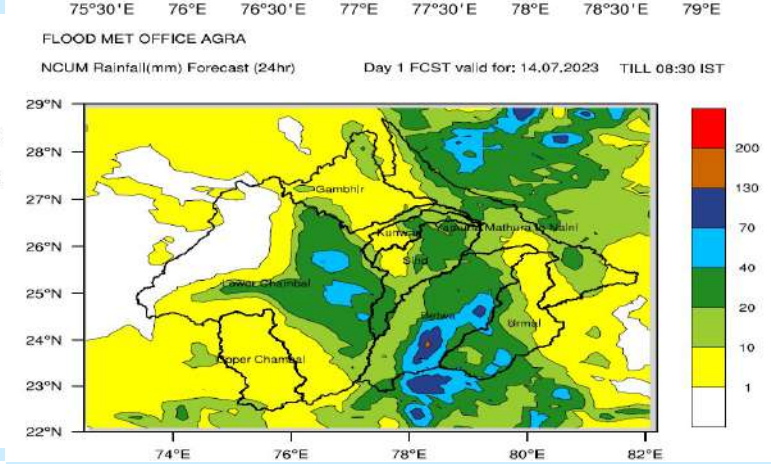
Final Forecast: i. QPF. ii. Heavy rainfall warning iii. Synoptic situation iv. Past 24 hour Rainfall AAP/QPE v. Significant Rainfall vi. PQPF

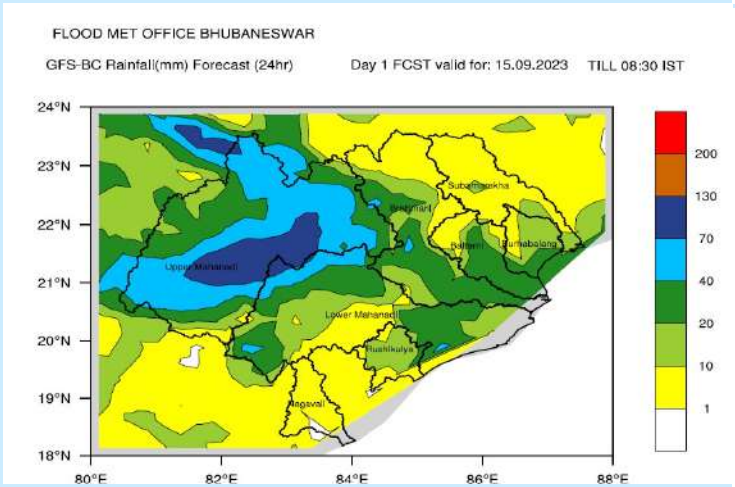
Application NWP modelling system in river sub-basins

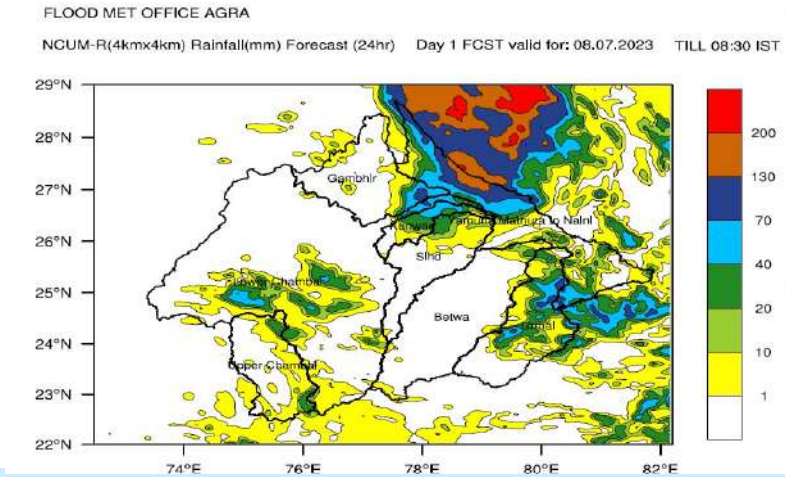


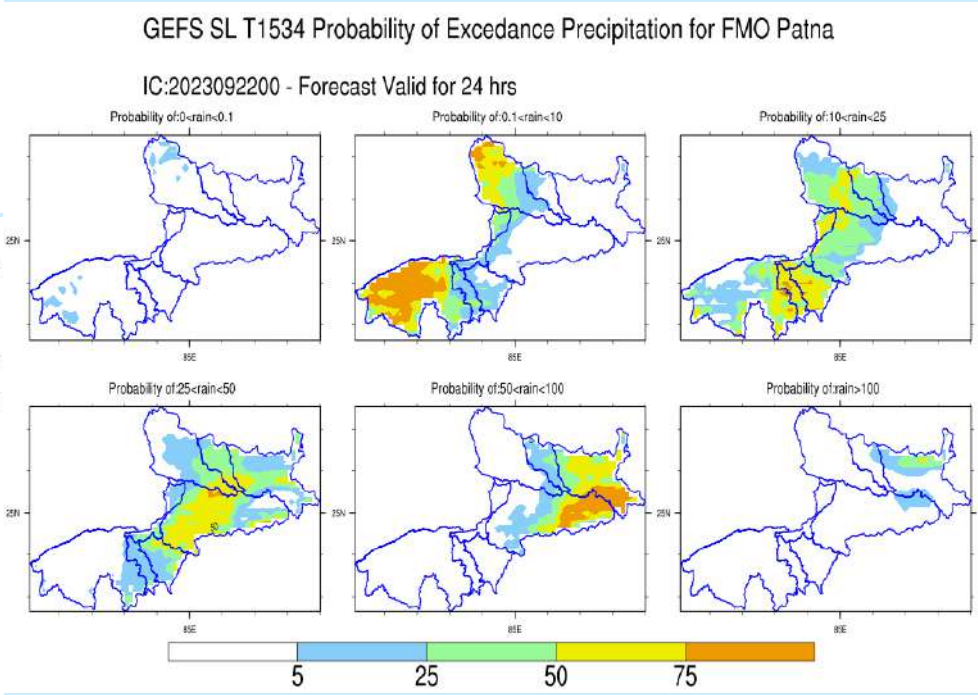












Inputs for Flood Monitoring and Forecasting

QPF in different ranges of Rainfall

a) River Sub-basin-wise Quantitative Precipitation Forecast (QPF)

S. No.	Basin Name	Sub-basin Name	QPF (mm)				
			Day-1 (25.09.21)	Day-2 (26.09.21)	Day-3 (27.09.21)	Day-4 (28.09.21)	Day-5 (29.09.21)
1	SUBARNAREKHA	SR	0.1-10	0.1-10	0.1-10	0.1-10	11-25
2	BURHABALANG	BB	0.1-10	0.1-10	0.1-10	0.1-10	11-25
3	BAITARANI	BT	11-25	11-25	0.1-10	0.1-10	0.1-10
4	UPPER BRAHMANI	UB	0.1-10	0.1-10	0.1-10	0.1-10	0.1-10
5	LOWER BRAHMANI	LB	0.1-10	11-25	0.1-10	0.1-10	0.1-10
6	UPPER MAHANADI	UM	0.1-10	26-37	26-37	11-25	0.1-10
7	LOWERMAHANADI	LM	11-25	51-75	11-25	0.1-10	0.1-10
8	RUSHIKULYA	RK	11-25	51-75	26-37	0.1-10	0.1-10
9	VAMSADHARA	VD	11-25	51-75	26-37	11-25	0.1-10
10	NAGAVALI	NV	11-25	51-75	26-37	11-25	0.1-10

Intensity and Distribution of Rainfall

3) River Sub-basin-wise Heavy Rainfall Warning

S. No.	Basin Name	Sub-basin Name	Day-1 (25.09.21)		Day-2 (26.09.21)		Day-3 (27.09.21)		Day-4 (28.09.21)		Day-5 (29.09.21)	
			I	D	I	D	I	D	I	D	I	D
1	SUBARNAREKHA	SR	NIL	NIL	H	ISOL	NIL	NIL	NIL	NIL	NIL	NIL
2	BURHABALANG	BB	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
3	BAITARANI	BT	NIL	NIL	H	ISOL	NIL	NIL	NIL	NIL	NIL	NIL
4	UPPER BRAHMANI	UB	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
5	LOWER BRAHMANI	LB	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
6	UPPER MAHANADI	UM	NIL	NIL	NIL	NIL	H	ISOL	H	ISOL	NIL	NIL
7	LOWER MAHANADI	LM	H	ISOL	VH	ISOL	H	ISOL	NIL	NIL	NIL	NIL
8	RUSHIKULYA	RK	H	ISOL	EH	ISOL	H	ISOL	NIL	NIL	NIL	NIL
9	VAMSADHARA	VD	NIL	NIL	EH	ISOL	H	ISOL	NIL	NIL	NIL	NIL
10	NAGAVALI	NV	NIL	NIL	EH	ISOL	VH	ISOL	H	ISOL	NIL	NIL

River Sub-basin-wise NWP forecasts uploaded in the IMD website

FLOOD SEASON

Flood season in different basins in the country
(CWC vide notification no 3/120/2019-FFM/ dated 22nd April, 2019)

- Brahmaputra & Barak (including Teesta, Rivers flowing in States of Tripura, Manipur, Mizoram, Nagaland, Meghalaya, North Bengal, Sikkim) Basins and Jhelum Sub-Basin of Indus Basin from 1st May to 31st October
- All other basins upto Krishna basin from 1st June to 31st October
- Basins south of Krishna basin (Pennar, Cauvery and southern rivers) form 1st June to 31st December.

