Role of Space Technologies in Disaster Management
ISRO-DMS Programme

Abhinav Shukla

Disaster Management Support Division

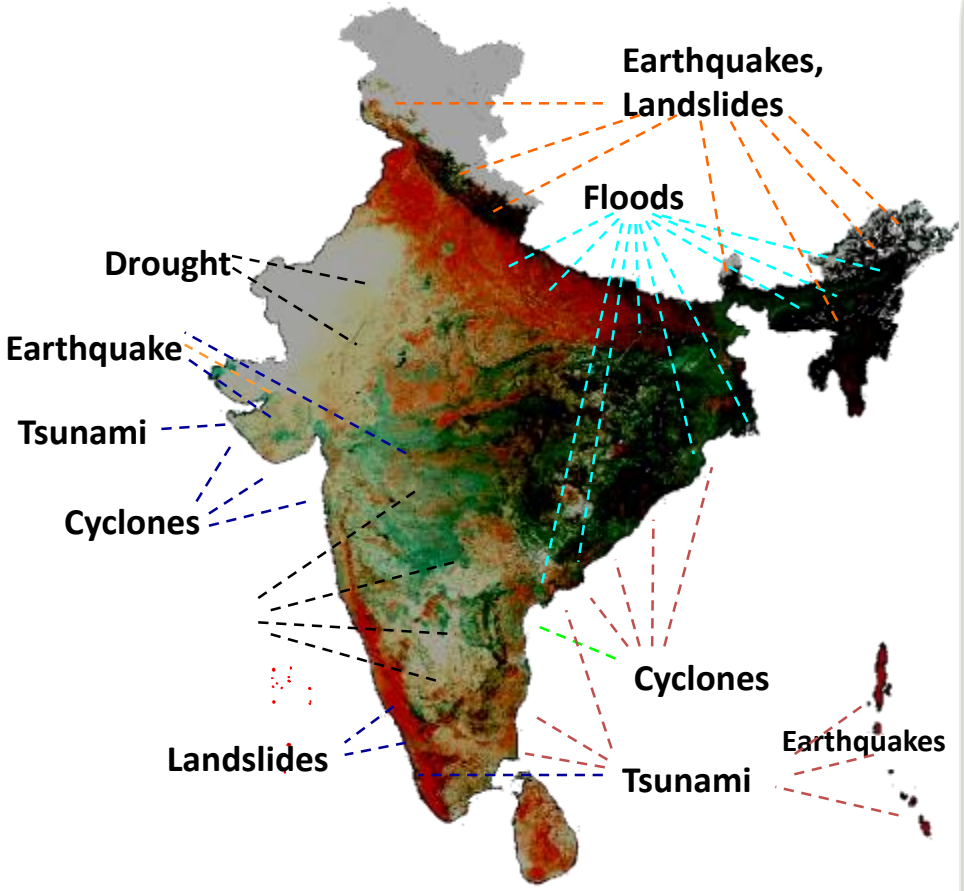
DMSG, RSA

National Remote Sensing Centre, ISRO

Balanagar, Hyderabad

Global Disaster Profile

India and the Disasters



Disaster Risk in the country

- 12% of land area (40 mha) - Flood prone
- 8% of land area (along 5,500 km long coast tract) - Cyclone prone
- Over 65% of land under cultivation - Drought prone
- Around 25% land area - Earthquake prone - Seismic zone IV-V
- Himalayan and Western Ghats region - Landslide prone
- Andaman Nicobar Islands, parts of East Coast, and Gujarat coast – Tsunami

Average Annual Loss

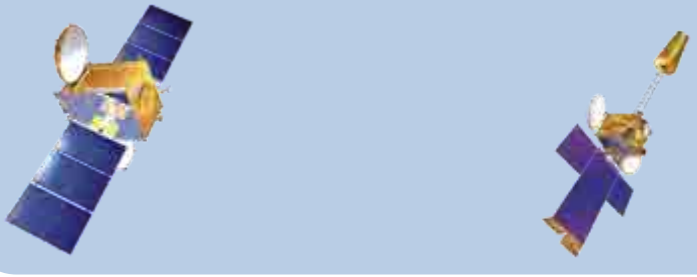
- Direct: Loss of life: 4350 ; Crop area affected: 1.42 Mha; Houses damaged: 2.36 M; Direct loss: 2 % of the GDP (Rs. 25000 Cr)
- Indirect: Expenses on emergency response and relief ; diversion of developmental fund; Indirect socio-psychological losses that can not be quantified

Space and Ground Assets for DRR

Communication Satellites

- **15 Operational**

  INSAT- 4A, 4B, 4CR
  GSAT-6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18 & 19



Earth Observation Satellites

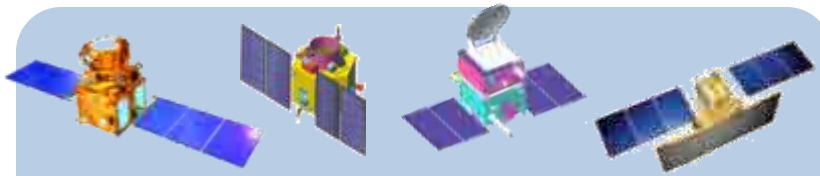
- **Three in Geostationary orbit**

  Kalpana, INSAT-3D& INSAT-3DR

- **13 in Sun-synchronous orbit**

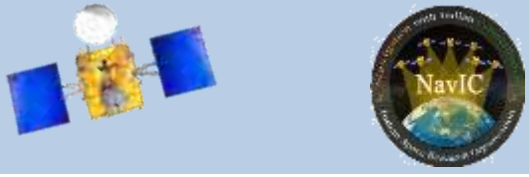
  RESOURCESAT- 2, 2A; CARTOSAT-1, CARTOSAT-2 series (6 Nos.), OCEANSAT-2, MEGHA-TROPIQUES, SARAL, SCATSAT-1

- **Data from RADARSAT, Sentinel etc**



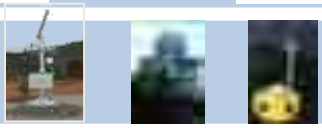
Navigation Satellites (NavIC)

- **Full Constellation of 7 satellites realized**



Aerial Platforms

Insitu Observations



Decision Support Centre, NRSC-ISRO

ISRO Disaster Management Support (DMS) Programme established Decision Support Centre (DSC) at National Remote Sensing Centre (NRSC), ISRO as a delivery point for space and aerial enabled inputs for disaster management

