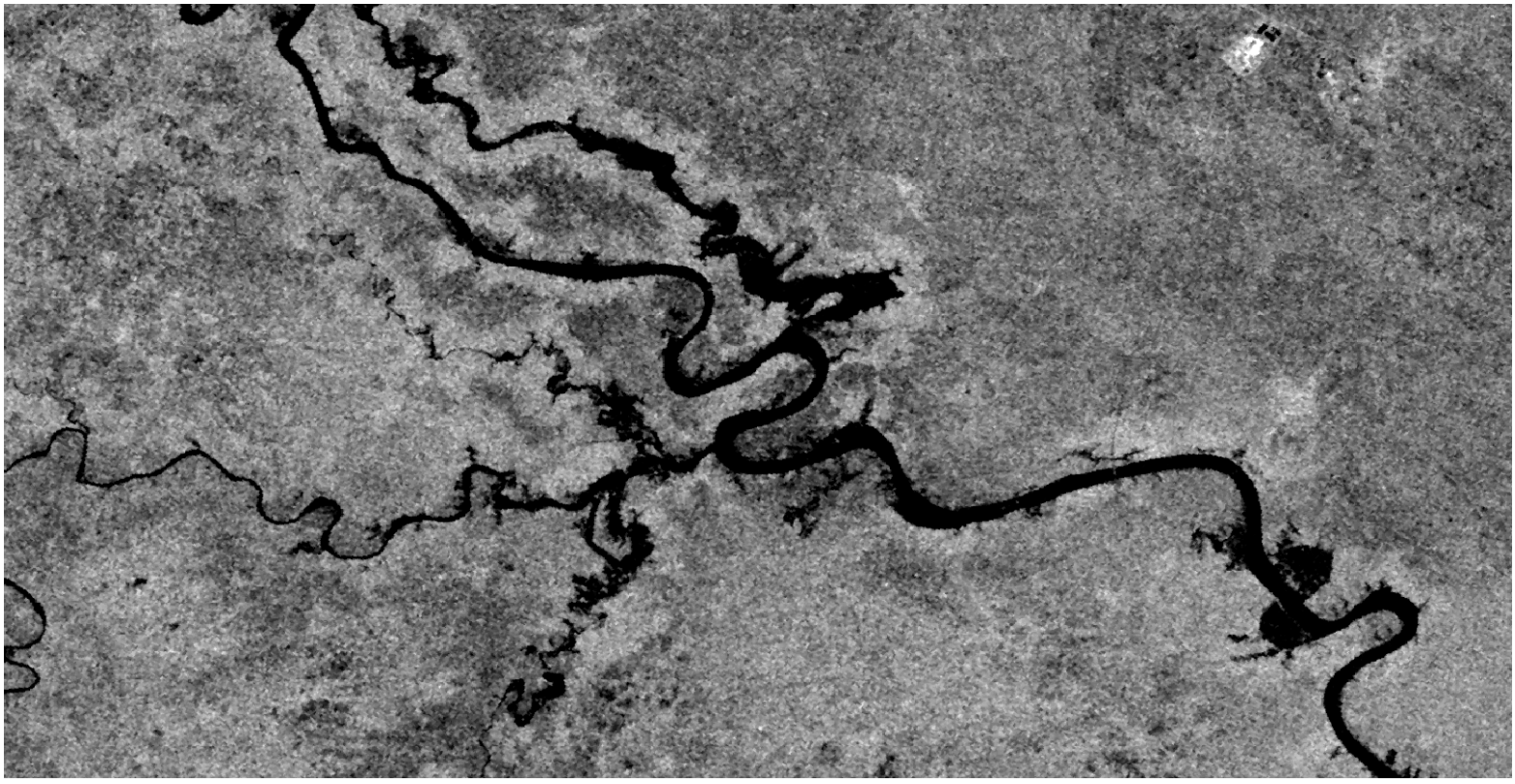
Satellite based Analysis - Flood Mapping & Monitoring in Uttar Pradesh State



Disaster Management Support Group
National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO)
Dept. of Space, Govt. of India , Balanagar, Hyderabad-37, Telangana State, India

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Document Control Sheet

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15.	Abstract:			

Heavy rainfall and heavy runoff during 9-25th, August 2022 in the Ganga River basin has hit Uttar Pradesh State and affected 21 districts in many locations along major river reaches. NRSC has initiated to acquire the satellite data and map & monitor the flood inundation starting from 9th August to 25th August 2022 for providing near real time flood inundation maps to the State and Central Disaster Management Support organizations. Summary of study is provided in this report.

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1. Introduction

Heavy rainfall and heavy runoff during 9-25th, August 2022 in the Ganga River basin has hit the Uttar Pradesh State and affected 21 districts in partial locations along major river reaches. NRSC has initiated to acquire the satellite data and map & monitor the flood inundation starting from 9th August to 25th August 2022 for providing near real time flood inundation maps to the State and Central Disaster Management Support organizations. Summary of study is provided in this report.

2. Spatial Surface Runoff analysis

Runoff Maps (current and one day forecast) of the country is computed using slope corrected curve number grids of different AMC conditions. All India CN grid is prepared using 250 k LULC, Soil Map from NBSS&LUP, and 30m CARTO DEM. Model computes 5 day Antecedent Moisture condition (AMC) condition based on GPM / IMD-GPM Merged/ GEFS (used in order, which is decided based on availability) rainfall source data. GPM/IMD-GPM Merged/GEFS rainfall data is used for current day runoff calculation and GEFS data is used for calculating one day forecast runoff in the country (previous day 8:30AM to current day 8:30 AM rainfall is considered as current day rainfall for example current date is 02-Jan-2018 then rainfall is used from 01-Jan-2018 08:30 AM to 02-Jan-2018 08:30 AM and runoff is calculated accordingly). The spatial surface runoff grids are computed for entire India as part of Disaster Watch report by Flood Modeling Division (FMD) is utilised for computation of overall runoff pattern across the country to assess flood situation. As these are calculated based on satellite based rainfall. National Database for Emergency Management (NDEM) Portal provides daily runoff at 3'x3'grid on daily basis and also one day forest is also provided. The source for the data captured in this report is www. ndem.nrsc.gov.in.

Continuous analysis has been made on daily and cumulative runoff which could result into inflows into Ganga river as shown in Figure.1. Runoff is higher in the range of 100-150mm in many parts of Ganga River Basin.