Joint Advisories on Flood by IMD, CWC & NDRF

Flood Situation in sub-basins (Only the Sites having rising trend)

QPF categories (mm)	0	0.1-10	11-25	26-50	51-100	>100

S. No.	River/Sub-Basin/Basin	State	District	Rainfall Situation					Remarks/ Advisories
				Day 1	Day 2	Day 3	Day 4	Day 5	
1	Ganga/Upper Ganga/Ganga	Uttar Pradesh	Budaun						UP: 10 teams available i.e., Gorakhpur- 3, Noida G.B. Nagar-1, Lakhimpur Kheri- 1, Bahriach-1, Bareilly-1, Lucknow-2, Varanasi-1
2	Ghagra/ Ghagra /Ganga	Utter Pradesh	Ballia						

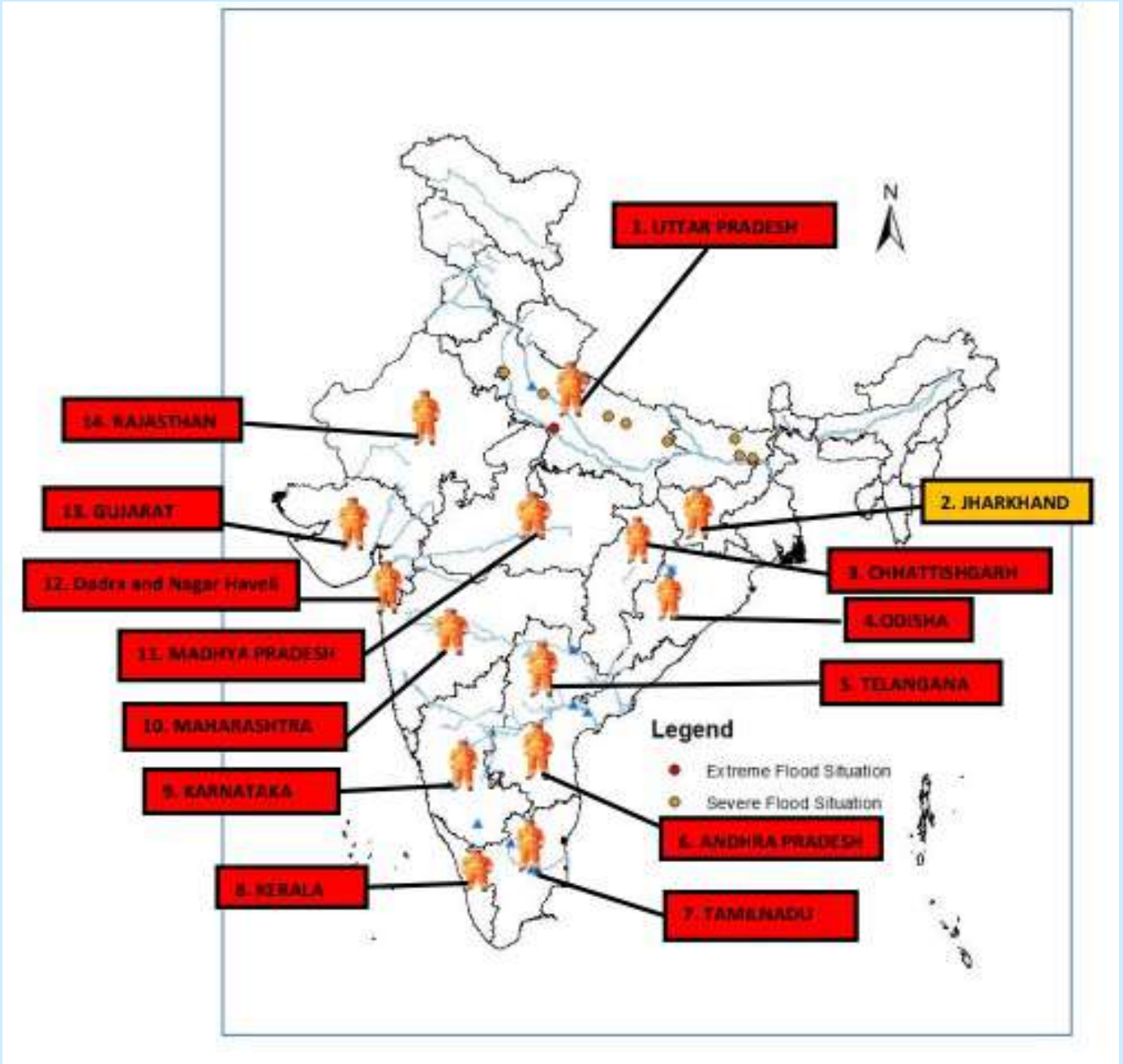
Storage above 85%	
Storage above 60%	

Reservoirs Position

QPF categories (mm)	0	0.1-10	11-25	26-50	51-100	>100

#	Reservoir/Dams	River/Sub-Basin /Basin	State	US/ DS District	Rainfall situation					Remarks/ Advisories
					Day 1	Day 2	Day 3	Day 4	Day 5	
1	Pulichinthala	Krishna/Lower Krishna/ Krishna	AP	Nalgonda(Tel)/Guntoor, Krishna (AP)						Andhra Pradesh: 04 team available i.e., Vishakhapatnam-3, Tirupati-1 Telangana: 03 teams available i.e. Hyderabad-2 & Bhadra Dari Kothagudem-1
2	Srisailam	Krishna/Lower Krishna/Krishna	AP	JogulambaGadwal(Telangana) Kurnool(AP)/ Nalgonda(Telangana), Guntoor (AP)						

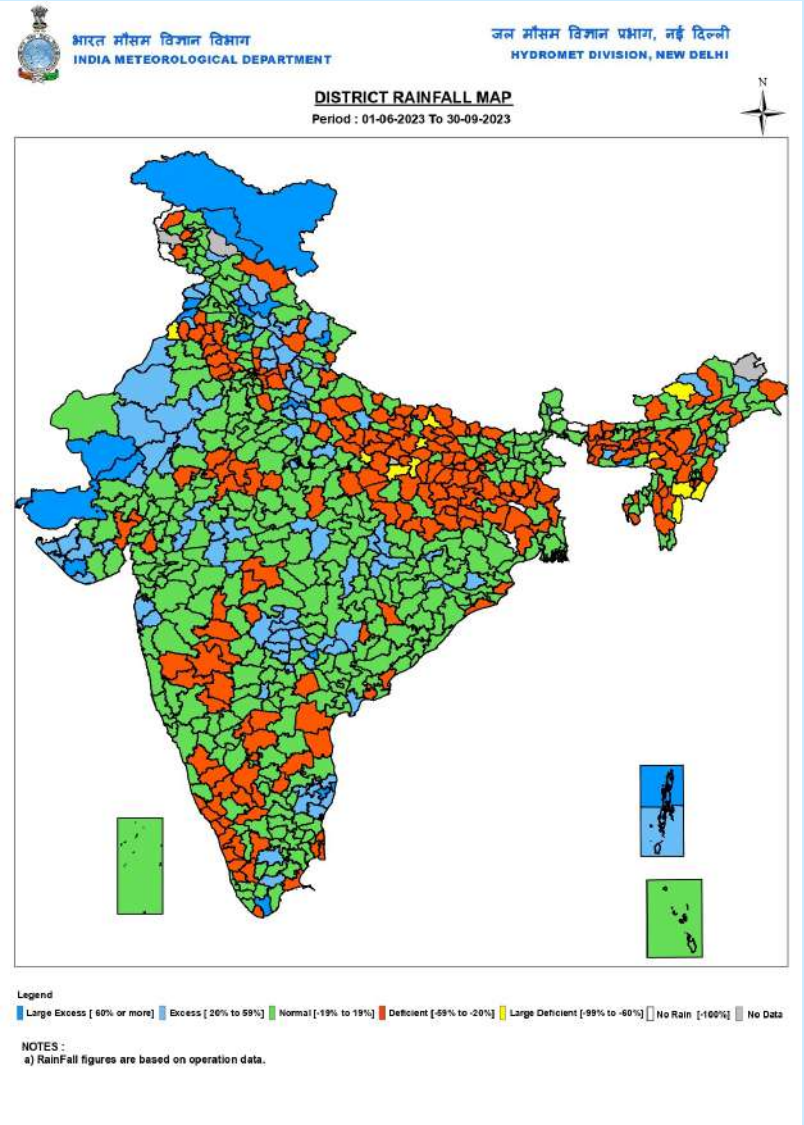
Joint Advisories on Flood by IMD, CWC & NDRF

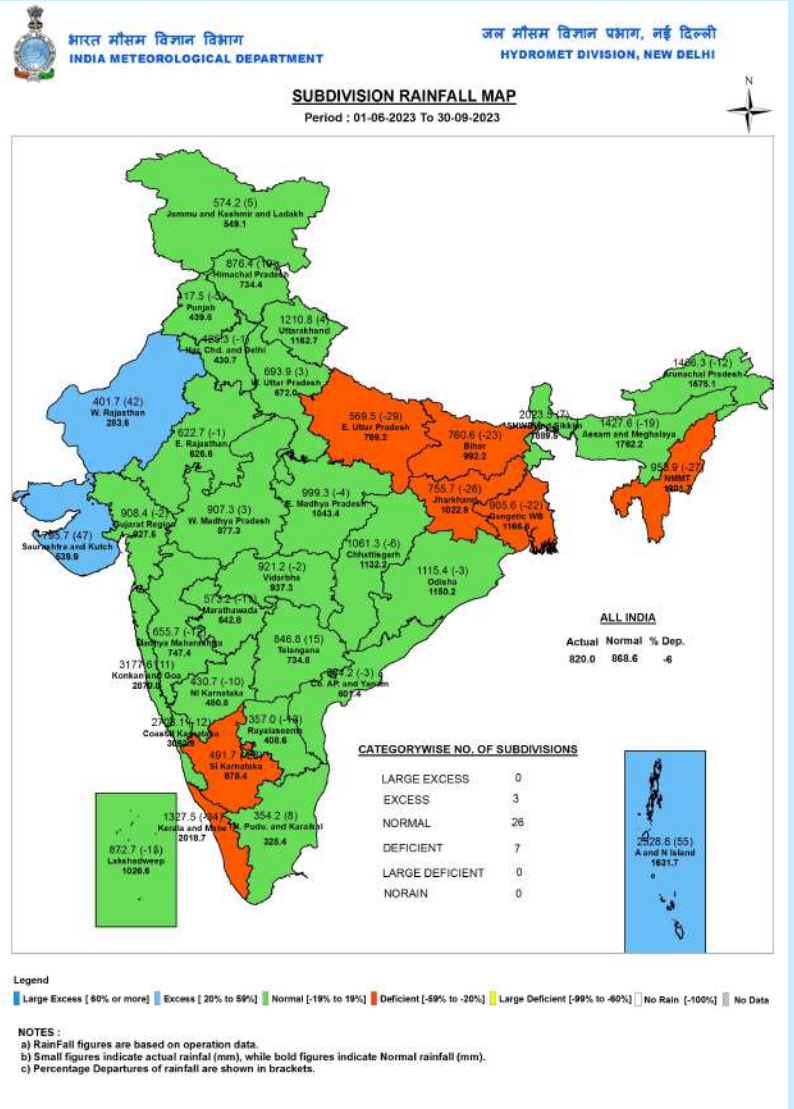


REAL-TIME RAINFALL MONITORING

Rainfall Statistics: Daily, Weekly, Monthly, Seasonal and annual time scales using real time rainfall data from 5896 Stations for:

- 717 Districts
- 36 Met Sub divisions
- All 36 States and UTs

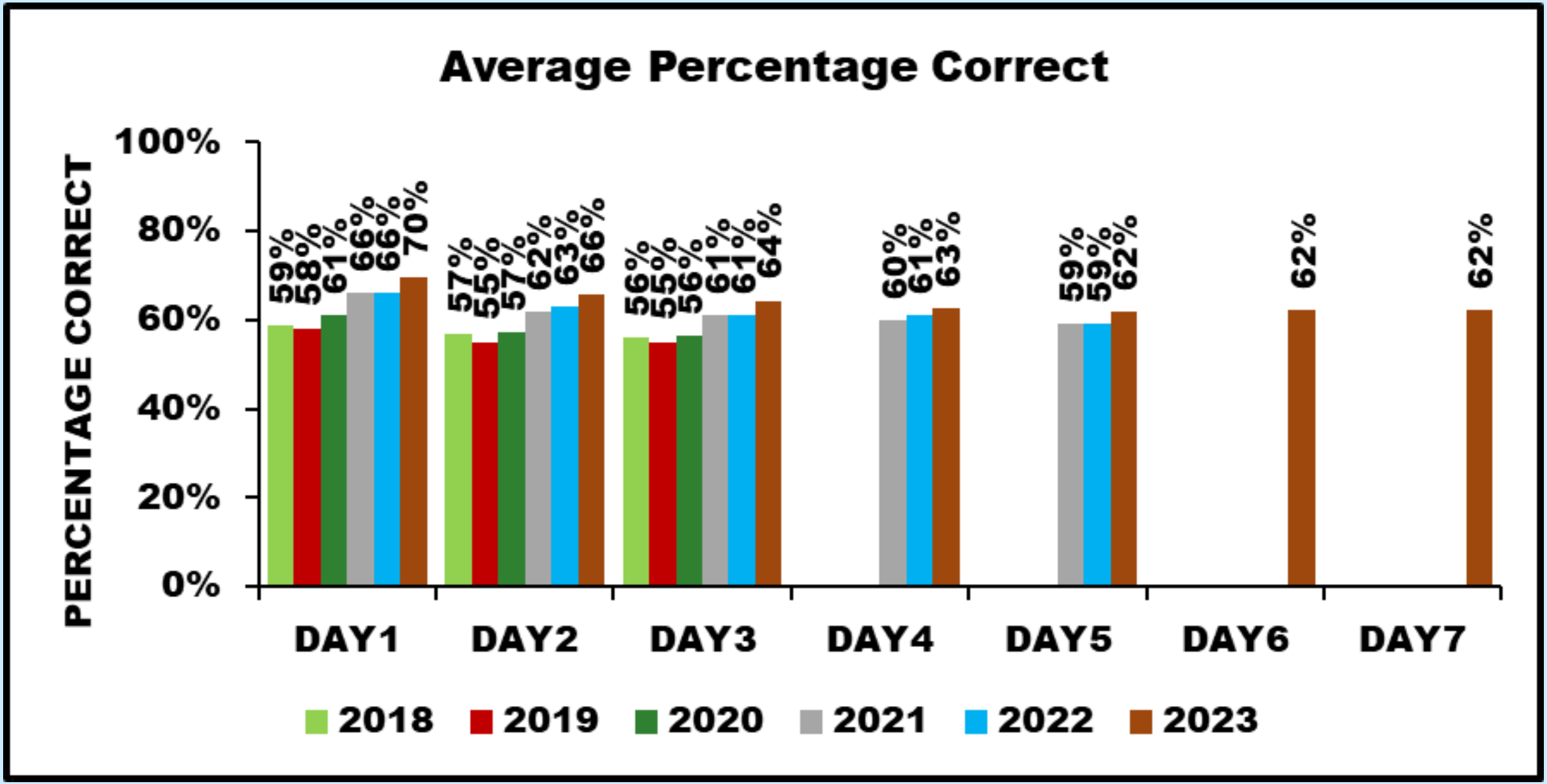




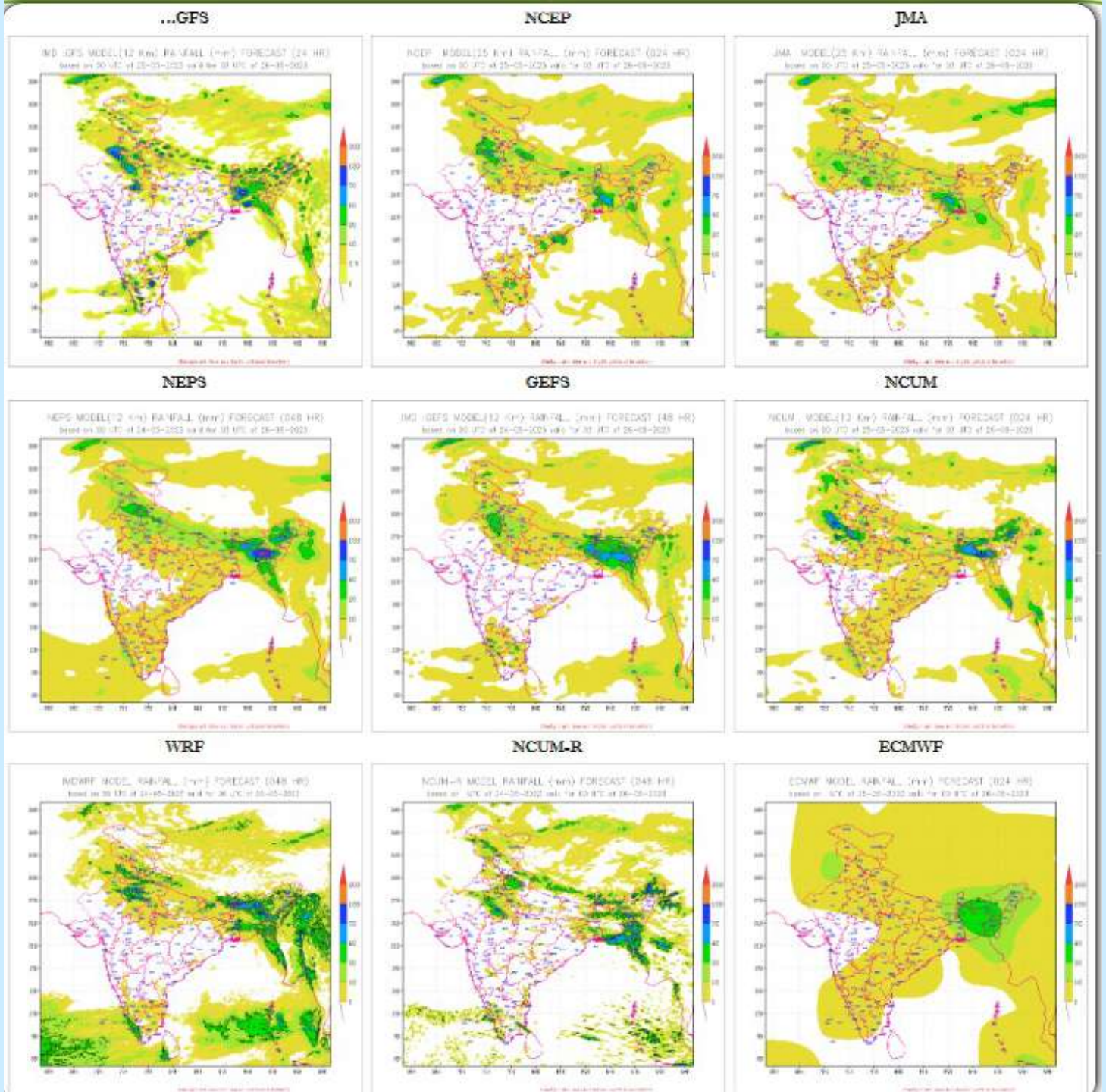
Recent Initiatives

- Lead period of River Sub Basin QPF increased from 5 days to 7 days
- Initiated issuing Probabilistic QPF
- Commissioned New FMOs at Srinagar, Bengaluru, Chennai and Thiruvananthapuram.
- Increased Rain gauge Network to 5896
- Utilization of more Models for decision making
- High Resolution dynamical model forecasts operationally provided to Central Water Commission for running their Hydrological modelling.
- Improvement in river Sub-basin wise Quantitative Precipitation Forecasts (QPF) skill by 6% in recent years.
- The Flash Flood guidance: Guidance (threats and warnings) now being generated for 100000 watersheds from 30,000 earlier
- Joint advisories by IMD, CWC and NDRF on Flood Status of the country