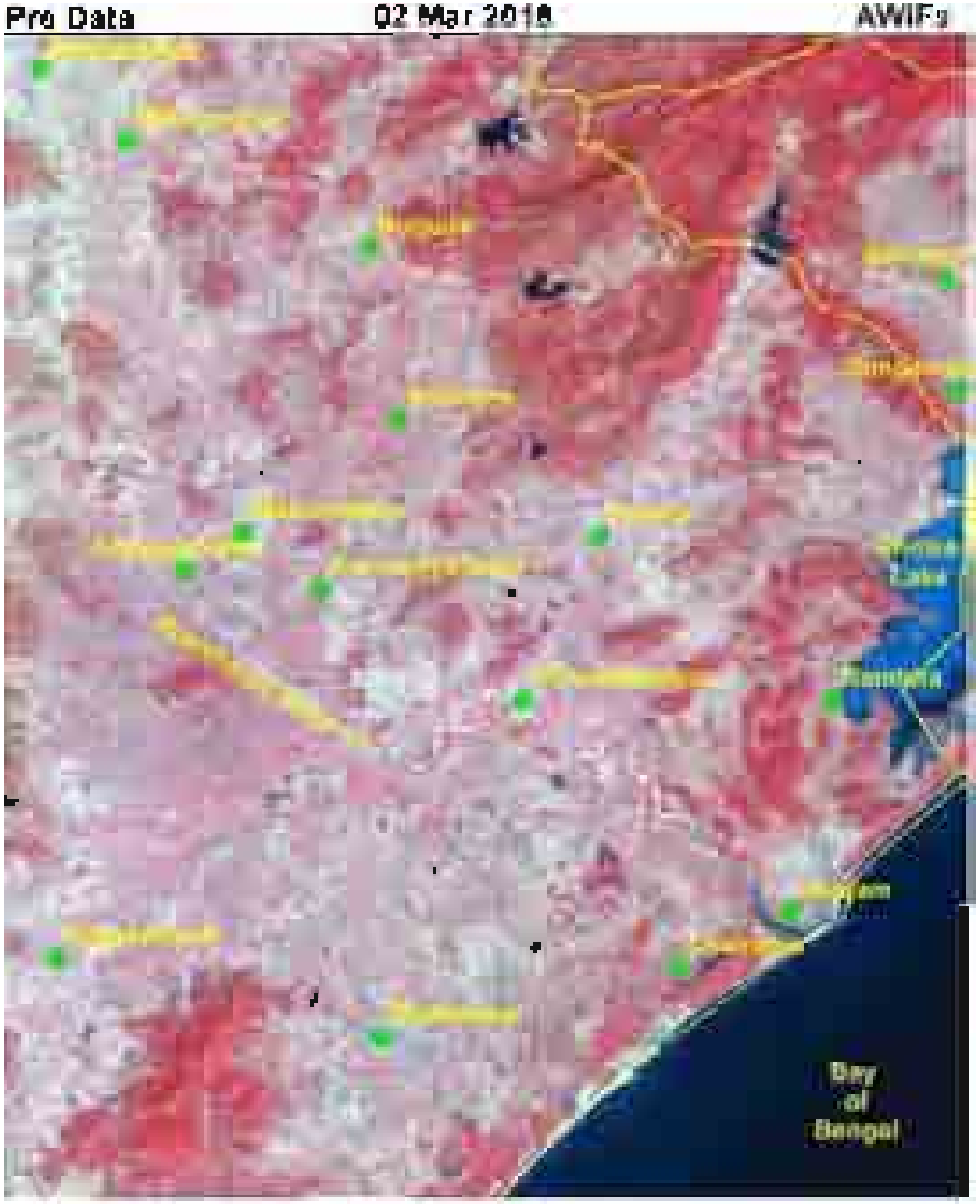
Major Activities

- Near real time monitoring of disasters (floods, cyclones, forest fires, landslides, earthquakes)
- Generation of vulnerability and hazard zonation maps and provide information for planning disaster mitigation measures.
- Provides comprehensive disaster specific multi-scale database through NDEM
- Providing inputs to MHA, NDMA, CWC, IMD, Central & SDMA
- Disaster Early Warning
- Capacity Building
- Sentinel and Charter activities

WHY SPACE BASED OBSERVATION ??

States	No. of districts Inundated
Andhra Pradesh	4
Assam	34
Bihar	34
Delhi	1
Gujarat	6
Haryana	5
Karnataka	20
Kerala	7
Madhya Pradesh	2
Maharashtra	3
Odisha	4
Punjab	15
Uttar Pradesh	33
West Bengal	3

Title Cyclone : Ganjam District

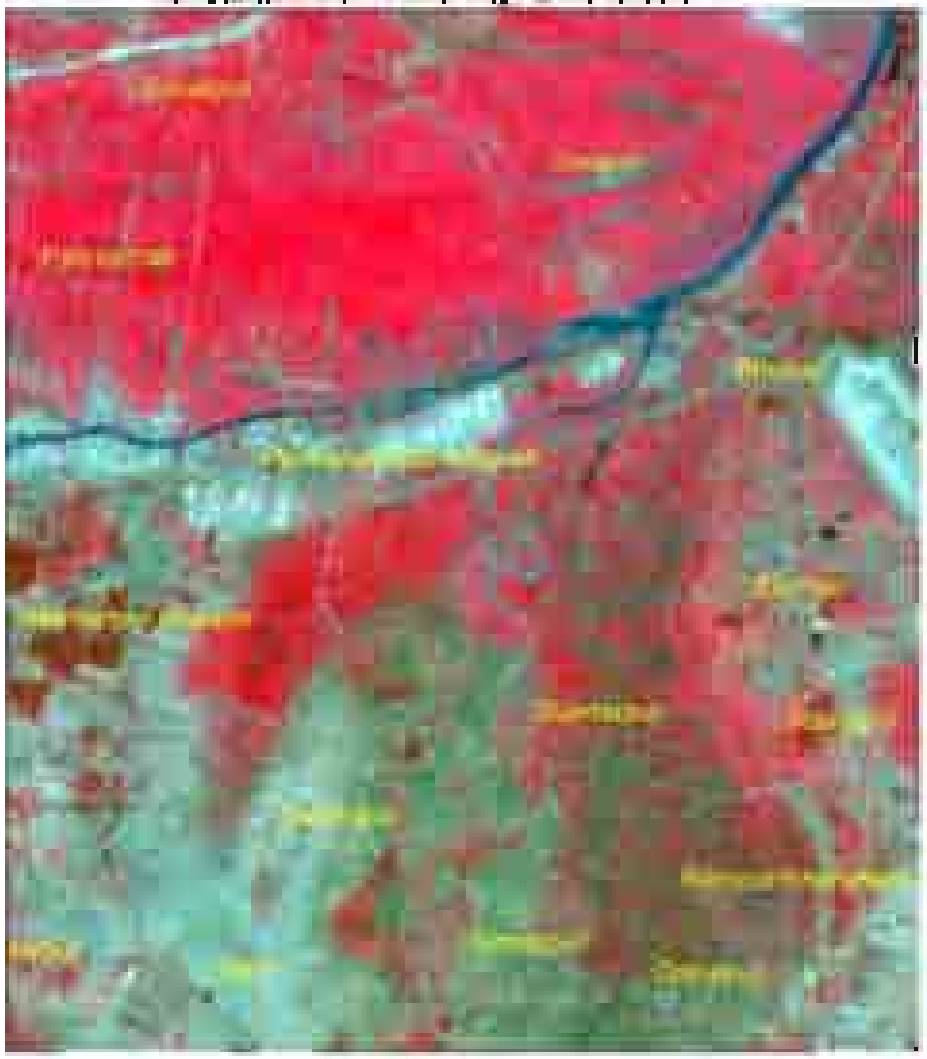


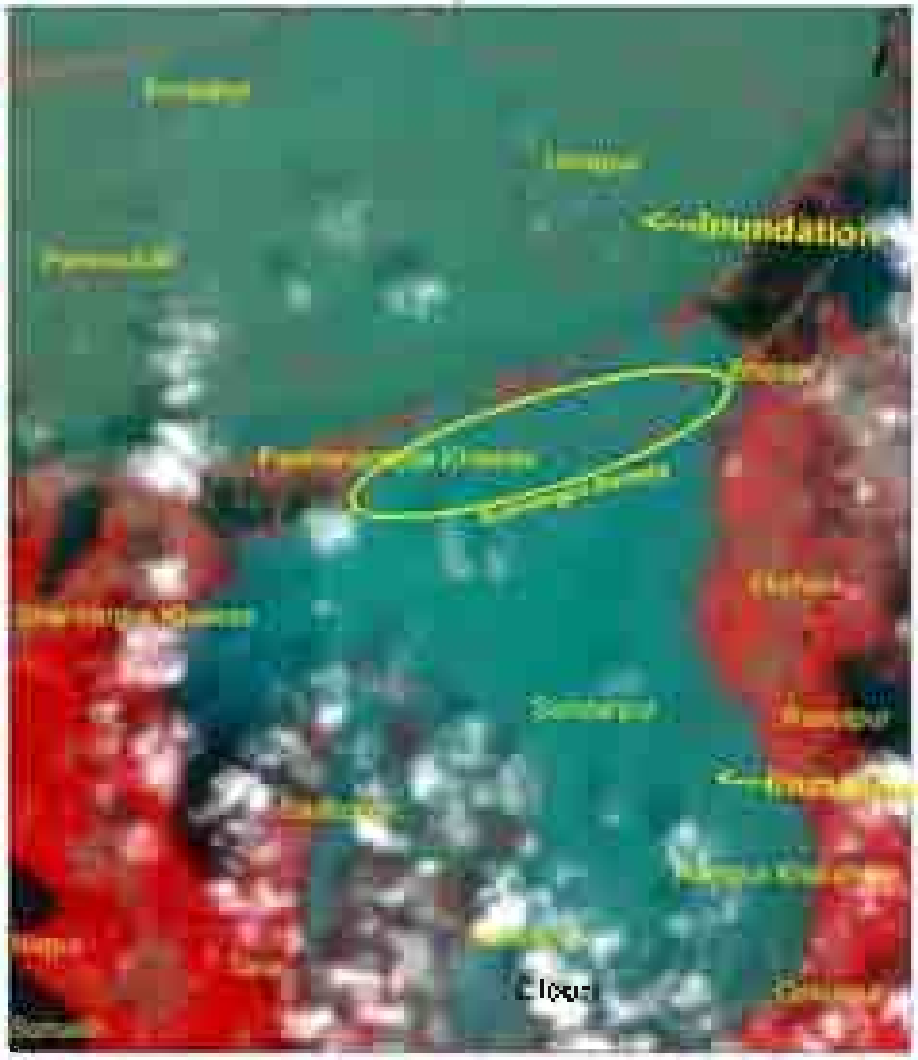
Flood Inundated areas in part of Bihar State