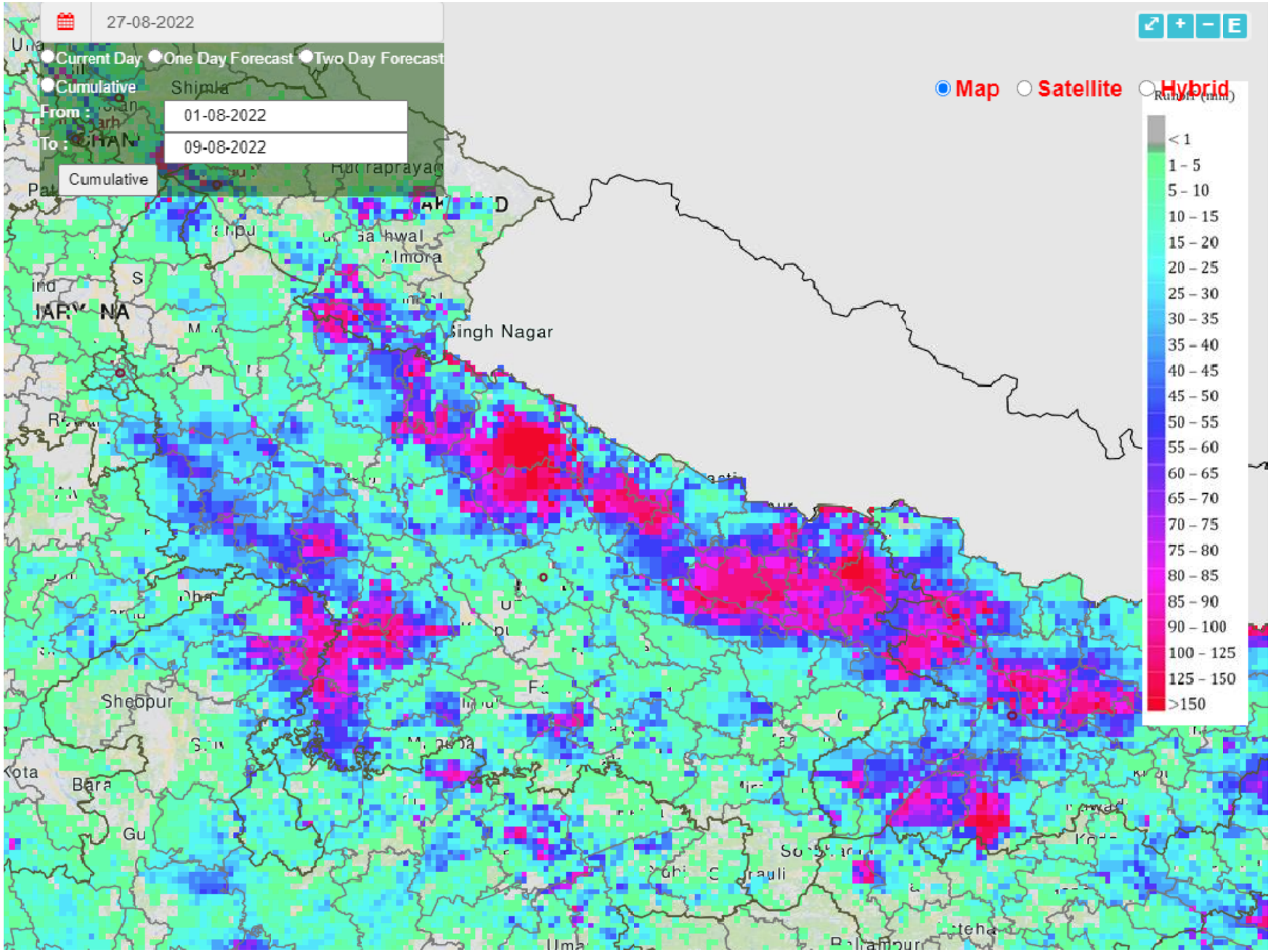

Figure..1. Runoff during 1st - 9th, August 2022 in parts of Uttar Pradesh State (Source : www. ndem.nrsc.gov.in.)

3. Satellite data planning and acquisition

Satellite data acquisition plan has been made based on the indications of flood inundation understood through the rainfall and runoff information at grid levels and also water levels gauge stations. The available satellite data of optical and Microwave SAR sensors have been utilized to the best possible acquisitions from multiple satellites.

3.1. List of Satellite Data Utilized

List of satellite data utilized for the study is listed in Table.1. Resourcesat 2 AWiFS, Sentinel 1A, Radarsat -2, ALOS PALSAR satellite datasets were utilized for large area analytics at district level for generation of flood inundation maps and reporting to the Disaster Management support organizations in near real time.

Table.1. List of satellite data used

S No	Date	Satellite / Sensor
1	09-August-2022	SENTINEL-1A / SAR
2	10-August-2022	Resourcesat-2 AWiFS
3	23-August-2022	SENTINEL-1A / SAR (1800 Hrs)
4	25-August-2022	Radarsat-2 SAR (1800 Hrs IST) & ALOS-2 PALSAR (1100 Hrs IST)

4. Methodology Satellite based Flood Inundation Mapping & Monitoring

Role of space applications in supporting flood disaster management is important, if the information can be provided to disaster management support organizations in near real time. Satellite remote sensing data provides information on spatial flood extent on a continuous basis.

Satellite data can be used at regular intervals for updation of the flood condition on the ground in terms of flood progression, recedence and persistence.

The advantage of using radar data over the optical data is its ability to penetrate cloud cover and also data acquisition during day and night. Water surfaces are generally smooth at radar wavelengths and can be regarded as specular reflectors which yield small backscatter. The surrounding terrain is assumed to be rough at radar wavelengths which exhibits diffuse scattering with moderate backscatter. Hence, water is regarded as low intensity areas whereas the surrounding terrain corresponds to brighter intensities.

Thresholding is the traditional method of detecting flooding in open areas. Intensities below the threshold are regarded as flood or open water, whereas pixels with intensities above the threshold are regarded as dry land. The threshold will depend on the contrast between the land and water classes, and generally needs to be set for each SAR scene. The backscatter depends on the frequency, incidence angle, polarization and is sensitive to the ripples on the water surface induced by wind waves.

Before the onset of flood season, pre-flood satellite data over flood prone states are acquired and analysed. River banklines, permanent water bodies and active river channel are extracted using digitization tools. These datasets and layers will be used as master data sets for further analysis. Detailed steps are as follows. The raw satellite data during floods will be geometrically co-registered with the respective state masters for positional accuracy. These rectified data sets are considered as master data sets for that particular year. Classification is performed to extract water bodies from the image.

In case of optical data, unsupervised classification will be performed giving maximum number of classes and main active river channel, its tributaries and permanent water bodies are classified and converted into vector format. Enhancement techniques are used for increase contrast between the features in the image. On-screen digitization techniques are used for delineation of river banklines from the image in GIS environment and after post editing, the final layer is stored in vector format. In case of microwave data, back scattering image (Sigma nought) is generated and water bodies are extracted using variable threshold technique model. State mask, hill mask, hill shadow mask are applied on the extracted water layer. Further, stray water pixels are separated by grouping and removing them. Flow chart of methodology for pre-flood data preparation is shown in Figure 3 . Flow chart of methodology for flood delineation from satellite data is shown in Figure. 4