Operational QPF Performance

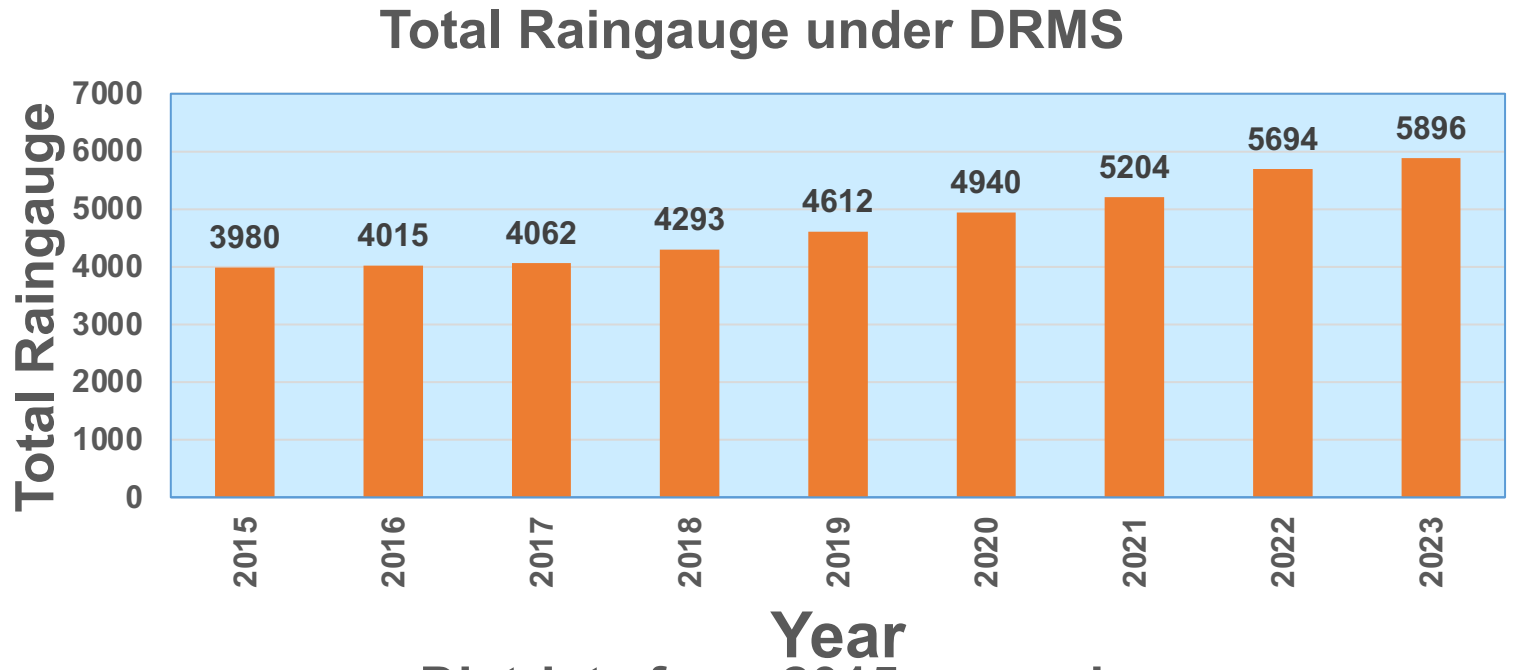


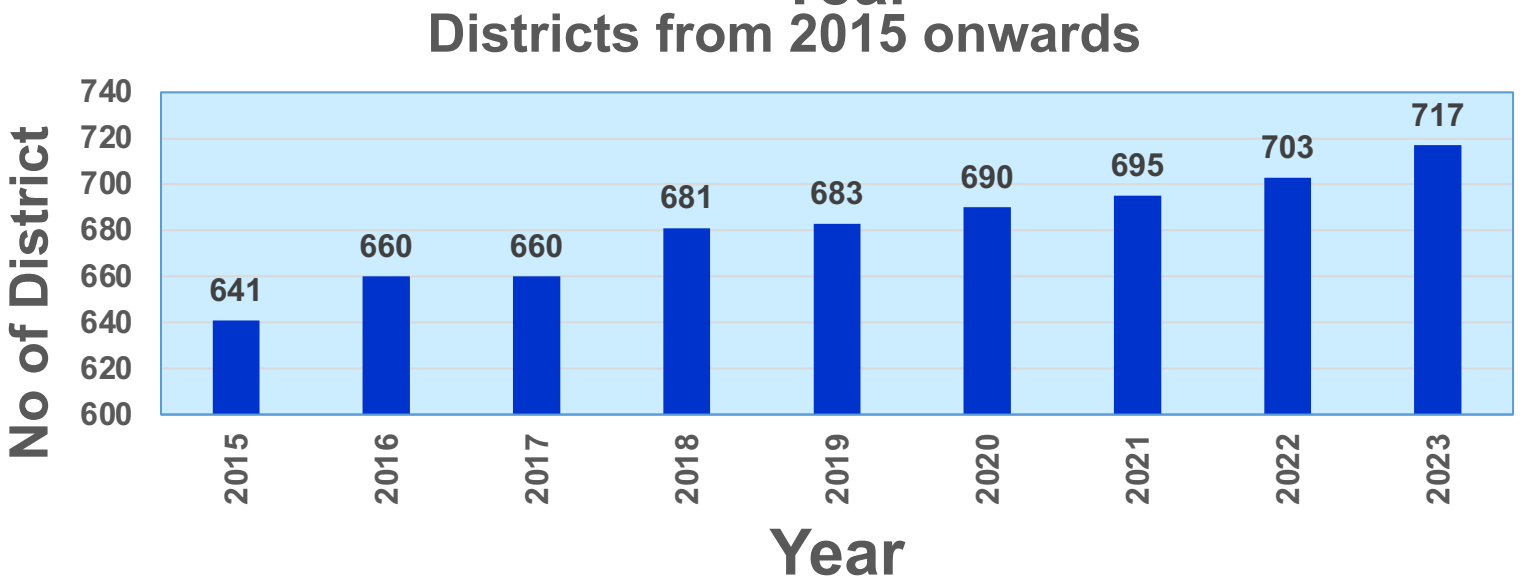
- ✓ **Introduction of New models to arrive at better decision**



Near realtime Rainfall Monitoring

- Addition of 1916 raingauge stations which increased Rain gauge Network to 5896 under District wise Rainfall Monitoring Scheme (DRMS).
- Increased the no. of Districts from 641 to 717 for preparation of daily realtime rainfall statistics under DRMS
- Initiated the preparation of daily near realtime rainfall statistics





Recent Enhancement in Raingauge network and districts under DRMS

Year → / Hydromet Services ↓	2015	2019	2023
Raingauge Stations under DRMS	3980	4612	5896
Flood Met. Offices	11	14	15
River Sub-basins	121	153	156

Gap Areas and Initiatives

GAP AREAS

- Network
- Accuracy of forecast of Heavy rainfall events?
- Quantitative Precipitation Forecast accuracy?

INITIATIVES

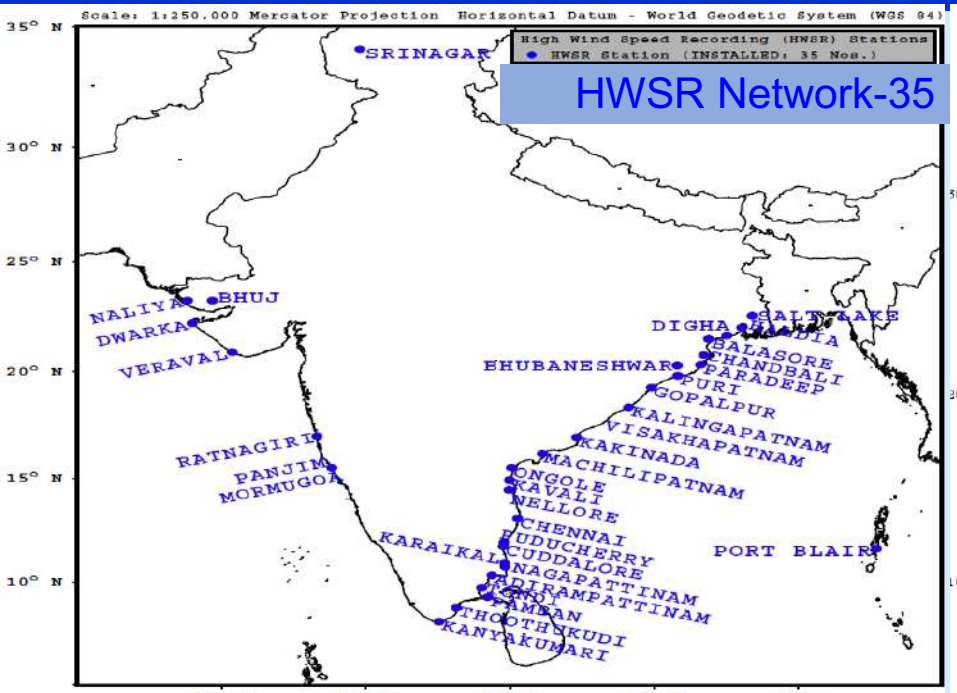
- High Resolution NWP modelling
- Post processing for NWP rainfall (BIAS Correction/downscaling)
- Multi-model ensemble for probabilistic sub basin wise categorical rainfall forecast
- Co-ordination and exchange of information among stakeholders
- Application of dynamic model in extended range forecast in river sub-basin/basin scale.

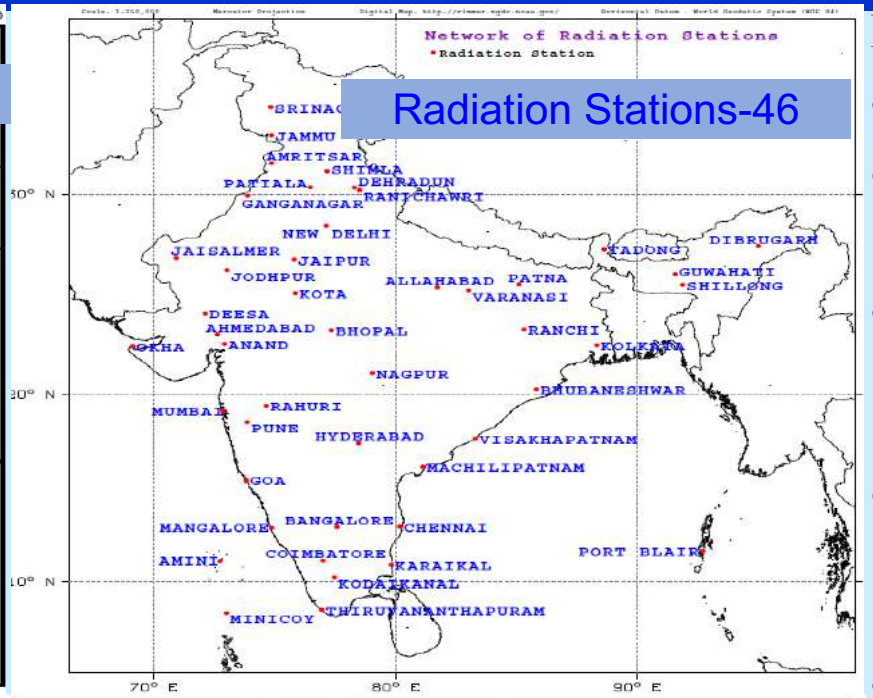
FUTURE PLAN / WAY FORWARD

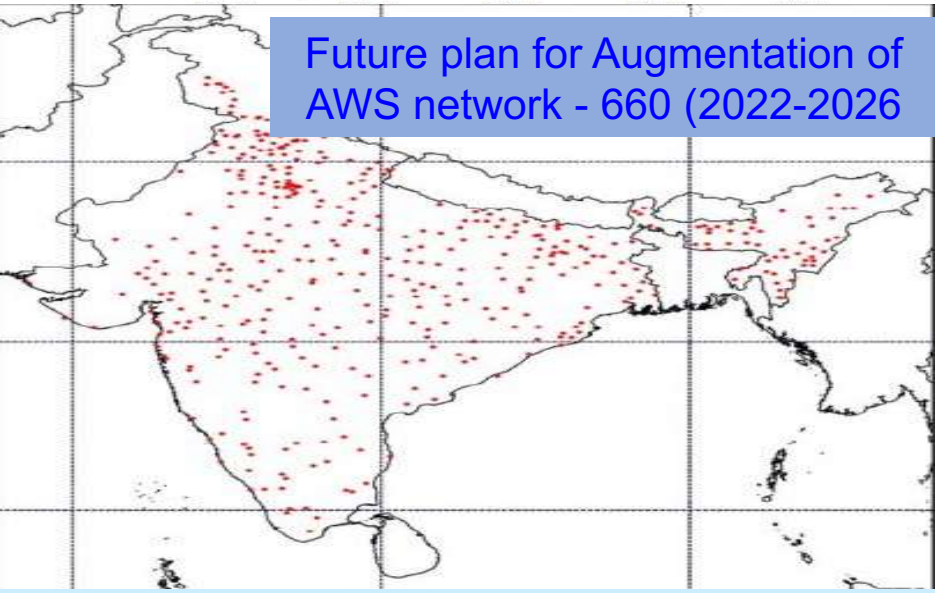
- Enhancement in observational network (both direct-AWS/ARG and remotely sensed DWR)
- High Resolution NWP modelling
- Post processing for NWP rainfall (BIAS Correction/downscaling)
- Multi-model ensemble for probabilistic sub basin wise categorical rainfall forecast
- Co-ordination and exchange of information among stakeholders
- Application of dynamical model in Extended Range Rainfall Forecast in the river sub-basins