Flood Inundation in part of Bhagalpur District, Bihar State

Pre Flood

Post Flood



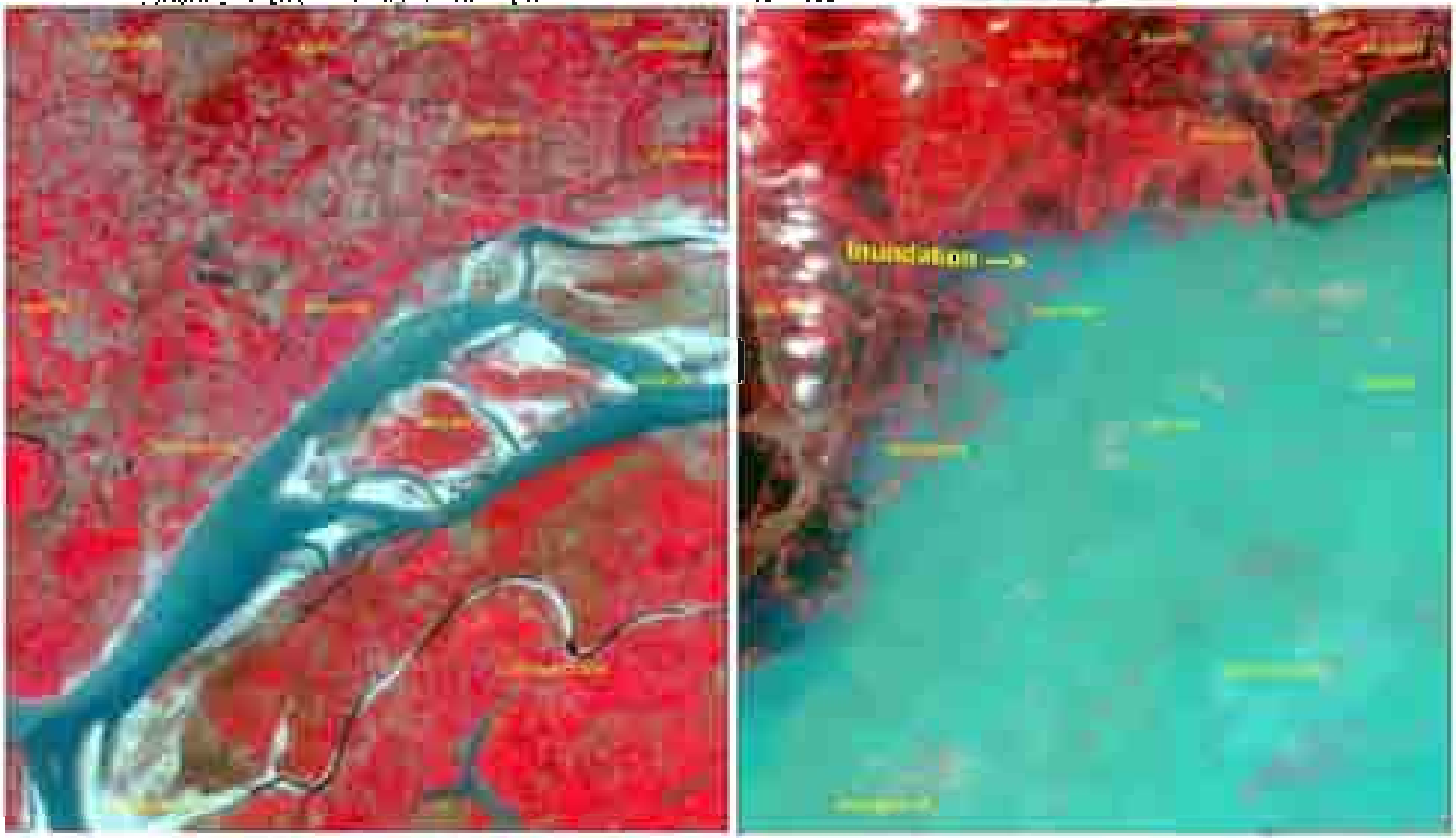


NRSC

Flood Inundation in part of Katihar District, Bihar State

Pre Flood

Post Flood



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USGS

Flood Inundation in Part of Dhemaji District, Assam State

Legend

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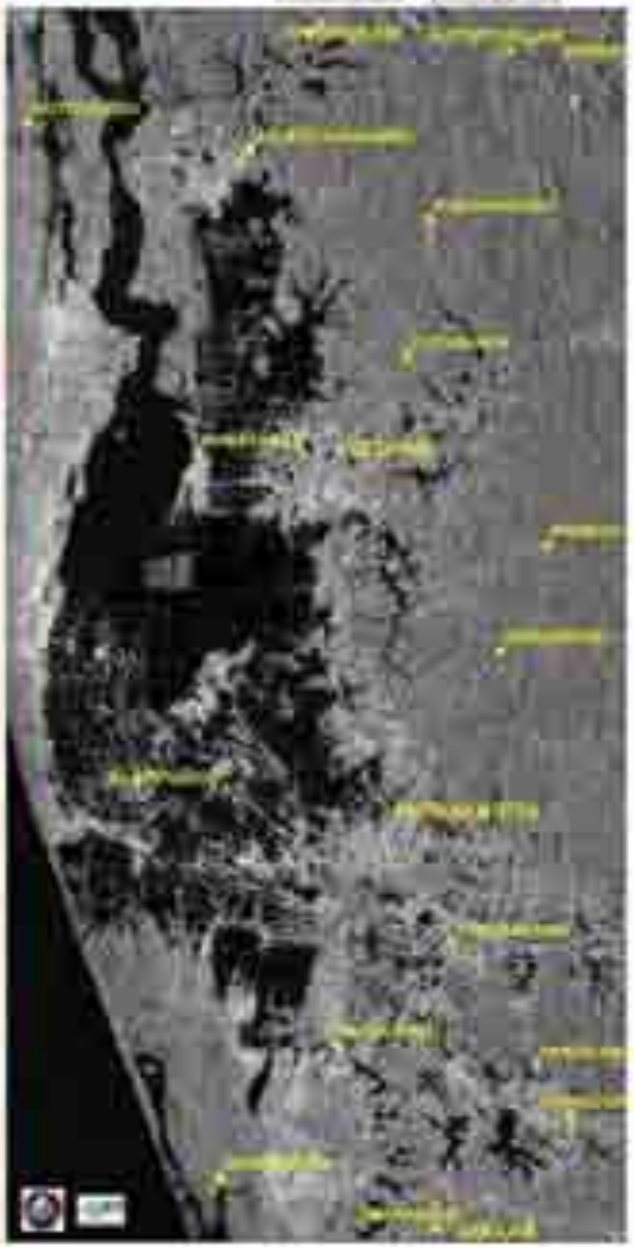
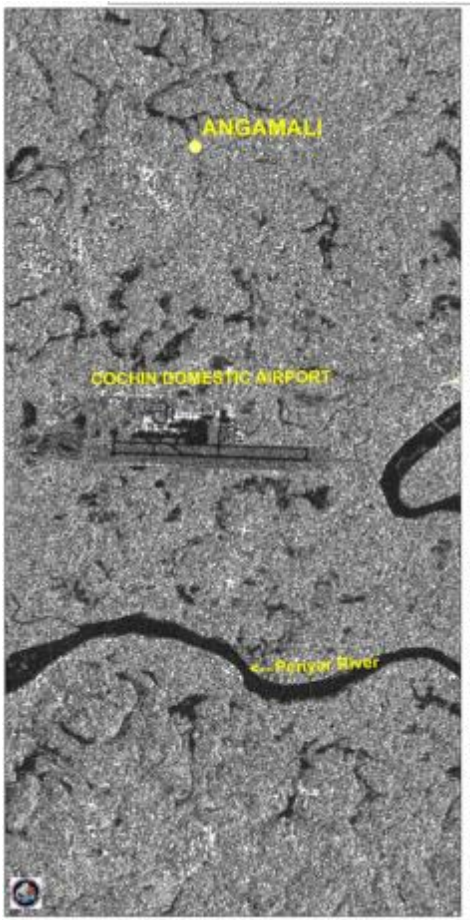
KERALA FLOODS-2018