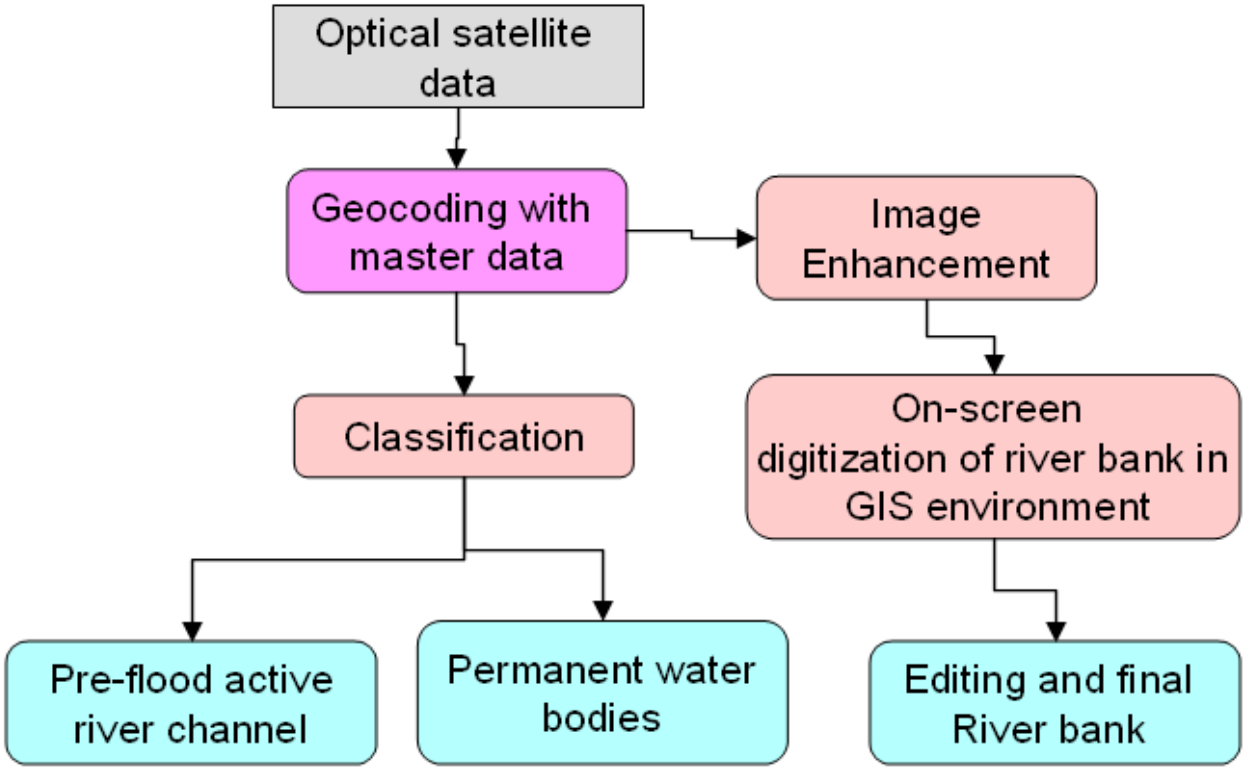

Figure.2. Methodology for Pre-flood data preparation

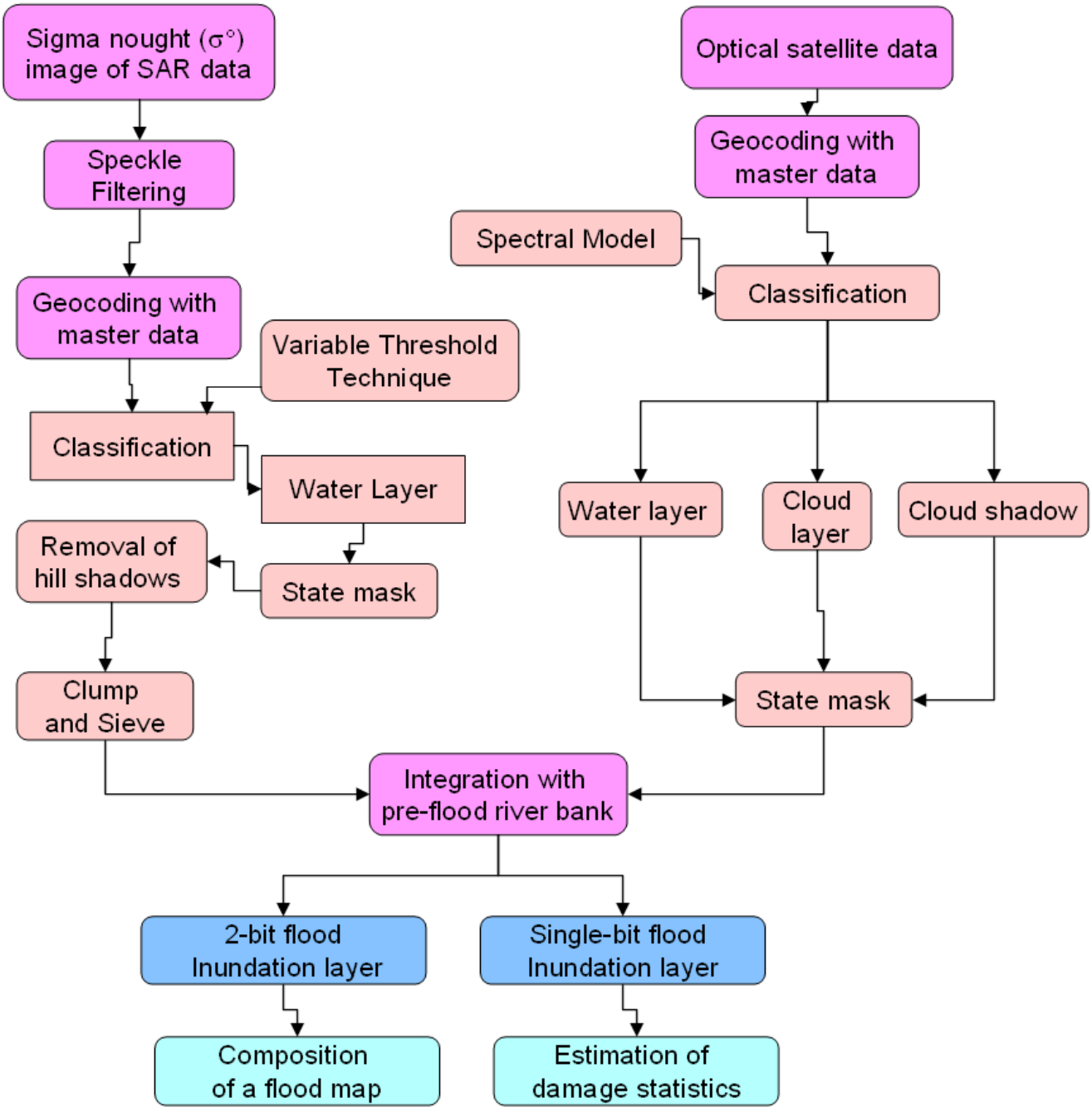

Figure.3. Methodology for flood mapping and monitoring

5. Flood Inundation Mapping and Monitoring

5.1. Analysis of Flood Inundation areas

Flood maps were prepared during 16th-25th August 2022 and 4 maps were sent to disaster management support organizations for supporting flood disaster management. It is observed that the 21 districts are affected due to flood as mentioned in the Table.2. Spatial flood inundation map showing the cumulative flood inundation during 16th-25th August 2022 is shown in Figure. 5 and further district wise flood inundation maps were presented in Page No. 9-14

Table.2. Cumulative Flood Inundation area statistics at district level in Uttar Pradesh State during August 2022

S no	DISTRICT	Area (Ha) under flood inundation
1	BANDA	11355
2	JALAUN	7636
3	FARRUKHABAD	6452
4	BARABANKI	3143
5	AGRA	3004
6	ETAWAH	2924
7	FATEHPUR	2656
8	SITAPUR	2573
9	BALLIA	2425
10	HAMIRPUR	2342
11	KASGANJ	2315
12	GONDA	2039
13	BAHRAICH	1916
14	KANPUR DEHAT	1727
15	CHITRAKOOT	1529
16	AURRAIYA	1352
17	KANPUR NAGAR	1267
18	BADAUN	1235
19	GHAZIPUR	824
20	LAKHIMPUR-KHIRI	752
21	AYODHYA	621
	Total	**60088**

Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022

Note: Standing Water in Low Lying Areas, Moist Areas may also show Signatures similar to Flood Inundation.