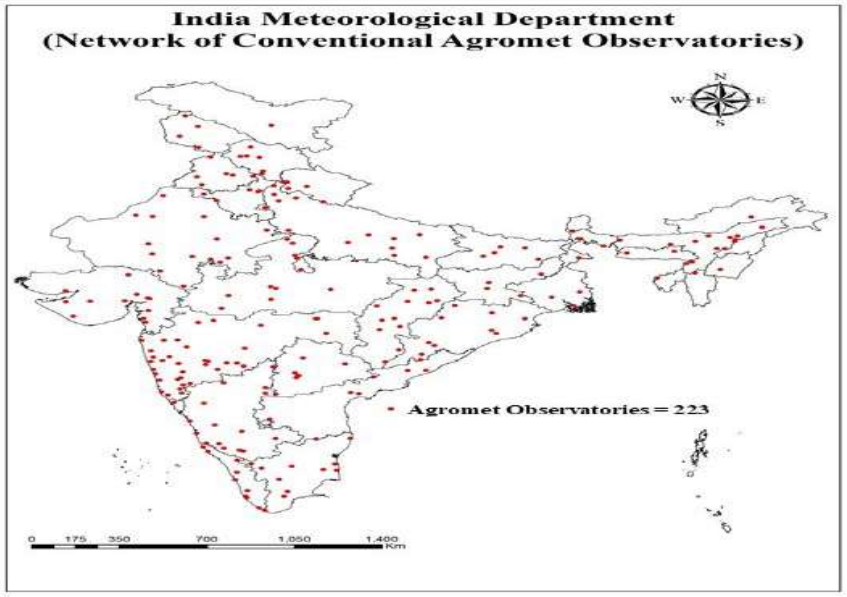
Thank you

Surface Observational Network









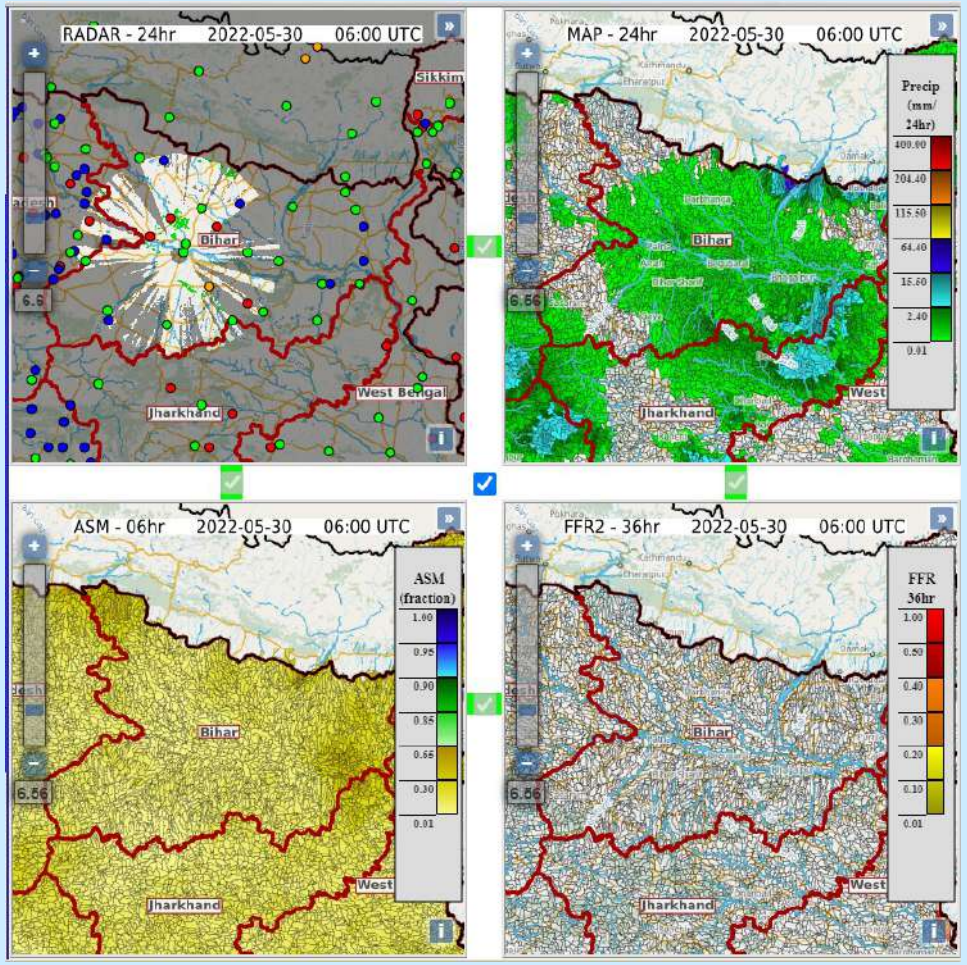
Future Plan

- 400 AWS by March, 2023.
- Additional 330 Agro-AWS by 2024
- 270 Nos. Of AWS/ARG/ASG for North-Eastern Region in 2023.
- 230 Nos. Of AWS/ARG/ ASG for Western & Central Himalayas in 2023.
- Upgradation of all Aviation Weather Observation System
- AWS/ARG Mesonet in major cities in next two years.
- Augmentation of Weather monitoring system in National Highways/ Railways

Flash Flood Guidance Advisory (Every 6 hours)

SAsiaFFGS System

- Diagnostic Products: 33
- Prognostics Products:18
- Threat Products: 12
- Risk Products: 9
- LSM: SACSMA Lumped Model
- Watershed Count: 1×10^5
- NWP Model: GFS, WRF & NCUM
- Watershed Size : Varying up to 16 sq. km (Vector)
- Spatial R: 4km × 4km
- Temporal R : Every 6 hours/ Hourly Satellite Update
- Static GIS Layers: 10
- Host: MAPSERVER



National Bulletin

GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT
HYDROMET DIVISION
FLASH FLOOD GUIDANCE CELL

National Flash Flood Guidance Bulletin

DATED: 23.07.2022 **TIME OF ISSUE: 1300IST** **VALID TILL 1730 IST**

From: India Meteorological Department, New Delhi (Email Id: sasiaffg.imd@gmail.com)

To: **RMC New Delhi, RMC Chennai, RMC Nagpur, MC Dehradun, MC Shimla, MC Srinagar, MC Hyderabad, MC Amrawati, MC Nagpur and concerned FMO's.**

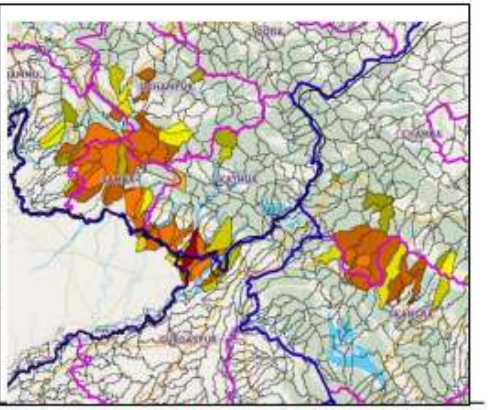
Area of Concern (AoC): Few Watersheds & neighborhoods of western parts of Jammu & Kashmir, Uttarakhand, Himachal Pradesh, Telangana, adjoining Marathawada & adjoining Vidarbha Met subdivisions.

Diagnostic Guidance: Based on Merged Mean Areal Precipitation at 1130 IST, recorded rainfall is up to 105 mm in last 6 hours and up to 240 mm in last 24 hours over few watersheds and neighborhood of Telangana, Jammu & Kashmir & Ladakh, Uttarakhand, and Kerala & Mahe met subdivisions. Land Surface Model shows few fully 100% saturated watersheds & few nearly saturated watersheds up to 85% over Telangana, Jammu & Kashmir & Ladakh, Uttarakhand, Himachal Pradesh and Kerala & Mahe met subdivisions and up to 55% soil saturation over remaining parts of the country.

Prognostic Guidance: Dynamic Global (GFS) & Mesoscale Model (WRF & NCUM) forecasts **Moderate rainfall** up to **150** mm in next 24 hours.

Observed Flash Flood Threat (IFET) till 1130 IST of 23.07.2022:

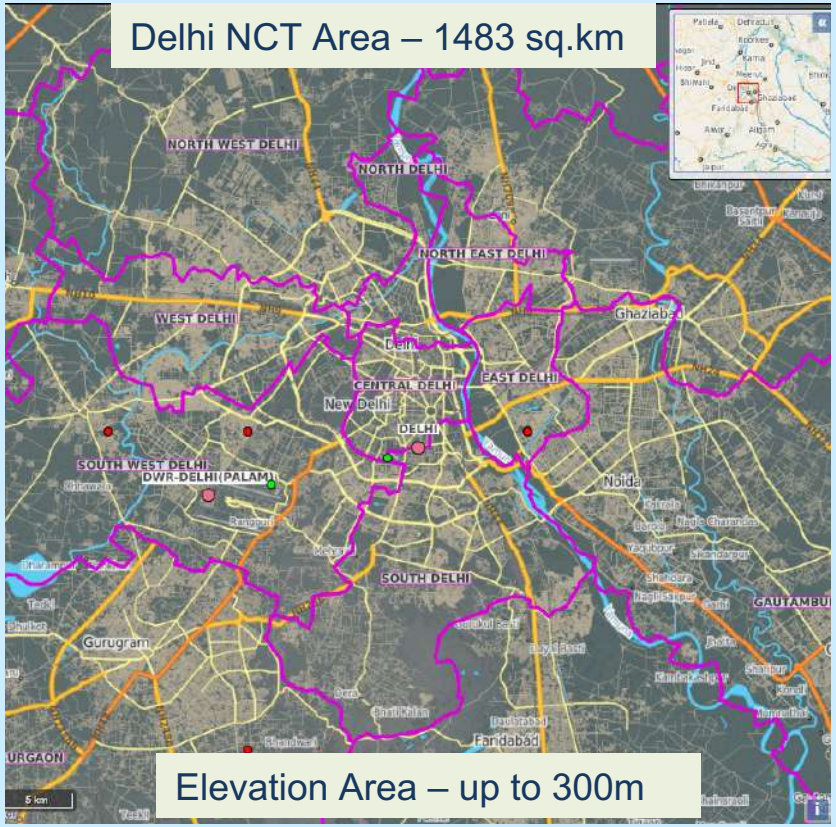
Moderate to High Flash flood threat over Samba, Udhampur, Jammu, Reasi & Kathua districts of Jammu & Kashmir and Chamba & Kangra districts of Himachal Pradesh Met Sub-division observed in last 06 hours.