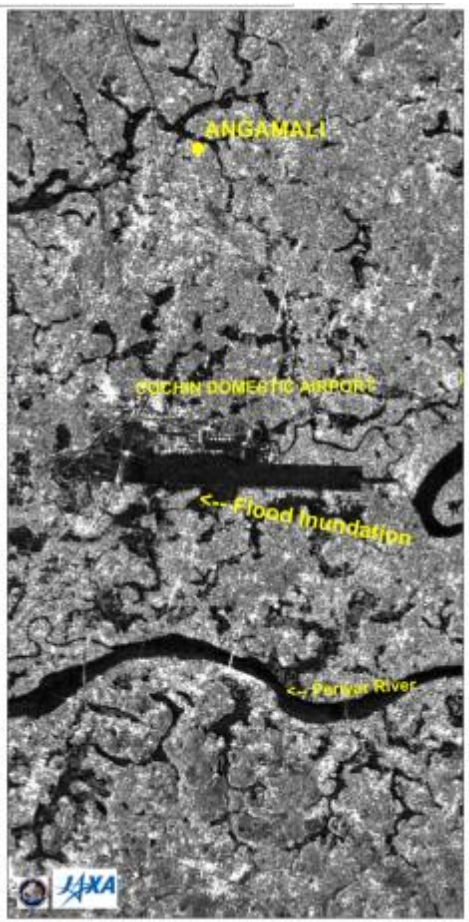
Pre-Flood : Resourcesat-2A LISS 3 Image
Date : 08-Mar-2018