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0 25 50 100 150
Kilometers

Legend

- District Boundary
- Inundation
- River/Waterbody

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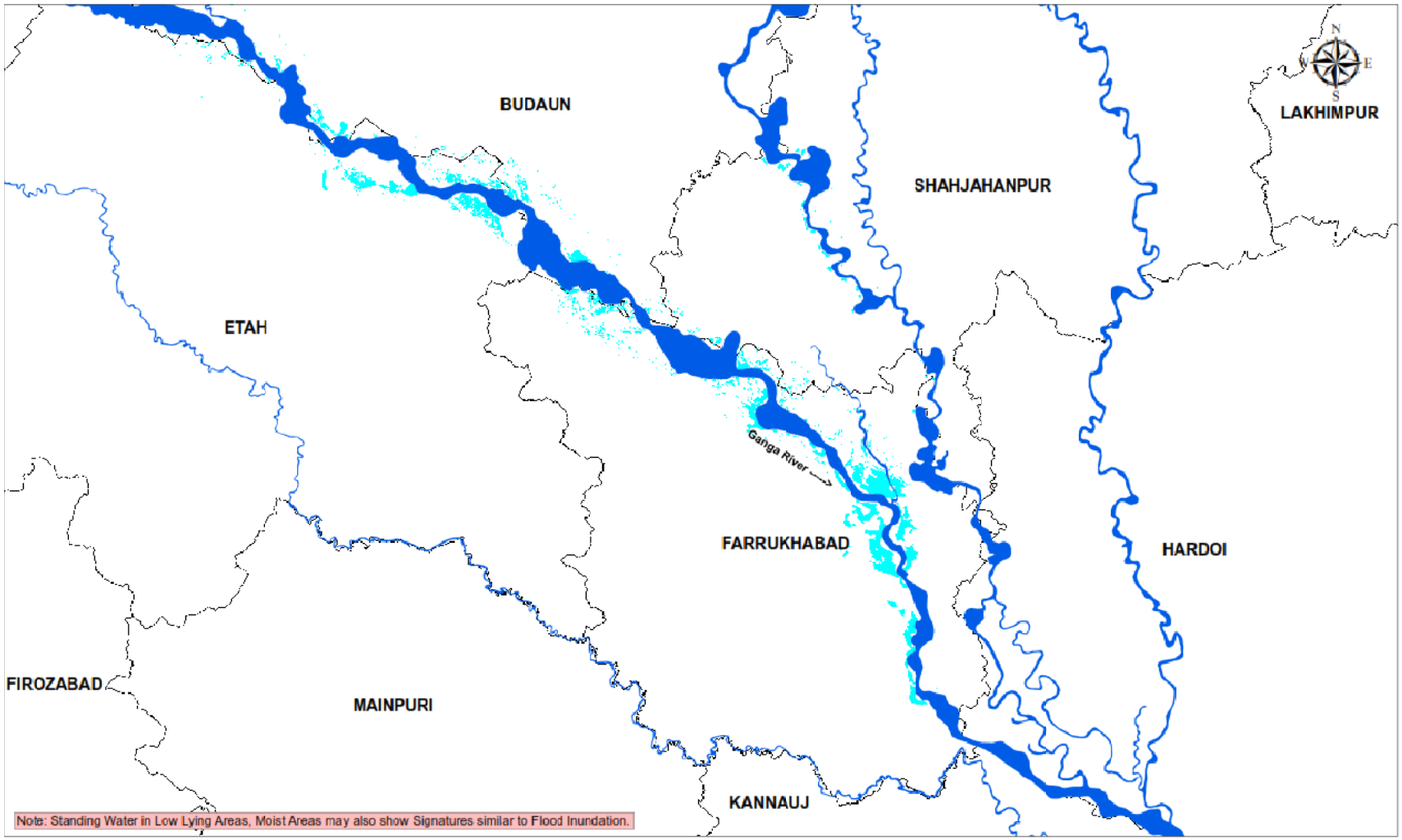
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Etah, Budaun, Farrukhabad Districts)



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0 4 8 16 24
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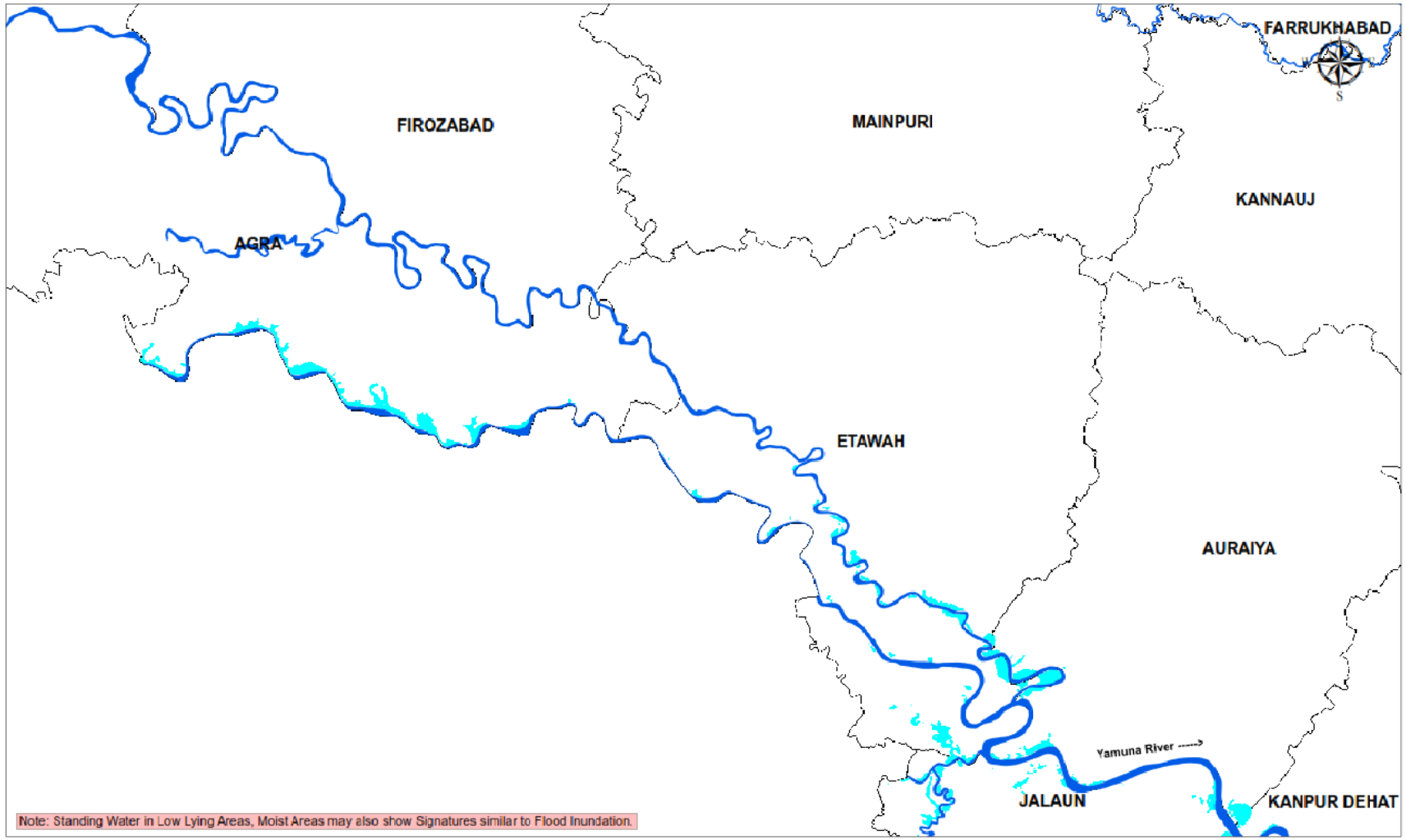
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Agra, Etawah, Auraiya Districts)