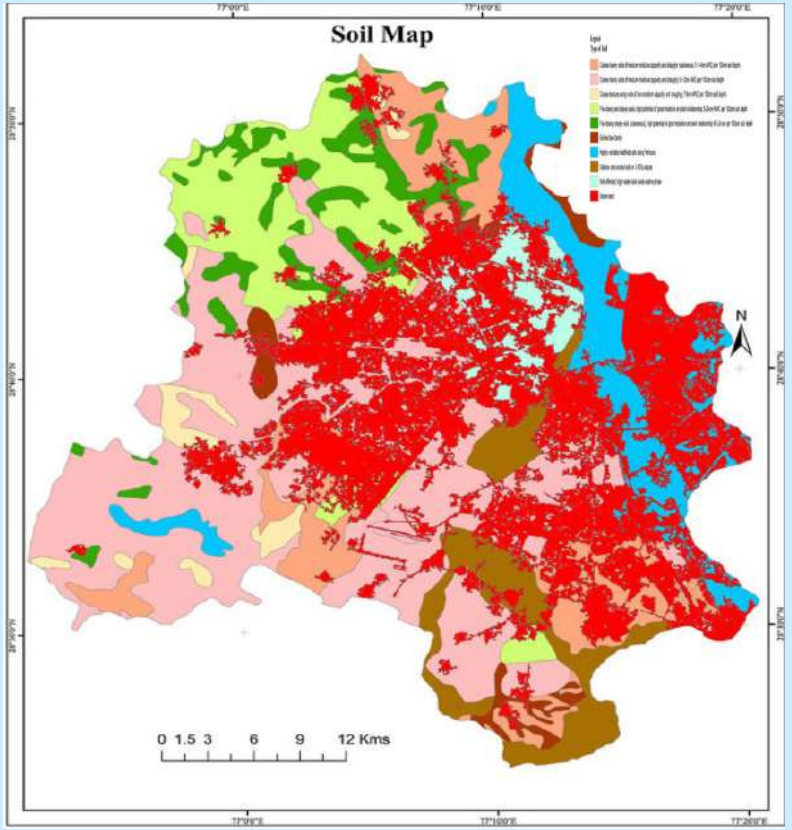


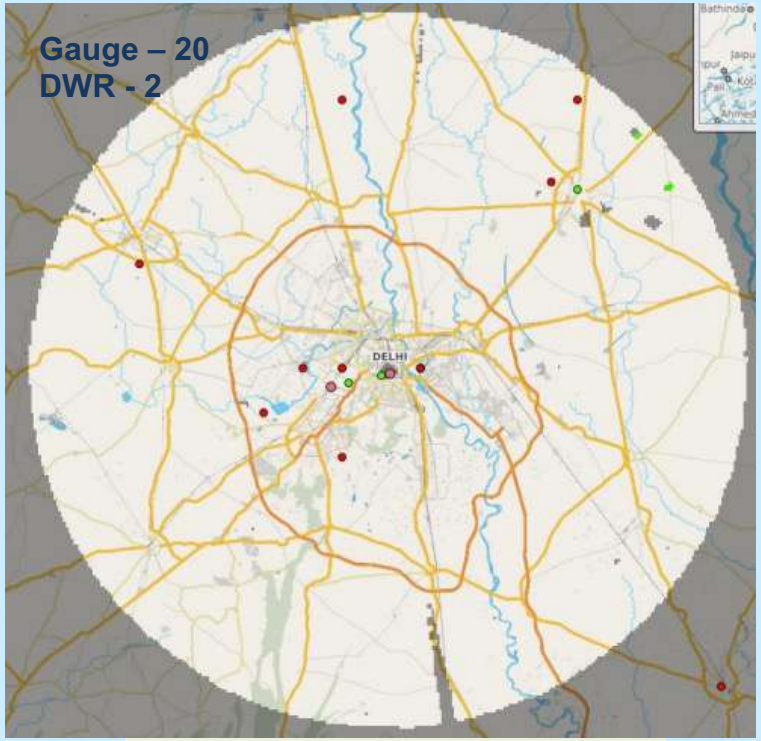
Disclaimer: This is only a guidance bulletin and not a warning for flash floods.

Urban Flood: Integration of City Specific Flooding Module in SASIAFFGS for Delhi

- **WMO agreed to the IMD proposal of financial support for Integrated Flood Warning System for Delhi city in SASIAFFGS. Delhi has been selected for the pilot study based on the increasing growth potential, vulnerability of sudden floods/ water logging.**
- **HRC started the project with IMD and requested additional data for its test and development.**







Population – 1.9 crores (2012)

URBAN FLOODING : Data Requirements

Meteorological Data (IMD)

1. Historical data from additional gauges
2. Operational high resolution (e.g., 1km) mesoscale forecast model.
3. Operational nowcast from Radar.

Geo Spatial Data :

1 High resolution DEM (10m resolution or finer)
2. Stream network, which includes both natural channels and man-made channels (e.g., open channel storm sewers, canals etc.)
3. Major flow control structures and their quantitative operating policies (e.g., sluice gates etc.)
4. Underground storm sewer system network
5. Points of interest to be included in the system interface (e.g., schools, hospitals, government buildings etc.)

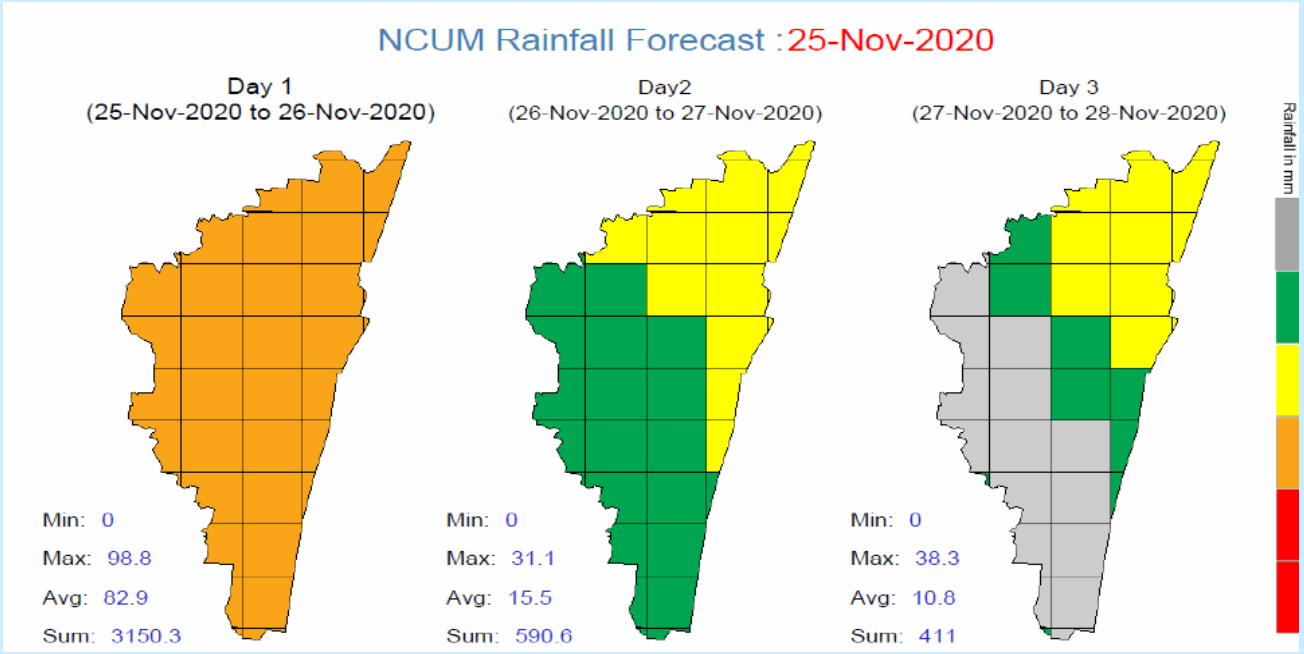
Soil

1. Soil texture and soil depth
2. Land use and land cover data

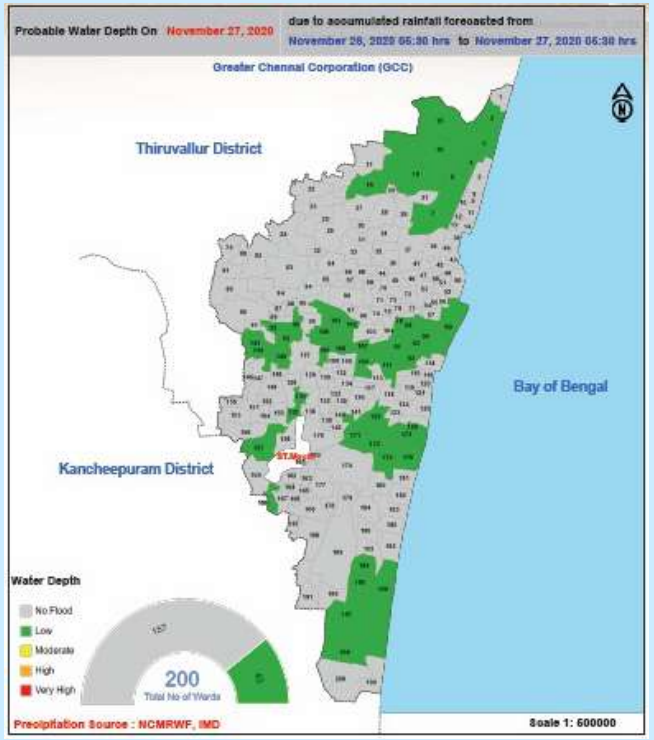
Routing

1. Cross-sectional profiles of natural streams of different sizes
2. Major flow control structures (e.g., sluice gates etc.)
3. Channel roughness data (Manning) and information
4. Historical flow observations with hourly or sub-hourly resolution (e.g., discharge, water level+rating curve)
5. Locations of areas prone to flooding
6. The regulations (e.g., controls etc.) of flow on the segment of Yamuna River that passes through Delhi.

Integrated Flood Warning System (i-Flows Chennai)