Post-Flood : ALOS PALSAR-2 Image
Date : 17-Aug-2018

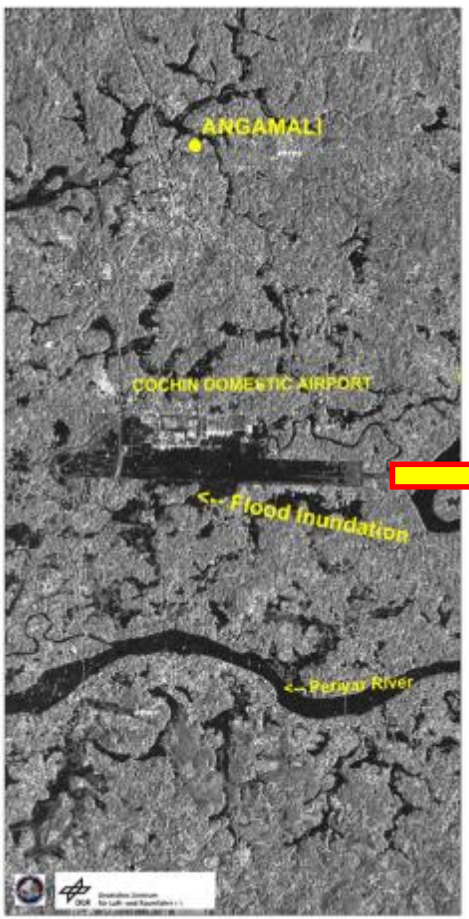
KERALA FLOODS-2018
FLOODING IN COCHIN AIRPORT AND ITS SURROUNDINGS



Pre-Flood : Sentinel- 1A SAR Image
Date : 09-May-2018

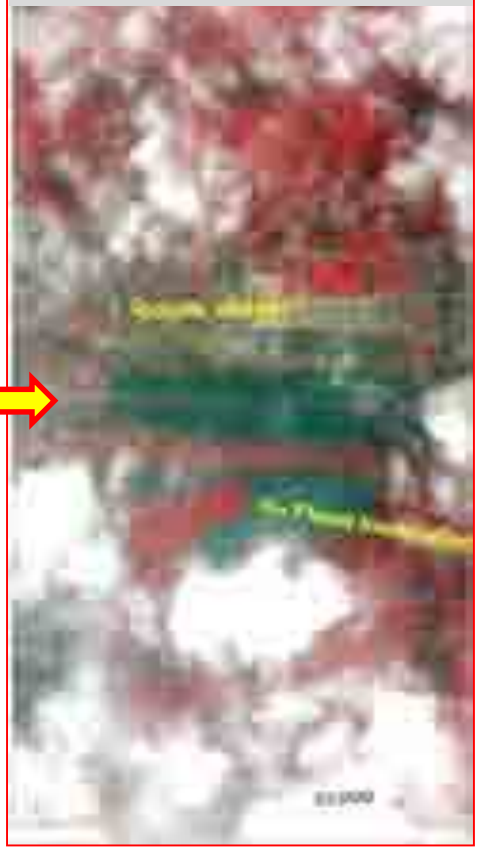


Post-Flood : ALOS PALSAR-2 Image
Date : 17-Aug-2018



Post-Flood : TERRA SAR –X Image
Date : 18-Aug-2018

Enlarged View of Cochin Airport as On Aug 19, 2018

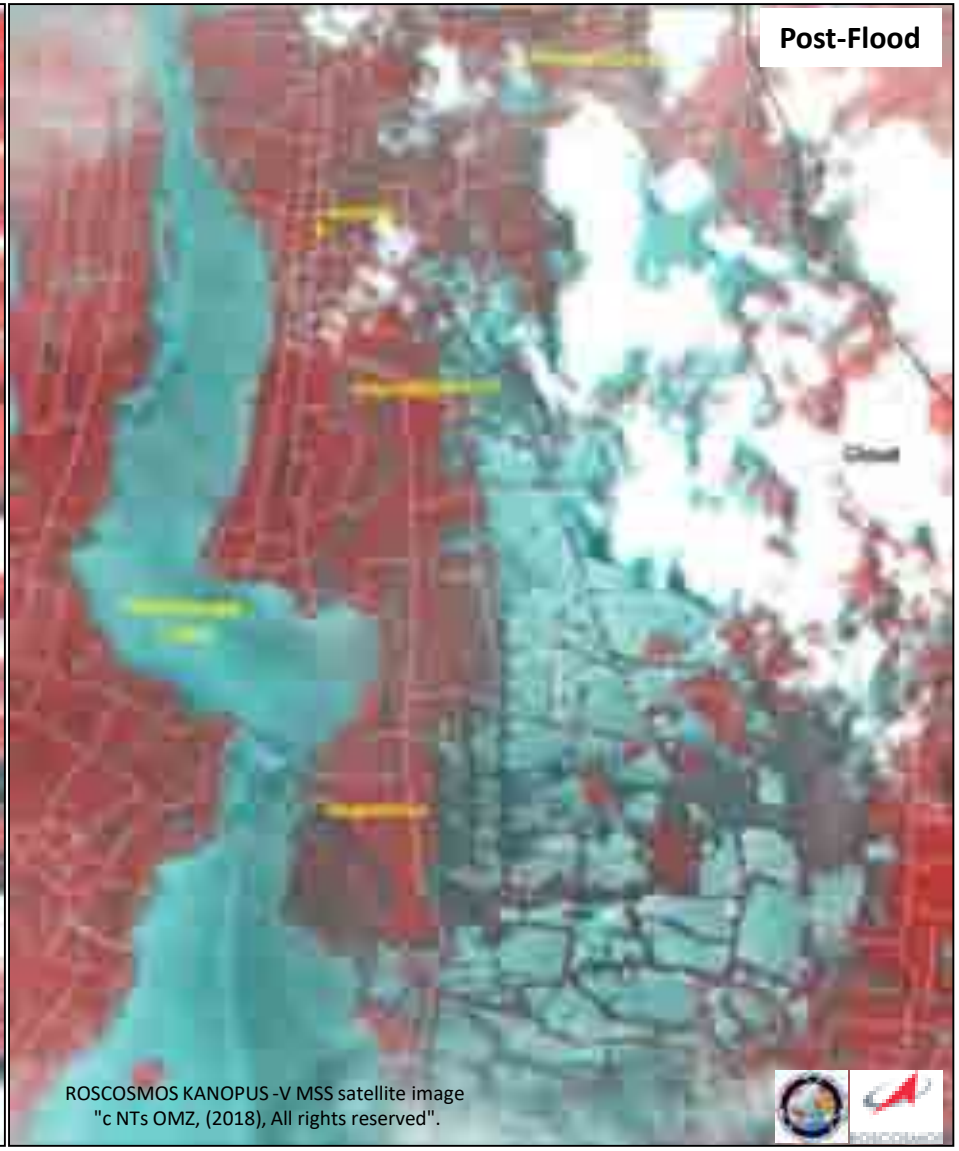


Post-Flood : CARTOSAT-2E Image
Date : 19-Aug-2018

KERALA FLOODS-2018

Resourcesat-2A LISS III Image of 08-Mar-2018

ROSCOSMOS KANOPUS V Image of 19-Aug-2018



Flood Response- Products

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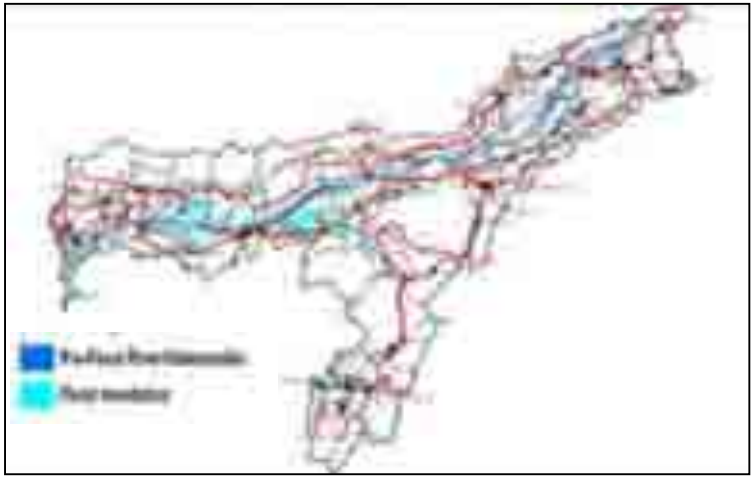
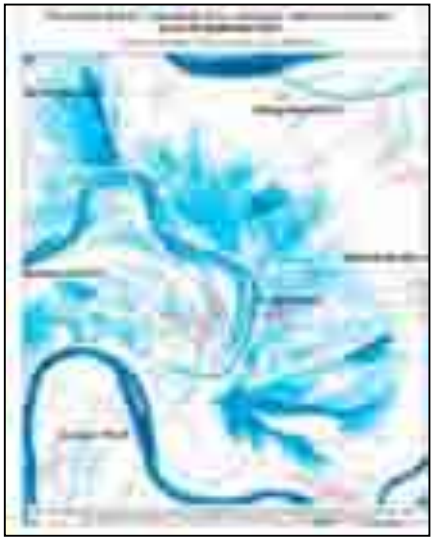
State-Level Flood Map



District-Level Flood Map

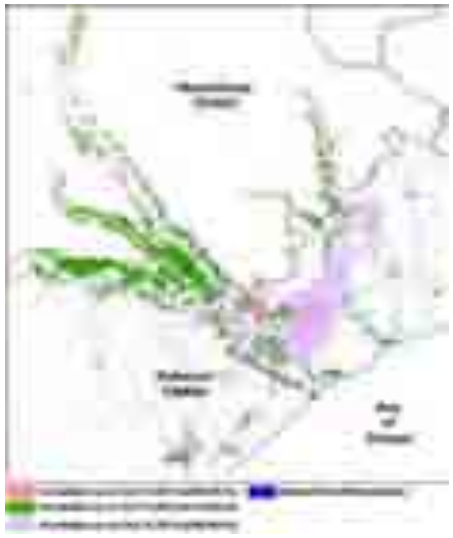
Detailed Flood Map

Flood Depth Maps

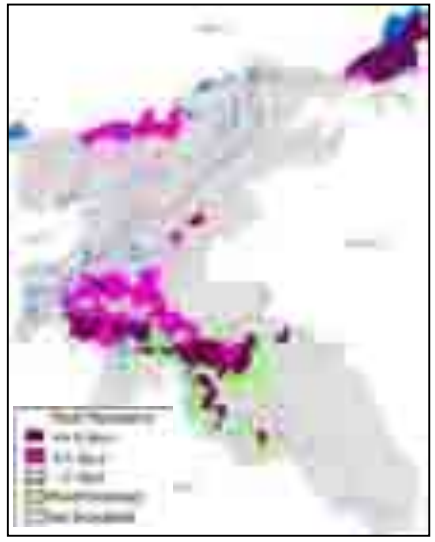


Cumulative Flood Maps

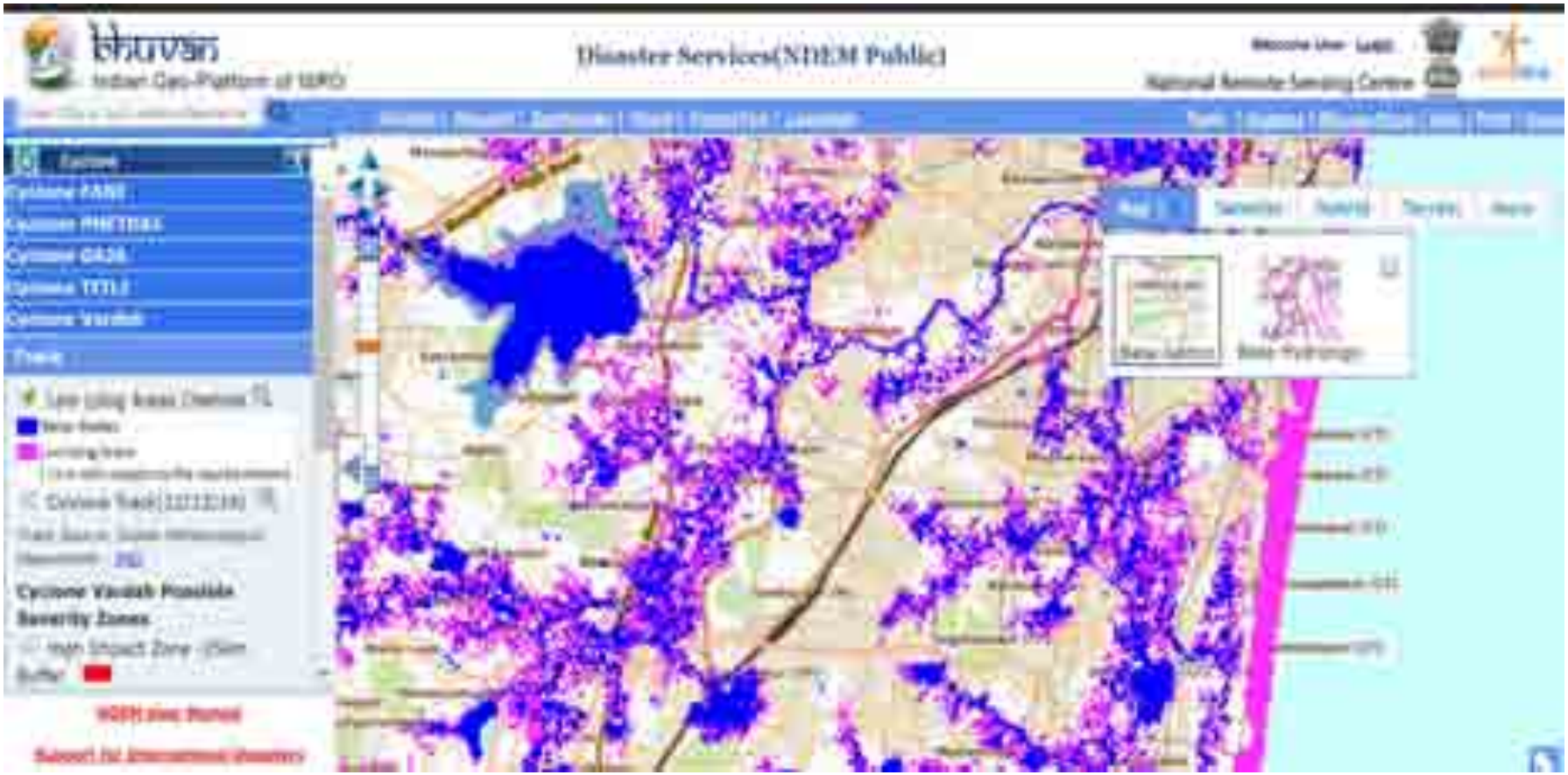
Flood Progr/Recess Maps



Flood Persistence Maps



Identification of Low Lying Areas



Using HAND model, low lying areas in Chennai were identified from a DEM. Areas within 2 metre height from the nearest drainage are located.