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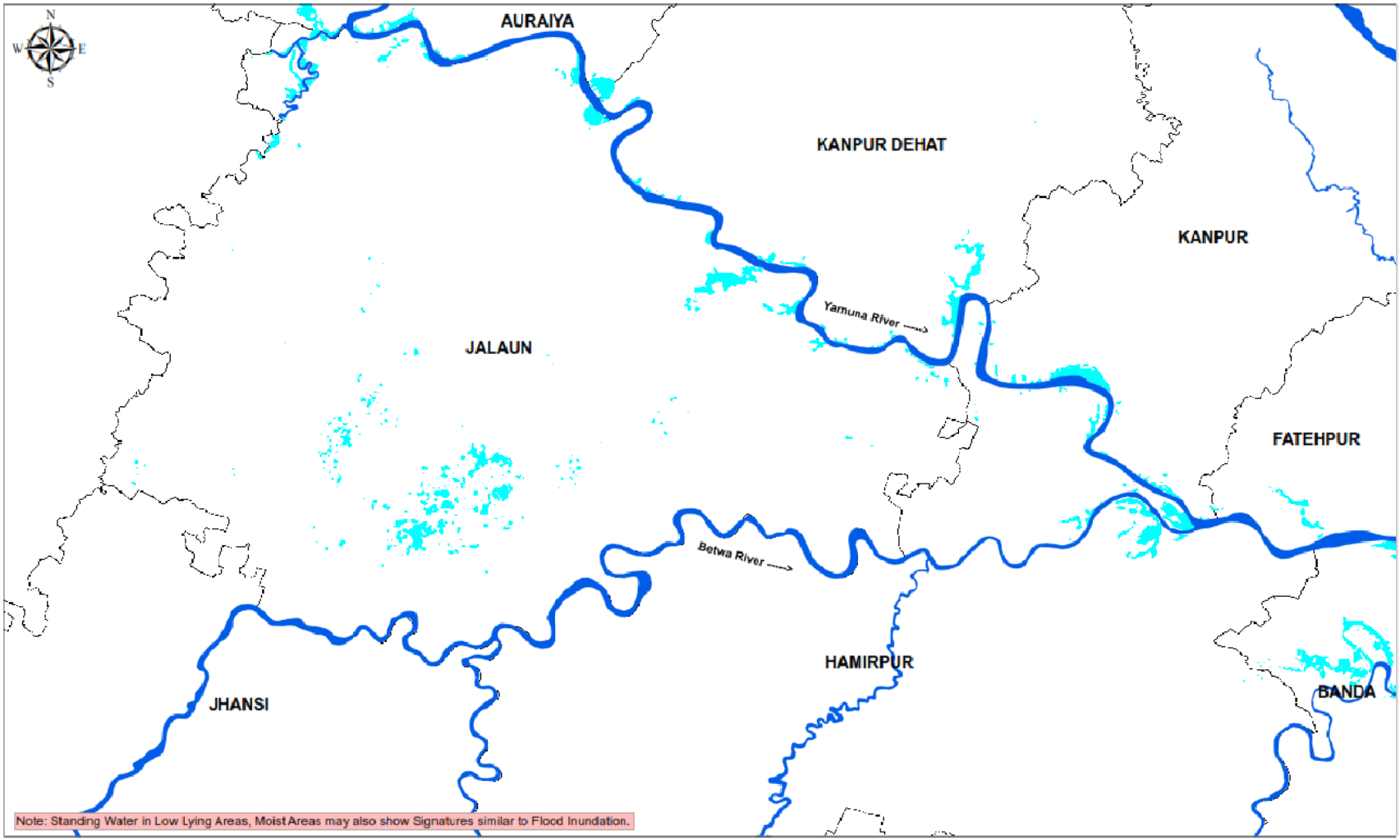
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Jalaun, Kanpur Dehat, Kanpur Districts)



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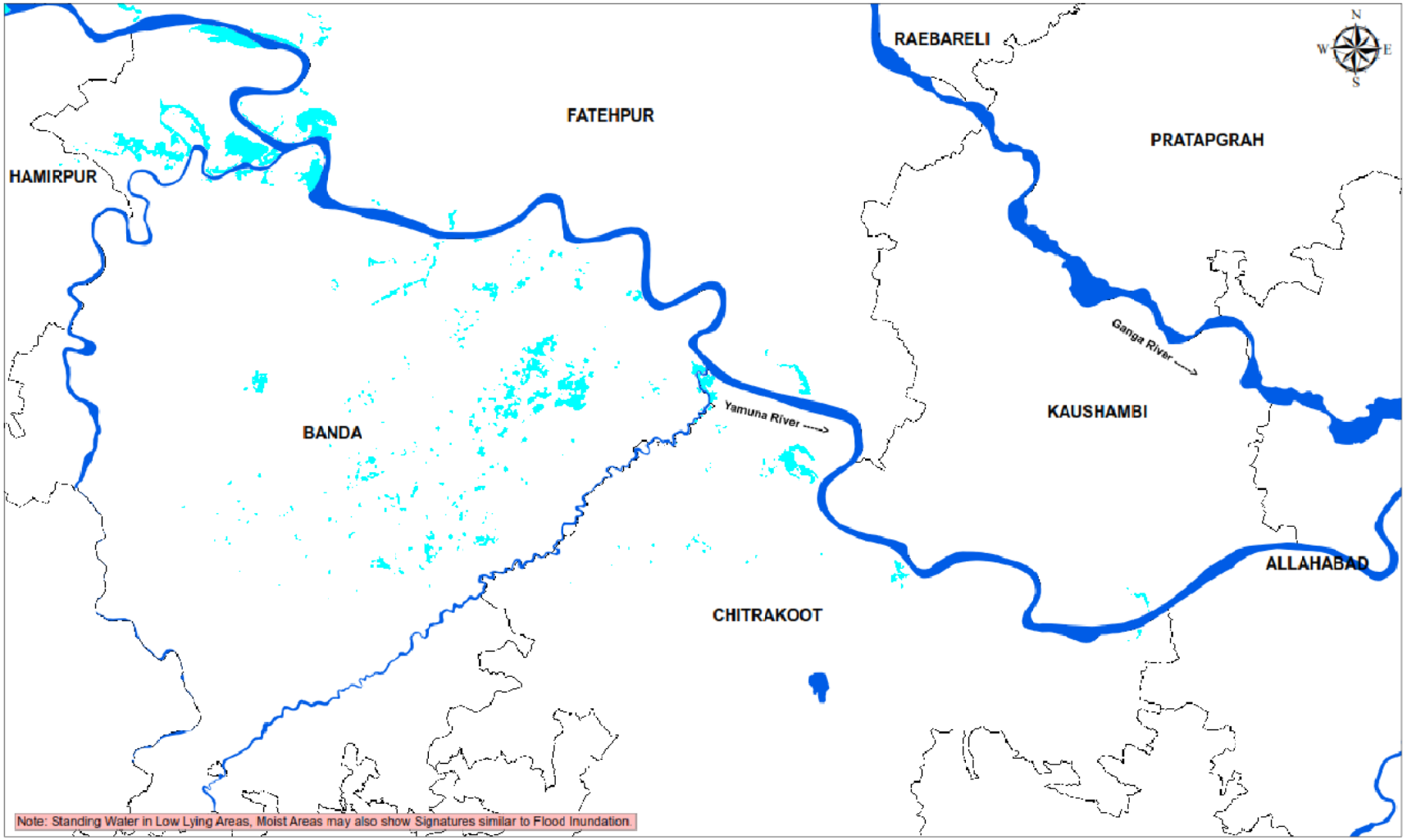
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Banda, Fatehpur, Chitrakoot Districts)