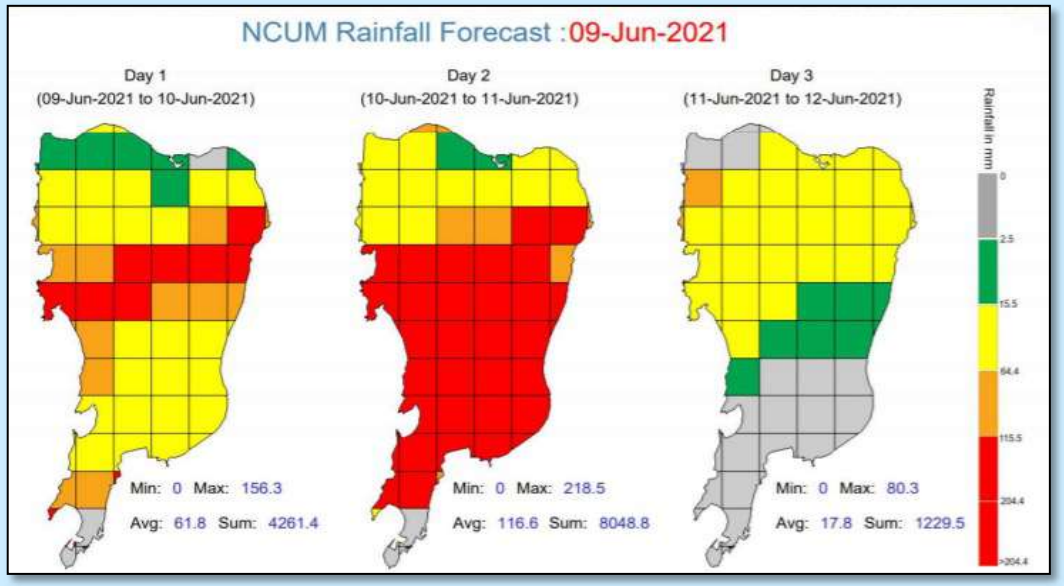


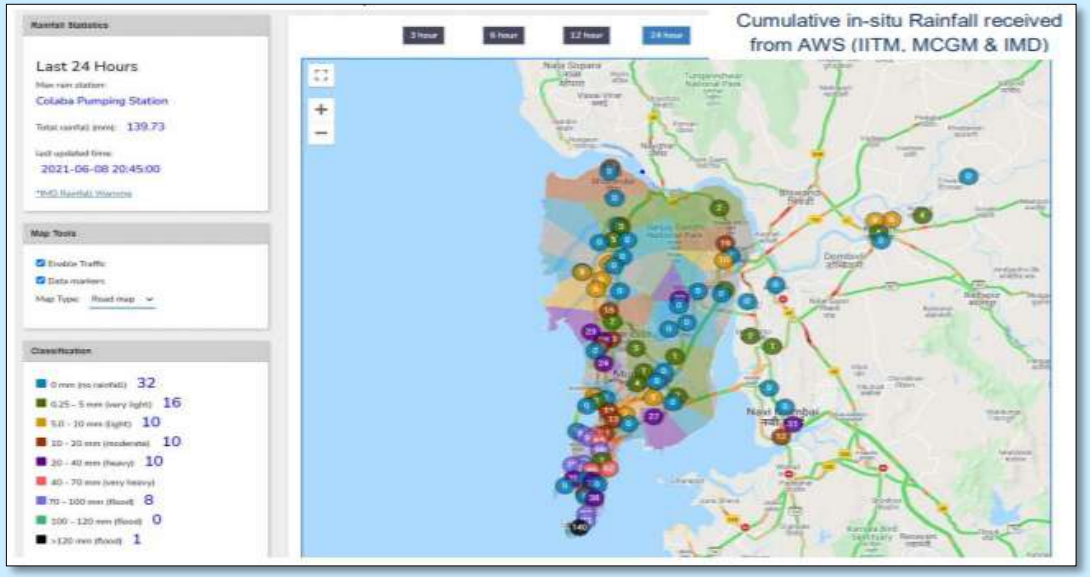
(mm) (mm) (mm)

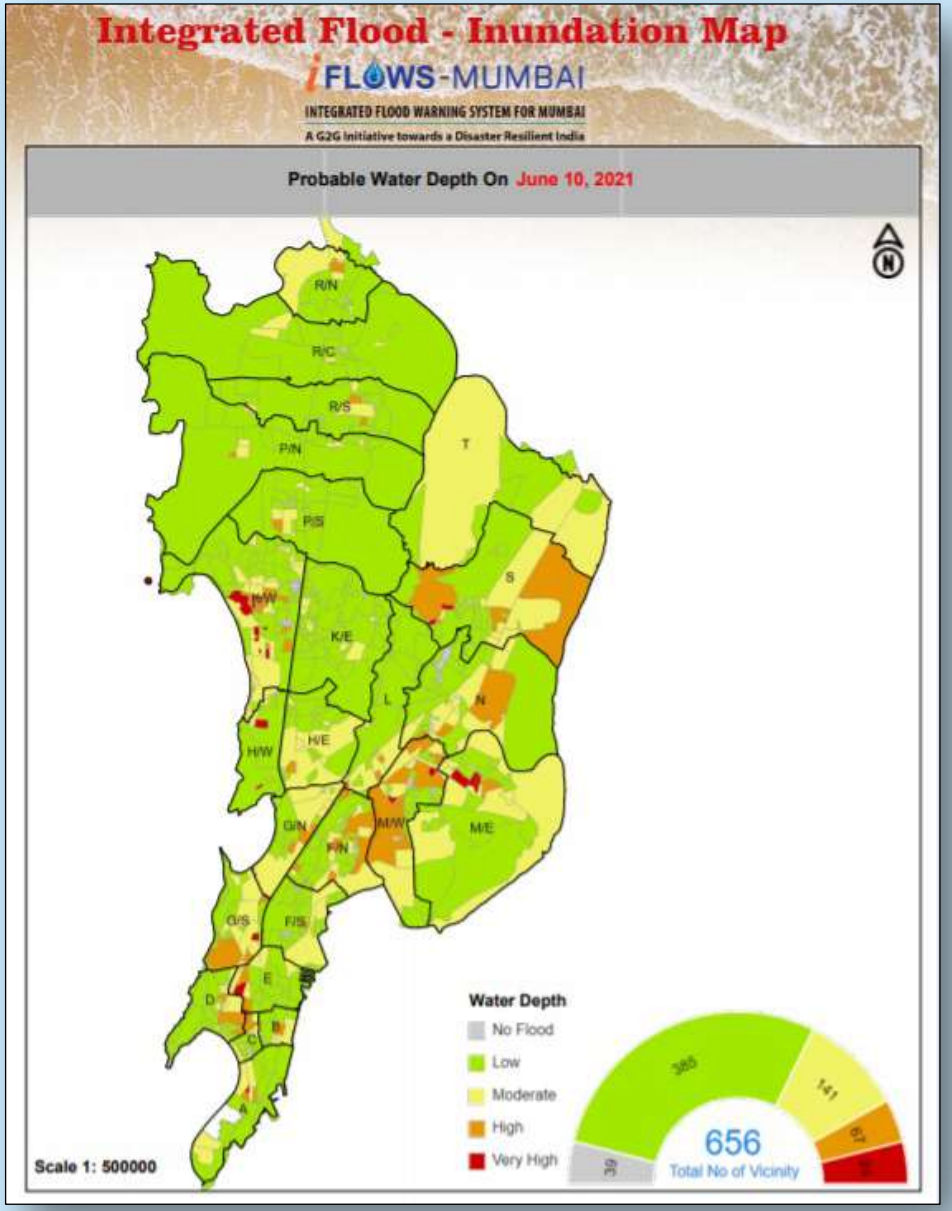


Code	Water Depth (feet)
	No flood
	3-4
	4-5
	5-6
	>6

Integrated Flood Warning System (i-Flows Mumbai)







Future Plan/Way forward

- Integration of **City Specific Flood Module into SASAFFGS** for real time flood monitoring of urban cities. In the recent years, many Indian cities witnessed inundation and water logging due to short time incessant rainfall.

- **Automatic generation & dissemination of Alerts**/ bulletins based on guidance information.

- Real time changes enabled in the FFG system for **creation of customised guidance maps** i.e., value added products after operational inputs.

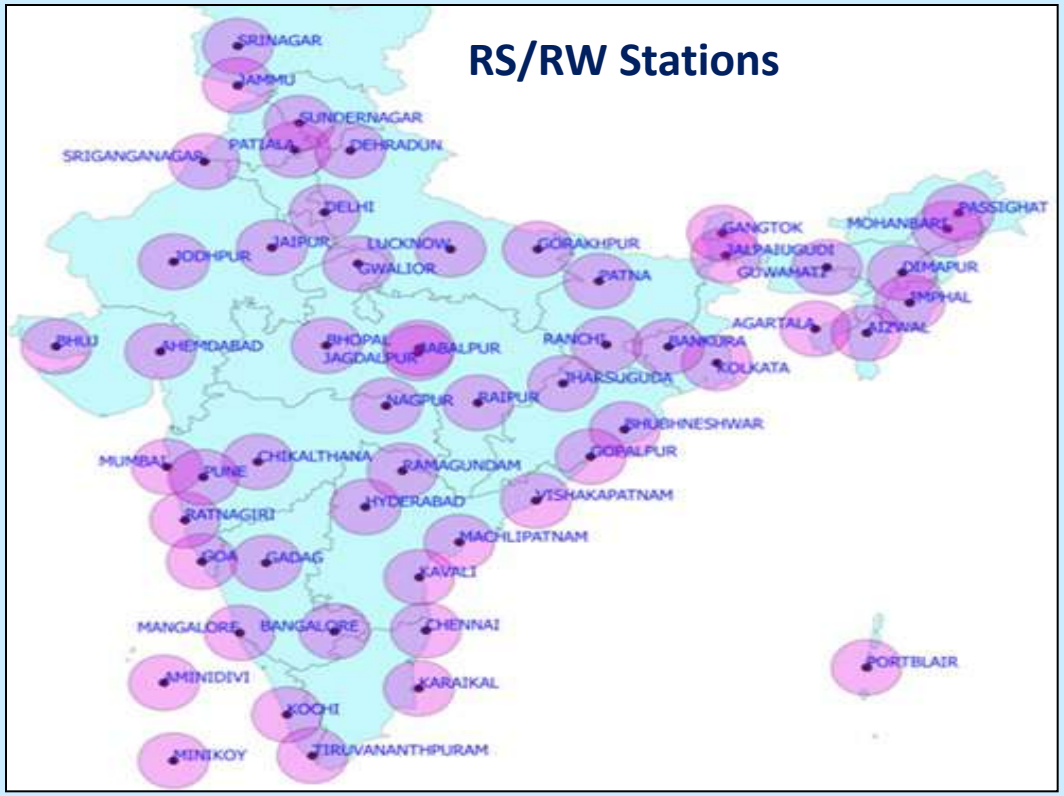
- Standardized **uniform data formats** for all Non-GTS Datasets for real-time integration (incl. AWS, ARG, Agro AWS, etc)

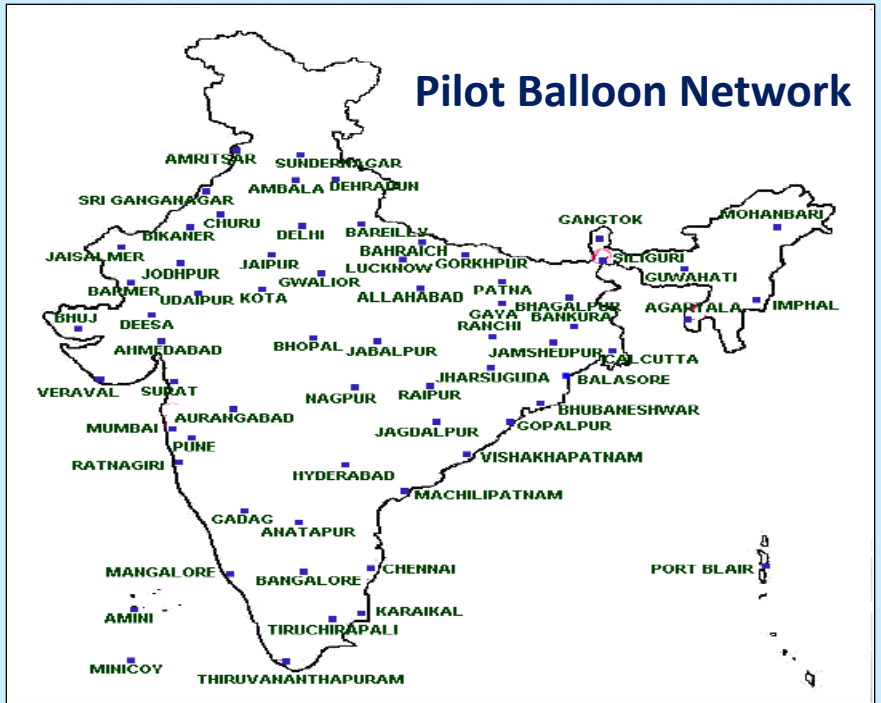
- Capable of Integrating **multiple NWP forecasts, Prognostics products up to 5 model** for ensemble predictions.