http://bhuvan-noeda.nrsc.gov.in/disaster/disaster/disaster.php

Crowd Sourcing

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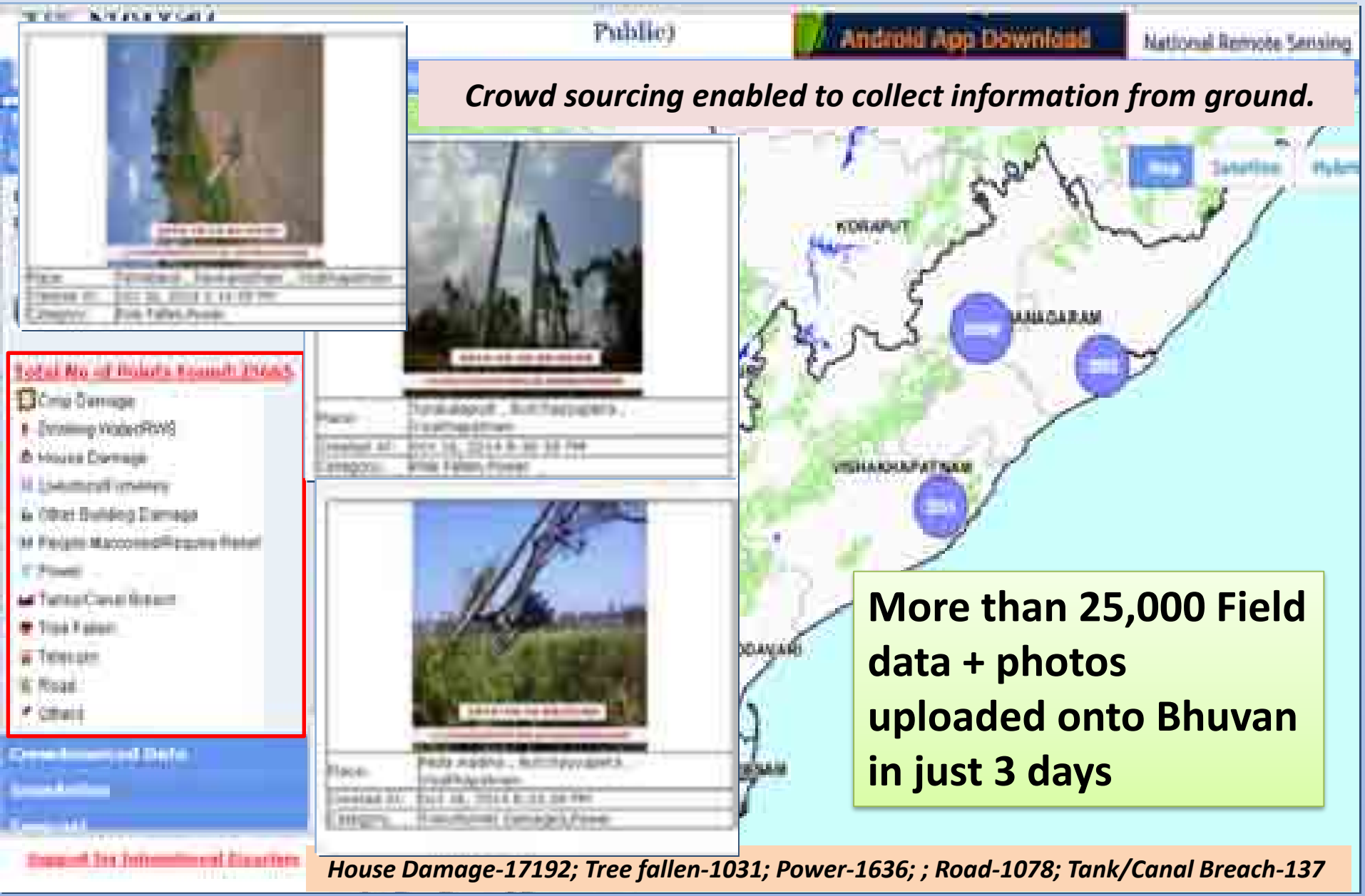


Real-time Spatial Flood Early Warning System Development

Flood Forecast Model Development for the Major Flood-prone Rivers of the Country

Medium-range Flood Forecast Model Development

- The Godavari Flood Forecast System
- Mahanadi Flood Forecast System
- FF for other Major Flood-prone Rivers

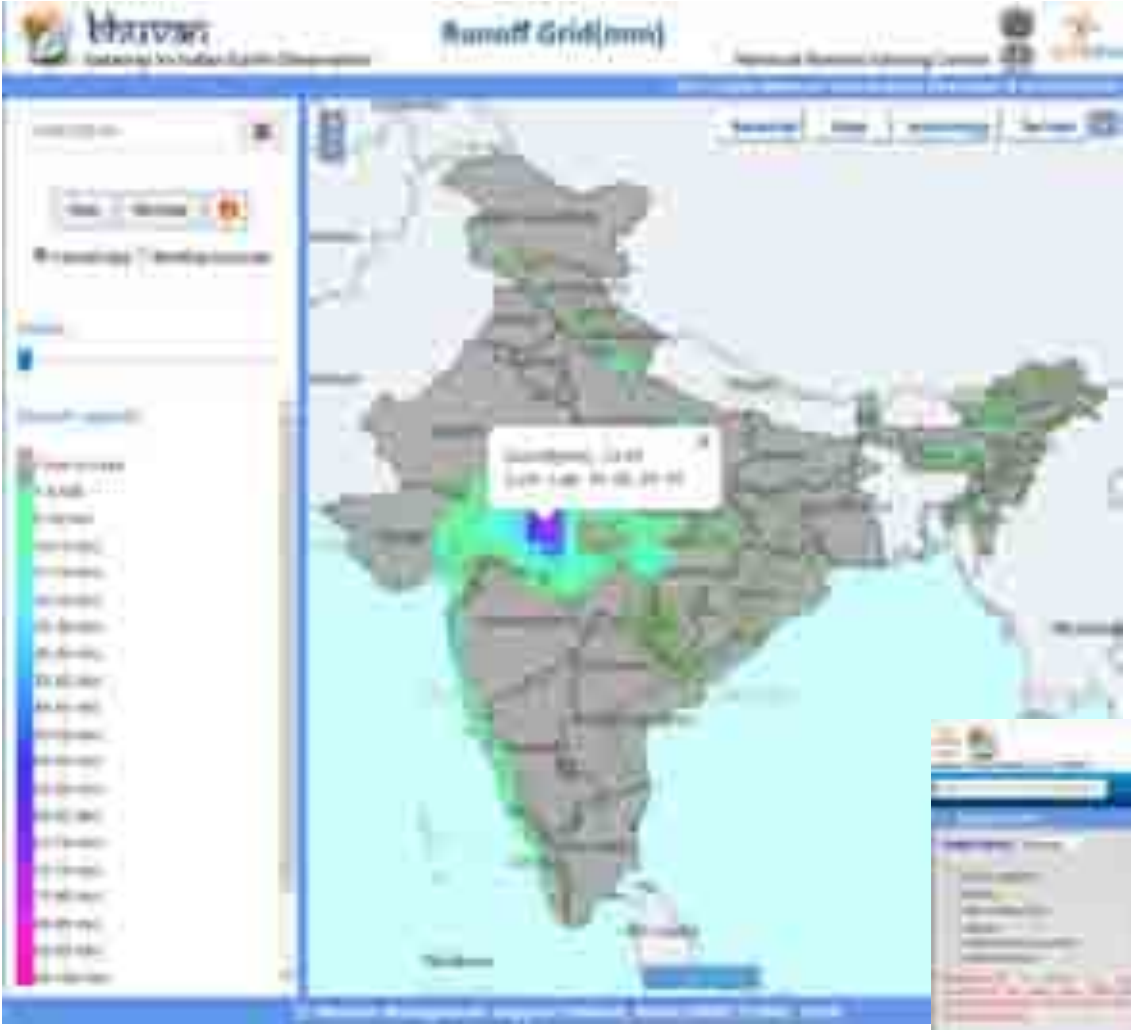
Flash Flood Studies in Near Real-time

Major Highlights:

- The approach is a complete transformation from a point based conventional flood forecast system to the spatial flood early warning
- Useful for spatial flood alarming, flood relief & rescue operations and flood management in real-time
- Triggered to start a new project under NHP to develop operational real-time spatial flood early warning model development for Various Rivers

Wed-enabled Spatial Flood Early Warning System for the Godavari Basin

Spatial flood early warning



Runoff at catchment scale

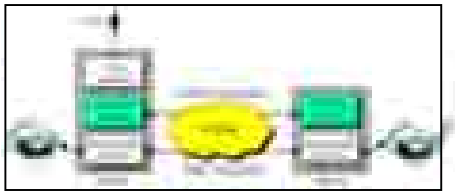
Dissemination

DMS- VPN network

NRSC website (www.nrsc.gov.in)

E-mail

FTP process



Bhuvan web portal (bhuvan.nrsc.gov.in)

NDEM web portal (ndmcc.gov.in)

DSC Dashboard

Towards Flood Hazard Mapping

Disaster Risk Reduction

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Hazard

potentially damaging physical event ..cause loss of life, property...