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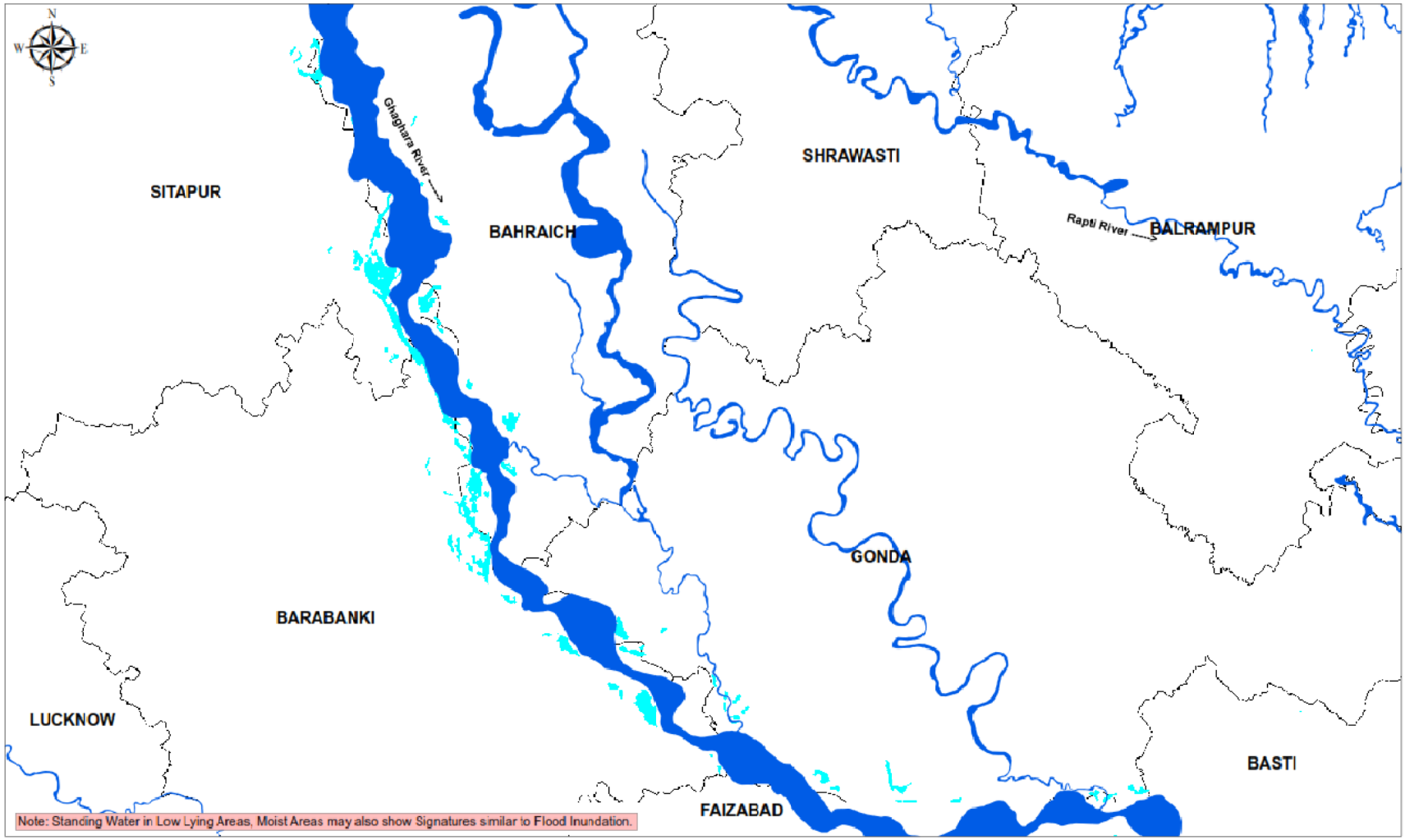
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Sitapur, Bahraich, Barabanki, Gonda Districts)



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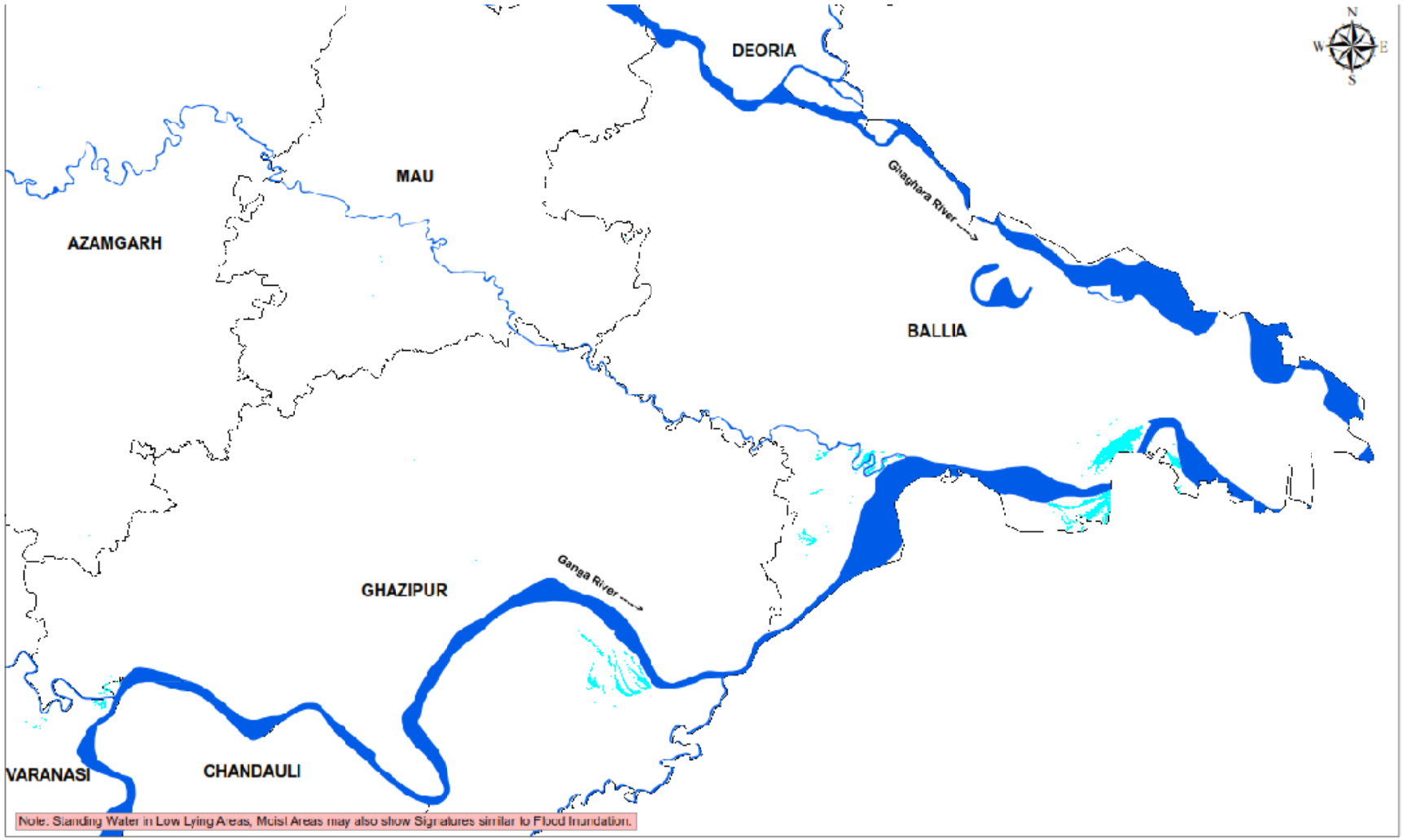
Cumulative Flood Inundation Map Derived from Satellite Data Acquired during 09-Aug-2022 to 25-Aug-2022
(Ballia, Ghazipur Districts)