- Capable of integrating multiple data (radars, gauges, satellite estimates) and static GIS layers on operational basis.
- **Landslide Susceptibility Module into SASIAFFGS** for better predictability of rainfall induced landslides in the vulnerable hilly regions of Indian Subcontinent. Landslides are a major hydro-geological hazard that is invariably triggered due to incessant rains in conjunction with human intervention impacting the topographical features of the area.

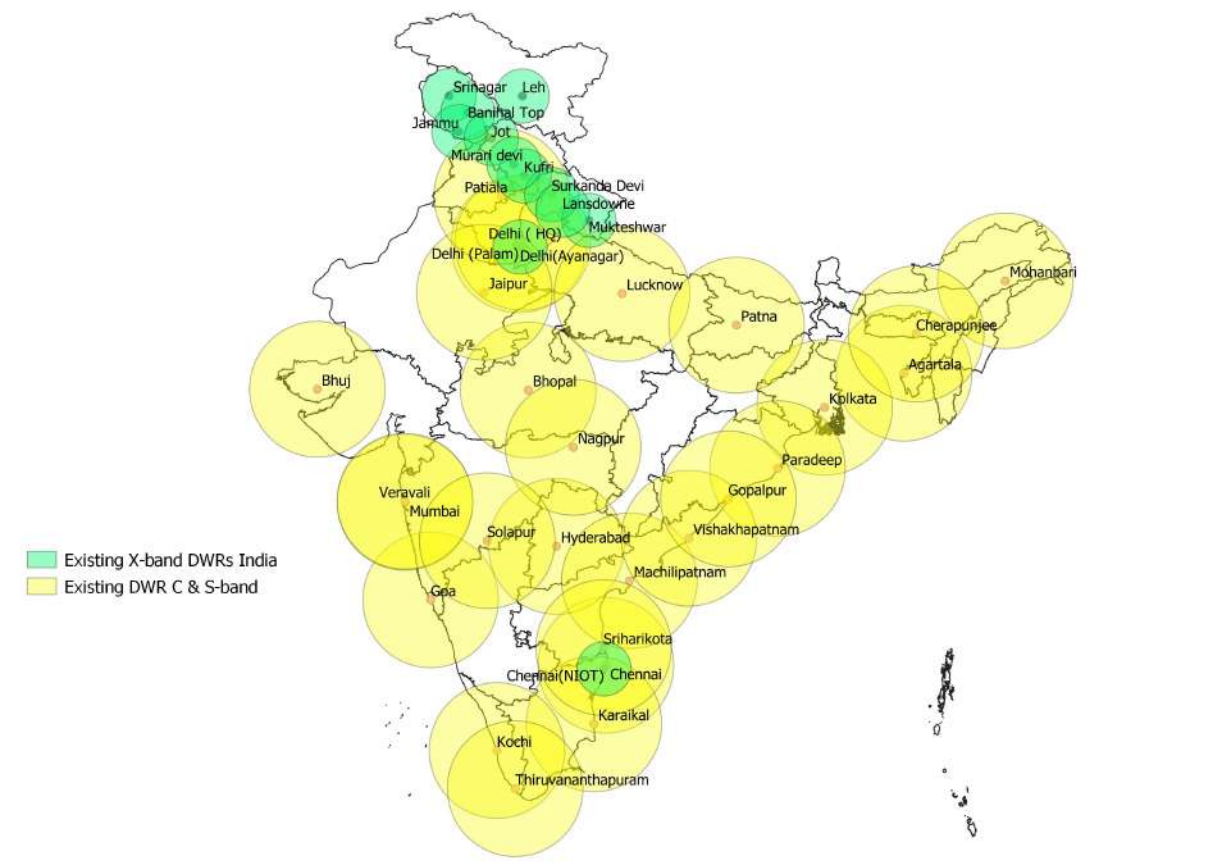
Upper Air Observation Network

- IMD has a vast network of upper air observatories comprising of 56 Radiosonde/ Radiowind (RSRW) and 62 Pilot Baloon observatories to measure vertical profile of atmosphere viz., temperature, wind and humidity.
- This data is used for weather forecasting. All these data are used in prediction models and real time analysis of weather systems

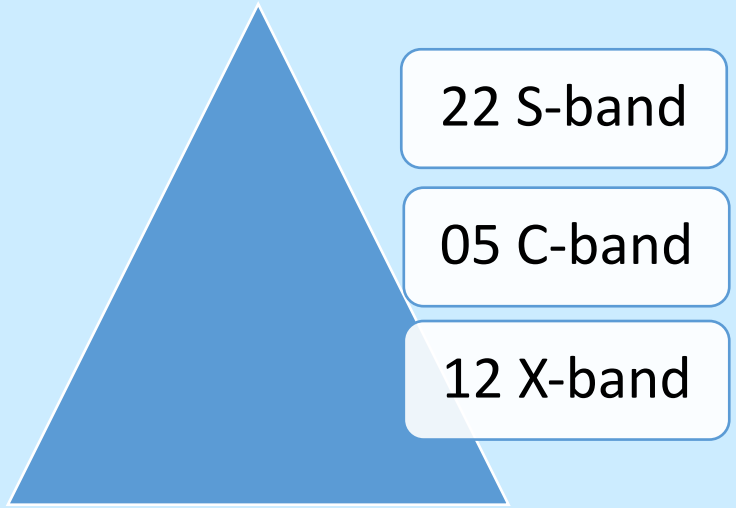




Radar Network



39 DWRs



- **39 Doppler Weather Radars operational in country**
- **Under establishment four radars in northwest India**
- **Proposed 10 Radars in NE States**
- **Proposed 21 Radars in plains of the country**
- **Proposed 6 Radars under Urban Meteorology programme**
- **76 Radars by 2025**

FLASH FLOOD GUIDANCE SERVICES

- IMD (Presently Regional Centre for South Asia) in collaboration with WMO jointly implemented South Asia Flash Flood Guidance System (SAsiaFFGS) project and provides flash flood advisories operationally to National Meteorological & Hydrological Centres in Nepal, Bhutan, Bangladesh Srilanka & India since October 2020.
- Presently, IMD provides location specific Flash Flood guidance advisory up to watershed level (1 lakh watersheds) four times a day.
- Categories of alerts: Threat (6 hr Lead time) & Risk (24 hr Lead time)

National Bulletin

GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT
HYDROMET DIVISION
FLASH FLOOD GUIDANCE CELL

National Flash Flood Guidance Bulletin

DATED: 03-10-2023 TIME OF ISSUE: 1905 IST VALID TILL: 2330 IST

From: India Meteorological Department, New Delhi (Email Id: sasiaffg.imd@gmail.com)

To: RMC Nagpur; RMC Kolkata; MC Raipur, MC Patna, MC Bhubaneshwar, MC Ranchi, MC Gangtok and all concerned FMO's.

Area of Concern (AoC): Few watersheds & neighborhoods of Jharkhand & adjoining Chhattisgarh and Bihar, Odisha, Gangetic West Bengal, and SHWB & Sikkim Met subdivisions.

Diagnostic Guidance: Based on Merged Mean Areal Precipitation at 1730 IST, recorded rainfall is up to 72 mm in last 6 hours and up to 134 mm in last 24 hours over few watersheds and neighborhood of AoC. Land Surface Model shows few nearly saturated watersheds up to 90 to 95 % over Chhattisgarh, Odisha, Gangetic West Bengal and Jharkhand Met subdivisions and up to 60% soil saturation over remaining parts of the country.

Prognostic Guidance: Dynamic Global (GFS) & Mesoscale Model (WRF & NCUM) forecasts very heavy rainfall up to 120 mm in next 24 hours.

Observed Flash Flood Threat (IFFT) till 1730 IST of 03-10-2023 :

Moderate flash flood threat observed over few watersheds & neighbourhoods of following Met Sub-divisions during last 6 hours.

Odisha - Kendujhar and Mayurbhanj districts.
Gangetic West Bengal - Eastmednipur and Pashchim Medinipur districts.

Disclaimer: This is only a guidance bulletin and not a warning for flash floods.
Contact: WMO Regional Centre (SASIAFFGS),
Hydromet Division, Flash Flood Guidance Cell
Phone: 011-43824359/011-43824410
Email: sasiaffg.imd@gmail.com

Regional Bulletin

GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
INDIA METEOROLOGICAL DEPARTMENT
HYDROMET DIVISION
FLASH FLOOD GUIDANCE CELL

South Asia Flash Flood Guidance Bulletin

DATED: 14.07.2023 TIME OF ISSUE: 0820 UTC VALID TILL 1800 UTC

From: India Meteorological Department, New Delhi (Email Id: sasiaffg.imd@gmail.com)

To: All National Meteorological and Hydrological Services (NMHS) – **Nepal, Bhutan,** Bangladesh and Sri Lanka.

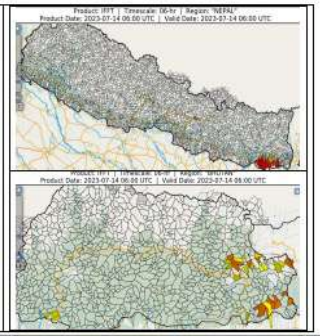
Area of Concern (AoC): **Few watersheds & neighbourhoods of Nepal & Bhutan**

Diagnostic Guidance: Based on Merged Mean Areal Precipitation at 12 UTC, the highest rainfall is up to 166 mm in last 6 hours & up to 221 mm in last 24 hours over watersheds & neighbourhoods of Nepal.
Land Surface Model shows nearly 98% soil saturation over a few watersheds & neighbourhoods of Nepal & Bhutan and 55% soil saturation over remaining parts of the region.
Prognostic Guidance: Dynamic Global (GFS) & Mesoscale Model (WRF & NCUM) forecast rainfall up to 150 mm in next 24 hours over the region.

Observed Flash Flood Threat (IFFT) Till 1200 UTC of 14.07.2023:

Moderate flash flood threat observed over few watersheds & neighbourhoods of Eastern Nepal in last 06 hours.

Low to Moderate flash flood threat observed over few watersheds & neighbourhoods of Eastern Bhutan in last 06 hours.



Regional Guidance Bulletin should be modified by the respective NMHS as per latest meteorological and hydrological conditions.
Disclaimer: This is only a guidance bulletin and not a warning for flash floods.
Contact: WMORegionalCentre (SASIAFFGS),
Hydromet Division, Flash Flood Guidance Cell
Phone: 011-43827359/011-43827410
Email: sasiaffg.imd@gmail.com

Flash Flood Threat	Flash Flood Risk
High Threat (Take Action)	High Risk (Take Action)
Moderate threat (Be Prepared)	Moderate Risk (Be Prepared)
Low Threat (Be Updated)	Low Risk (Be Updated)