Vulnerability

conditions which increase the susceptibility to the impact of hazards

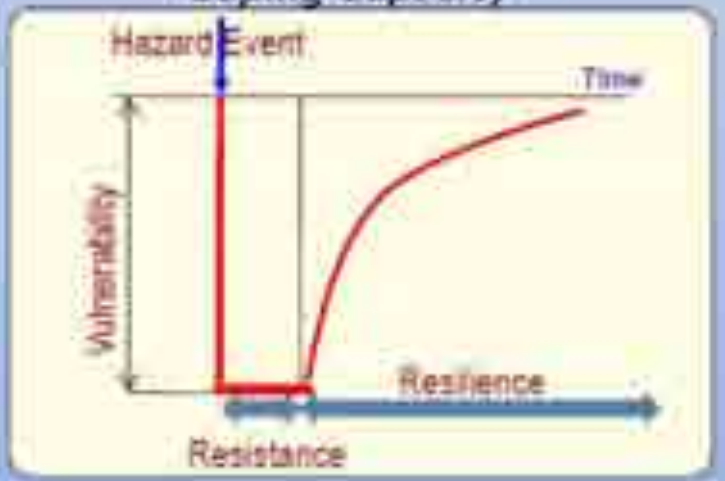
Risk

probability that a hazard will turn into a disaster

Disaster

A serious disruption causing widespread human/material economic/environ. losses

Resistance + Resilience = Coping Capacity



Resilience

capacity of a system (exposed to hazards) to adapt, by resisting/ changing

What is Disaster Risk Reduction ?

Disaster Risk Reduction (DRR) refers to the conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

What we can do?

Human societies have, therefore, the responsibility to identify the risks and factors leading to disasters and decide on the appropriate interventions to control or manage them. Risk assessment is then a central stage that, more than a purely scientific enterprise should be seen as a collaborative activity that brings together professionals, authorized disaster managers, local authorities and the people living in the exposed areas.

Disaster Risk Management (DRM) can be described as an array of measures involving public administration, decentralization, organizational and institutional development (or strengthening), community-based strategies, engineering, settlement development and land use planning. It also takes into consideration environmental issues as part of the risk mitigation and reduction strategies.

Steps in Disaster Risk Reduction

Sendai Framework for DRR

Post-2015 Framework Priority	Exemplary activities
1. *Understanding disaster risk*	Knowledge and information generation and management (including risk and vulnerability assessments, cost-benefit analysis, and information systems), research, innovation and technology transfer
2. *Strengthening governance/ institutional arrangements/ organizational, legal and policy frameworks to manage disaster risk*	Institutional capacity building, planning (ex-ante and ex-post), coordination, management, policies and regulation
3. *Investing in disaster risk reduction for resilience*	Hard and soft investment, land use and water management, infrastructure [illegible] social protection and basic service provision)
4. *Enhancing disaster preparedness for effective response, and to Build Back Better in recovery, rehabilitation and reconstruction*	Evacuation facilities, retrofitting schools, hospitals and other public buildings, training and contingency plans (including early warning systems)

Source: see the Post 2015 Framework zero draft at http://www.wcdr.org/documents/wcdr/Pre-zero_draft_post2015_frmwk_for_DRR_8_August.pdf

Sendai Framework recommended use of Space Technology for Achieving these goals

Hazard Zonation Mapping for Assam State, India

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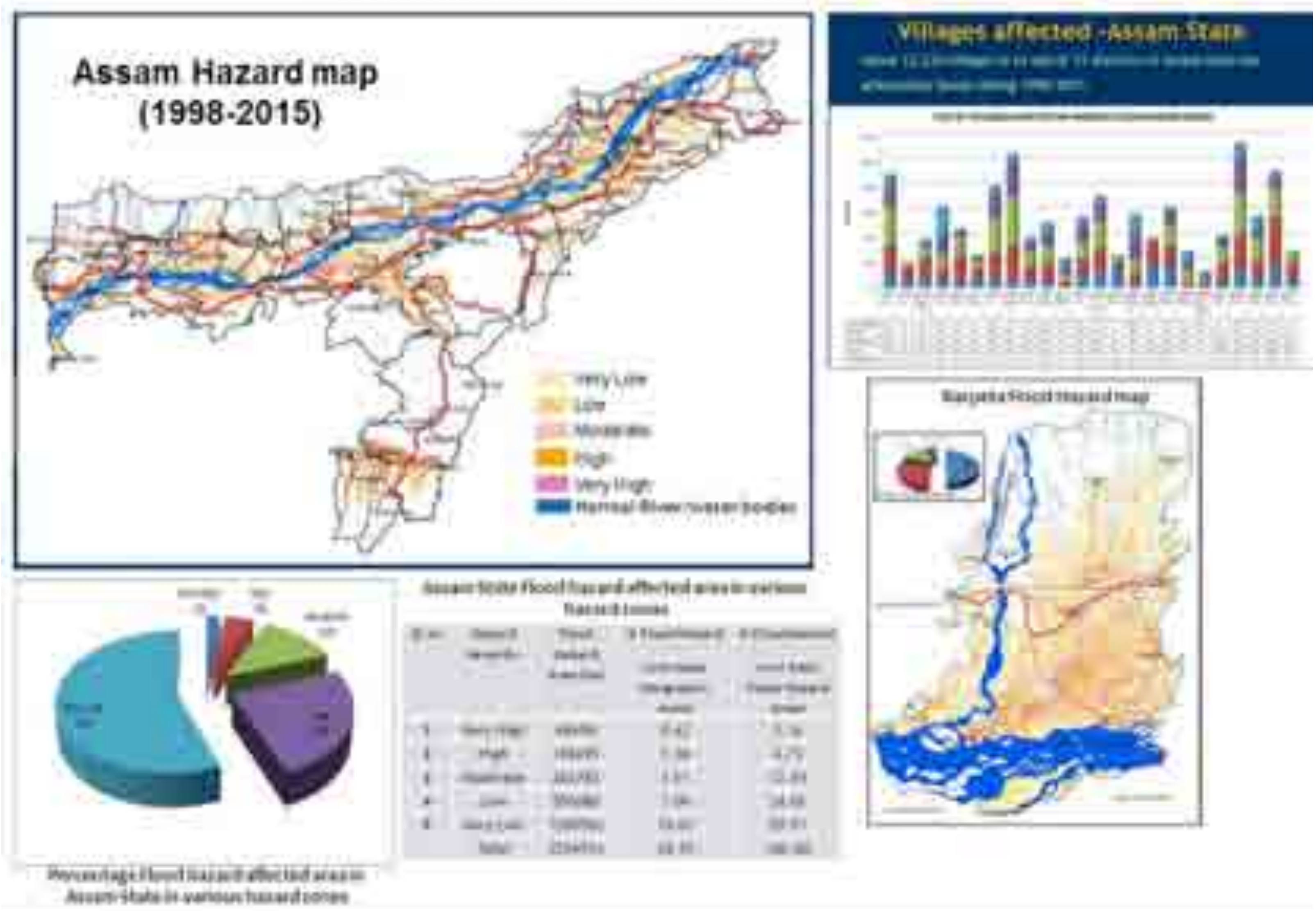
ASSAM HAZARD ZONATION ATLAS-1998-2015



Release of Flood Hazard Atlas

Shri Pallab Lochan Das, Hon'ble Minister of State for Revenue & Disaster Management, Government of Assam released the updated 'Flood Hazard Atlas for Assam State', on 6-Sep-2016 at Guwahati. Hon'ble Minister appreciated the efforts of NRSC in bringing out the updated atlas for the state of Assam. Assam is the first state in the country to release satellite based flood hazard atlas in 2011 and also the first state to update the atlas in 2016.

NDEM

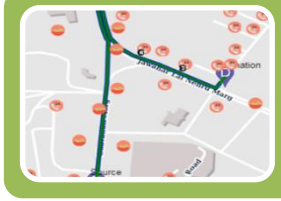
The **Committee of Secretaries** (CoS) has entrusted the responsibility of implementing NDEM to NRSC/ISRO.