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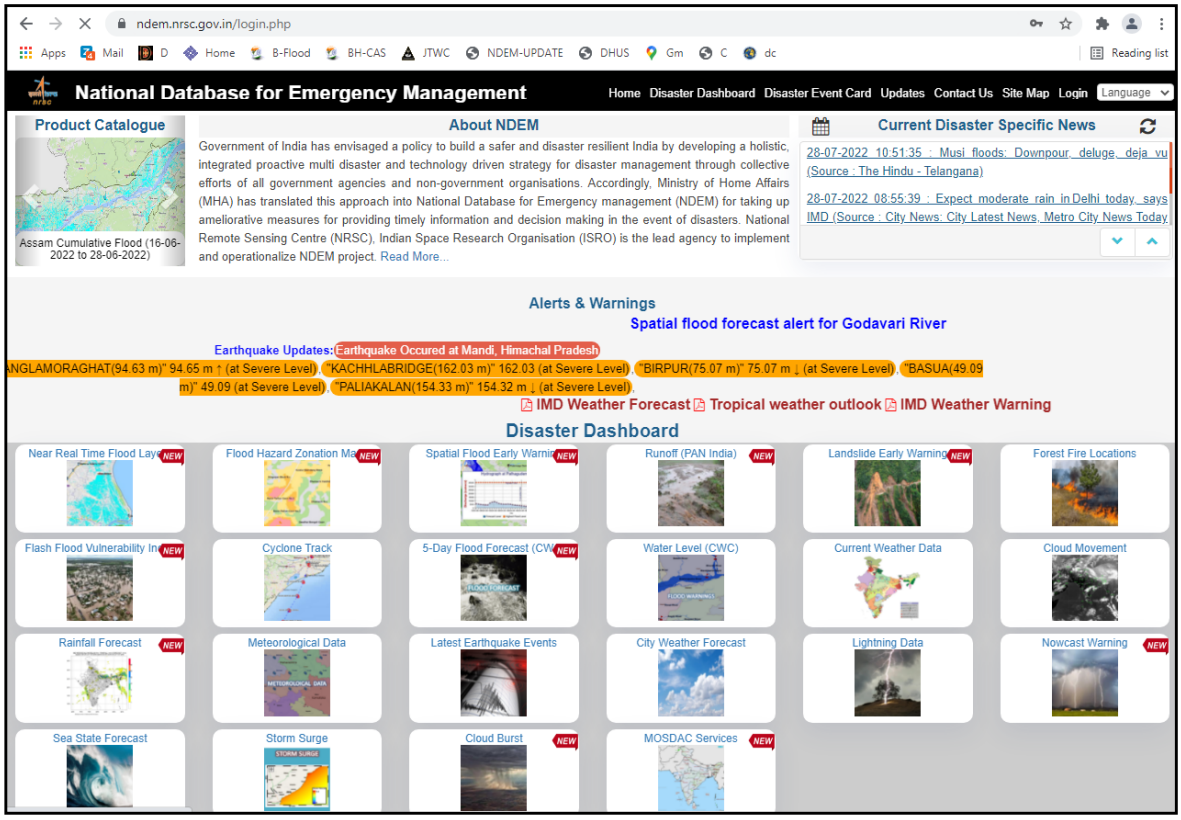
6. Dissemination to State / Central Disaster Management Organisations

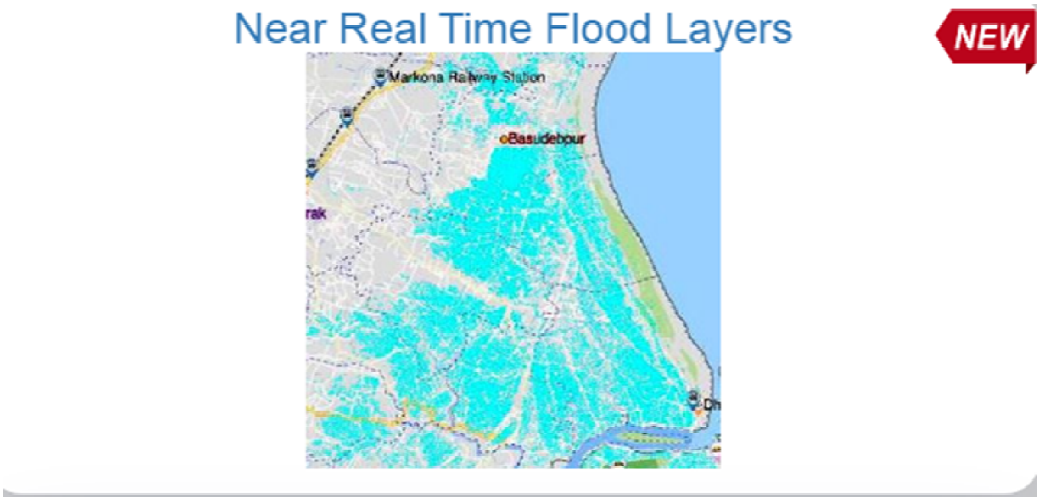
6. 1. Dissemination of Information through NDEM Web Portals

NRSC disseminated the maps and GIS and value added images by uploading GIS layers in National Database for Emergency Management (NDEM) portal for further visualisation of the current and historic flood information along with legacy layers and analytics

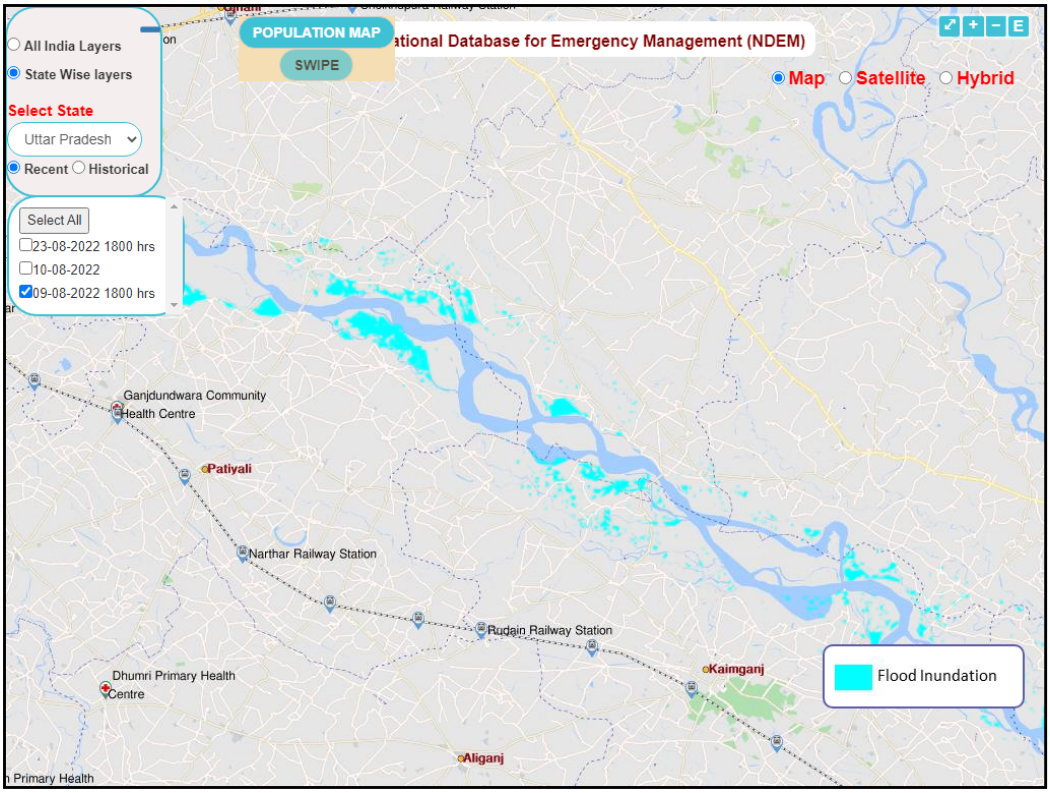
https://ndem.nrsc.gov.in



Click on **Near Real Time Flood Layers**

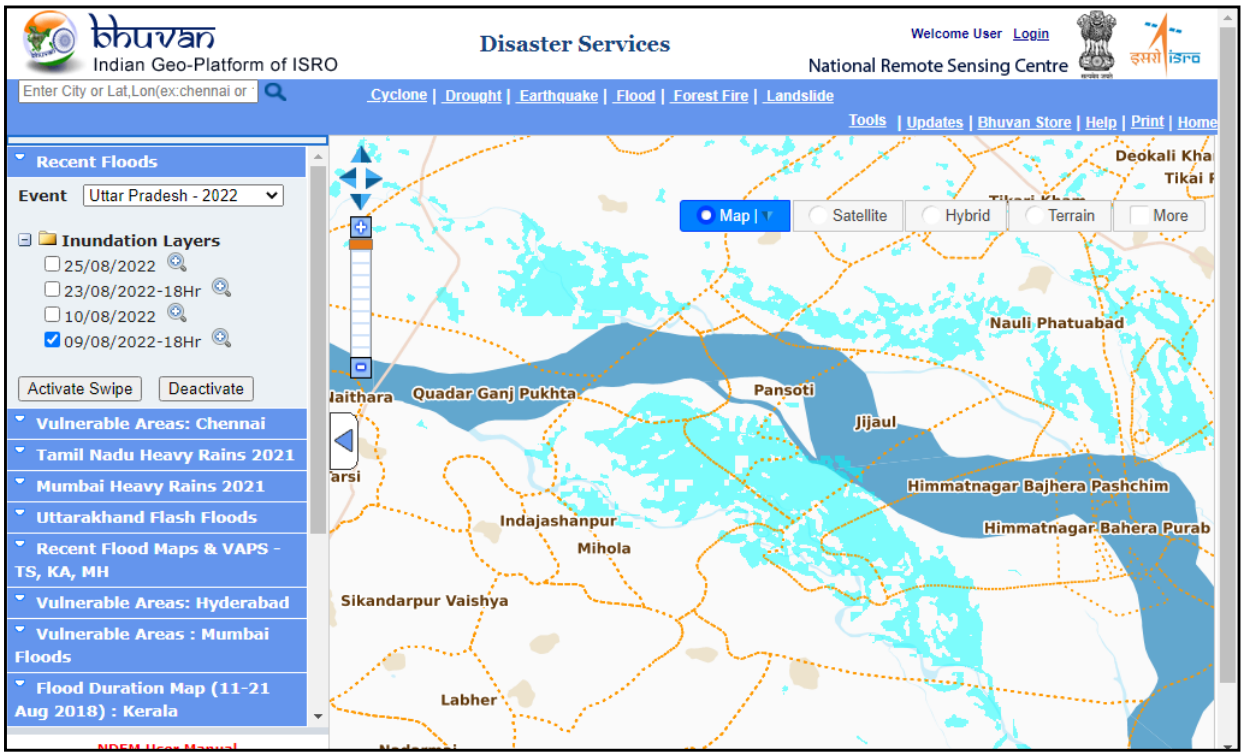


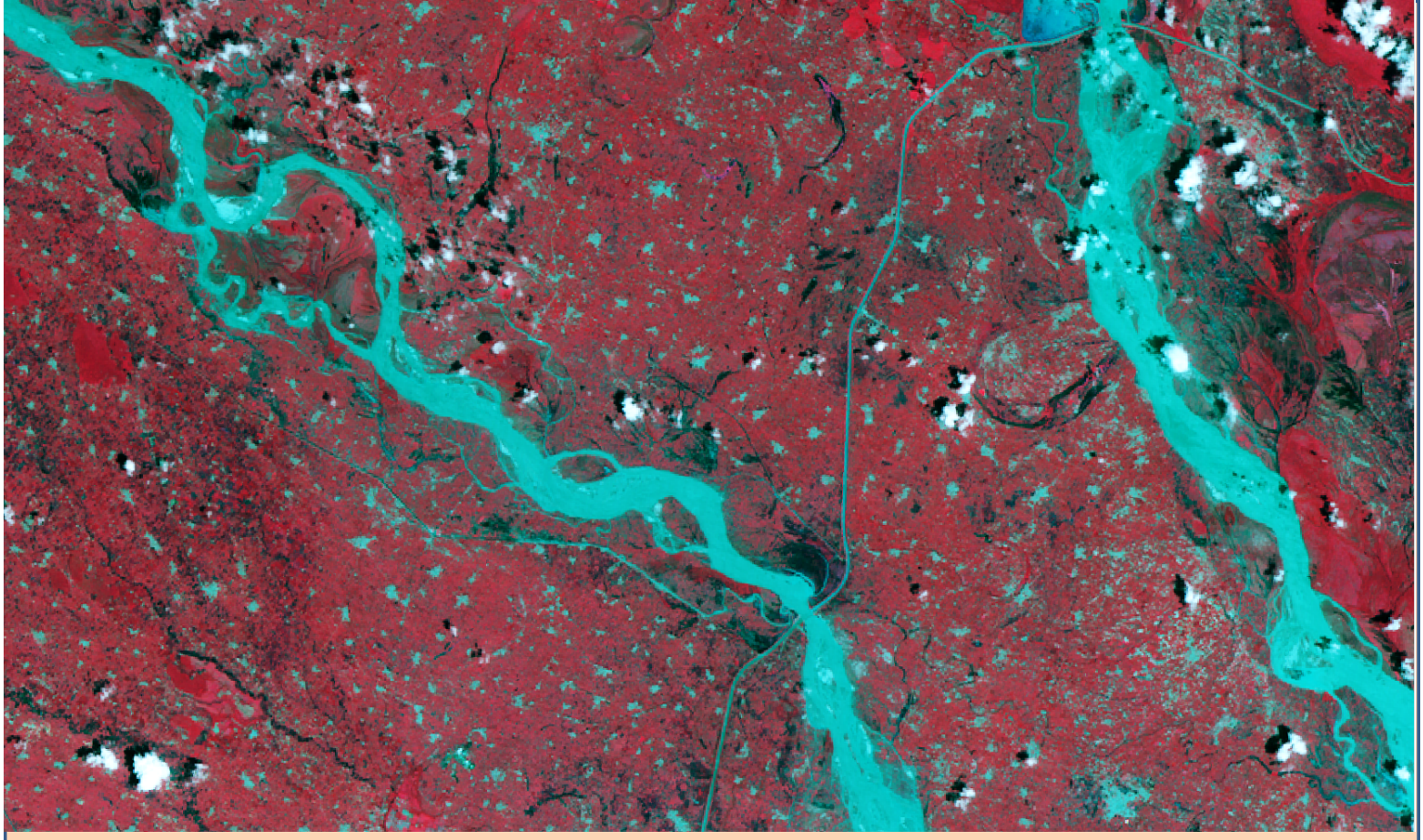
Select the State & Date of flood inundation map to zoom to the area of interest in NDEM Portal



6. 2. Dissemination of Information through Bhuvan Web Portals

Bhuvan Geoportal can be used for visualisation of the flood layers
https://bhuvan-app1.nrsc.gov.in/disaster/disaster.php?id=flood





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