NDEM is GIS based **National Repository** for entire country coupled with a set of **Decision Support System** tools to assist in disaster management.

Objectives

Multi-scale geospatial database at

- 1:50,000 scale for the entire country
- 1: 10,000 scale for 350 multi-hazard prone districts
- 1:2,000 scale for Delhi, Mumbai, Kolkata, Bengaluru, Hyderabad



Development of DSS tools for disaster/emergency management

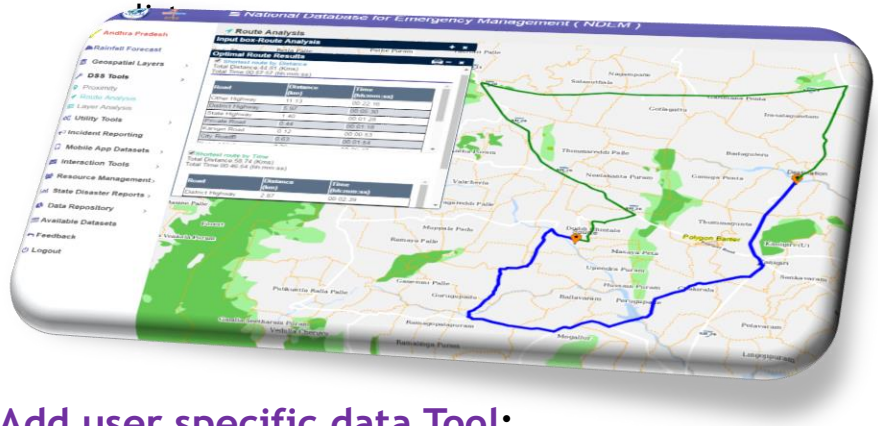
Establishing a mirror facility at MHA, New Delhi

Implemented on the behest of **Ministry of Home Affairs** (MHA) with multi-institution participation.

Decision Support Tools

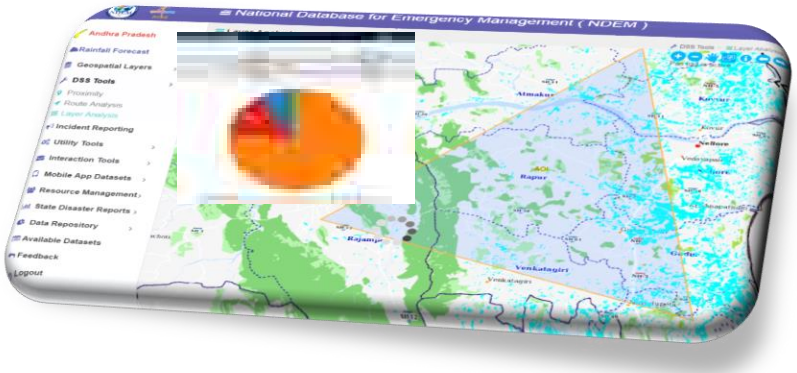
Proximity Tool:

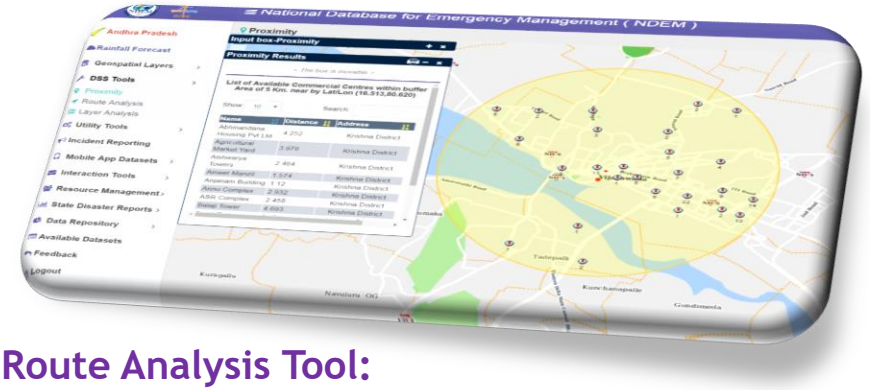
- Proximity tool for identifying emergency facilities.
- It provides optimal search for emergency facilities such as hospitals, shelters, rail/bus stations etc. within the user defined buffer



Add user specific data Tool:

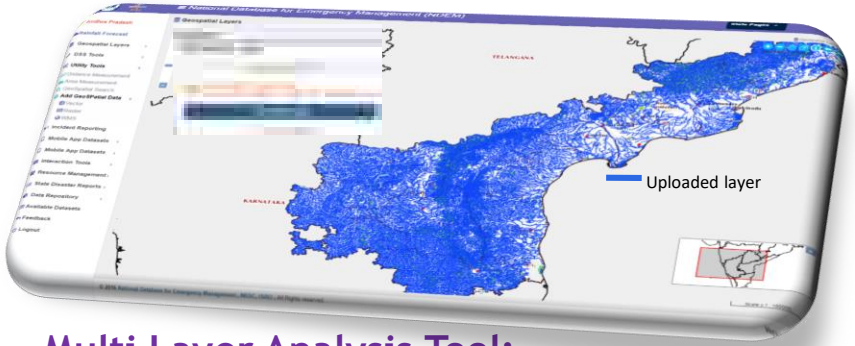
- The tool allows users to add specific custom vector data in standard GIS format.
- The user data is overlaid on the NDEM viewer to visualize and analyze for further decision making.





Route Analysis Tool:

- Route analysis facilitates the user to find out the shortest route between emergency facility and user interested location/disaster site with details of the route.
- The routing tool enables finding out shortest way to locate shelters, hospitals etc. with road network data.



Multi Layer Analysis Tool:

- Spatial analysis tool enables the user to add multiple layers on NDEM Map Viewer for analyzing the features for effective decision making.

Salient Feature of NDEM Version 3.0

"NDEM V 3.0 is equipped with comprehensive multi-scale database, decision tools and Mobile Apps."

Disaster Dashboard
Alerts & Warning, Disaster related Current News.

Data Visualization
Multi-Scale Geospatial Data Services, Satellite Imagery.

Mobile Applications
Apps for Relief Management, Attribute Collection & Geo-tagging of emergency facility.

Resource Management,
Resource allocation, Organisation and tracking of essential commodities

Damage Statistics
Submission of damage statistics by States to MHA

Incident Reporting
Disaster event reporting through Mobile Apps, SMS, Portal.

Decision Support Tools
Customized GUI based tools for decision making

Interaction Services
Communication & data exchange among users.

Rainfall Forecast
Rainfall Forecast & alerts for heavy & extreme rainfall.

Data Inventory
Geo-spatial data statistics, charts

International Support

ISRO Support to SAARC & Asian Countries

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South Asian Association for Regional Cooperation (SAARC) Countries

- Disaster Management Support (DMS) for major disasters like Floods in Laos, Vietnam, Thailand 2019, Nepal Earthquake - 2015 and Sun Koshi Landslide in Nepal during 2016.
- Launch of GSAT-9 satellite for strengthening support to SAARC nations.
- Under UNESCAP aegis ISRO has extended its support towards Sri Lanka & Myanmar Drought during 2016.
- Capacity building to various officials of SAARC under CSSTEAP programme.

Sri Lanka Floods - 2017

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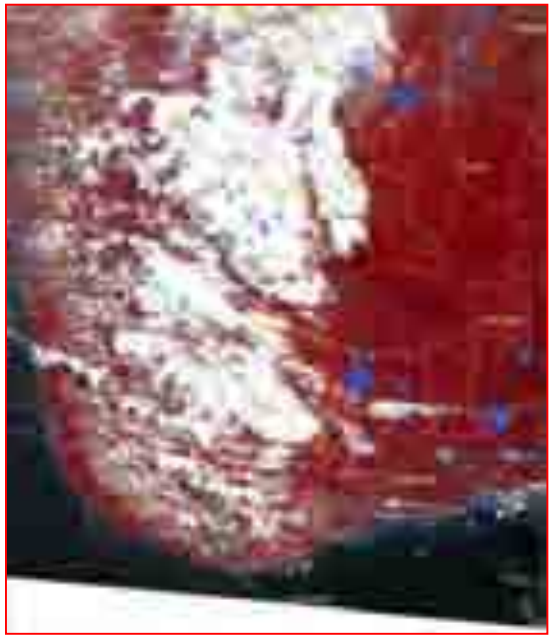
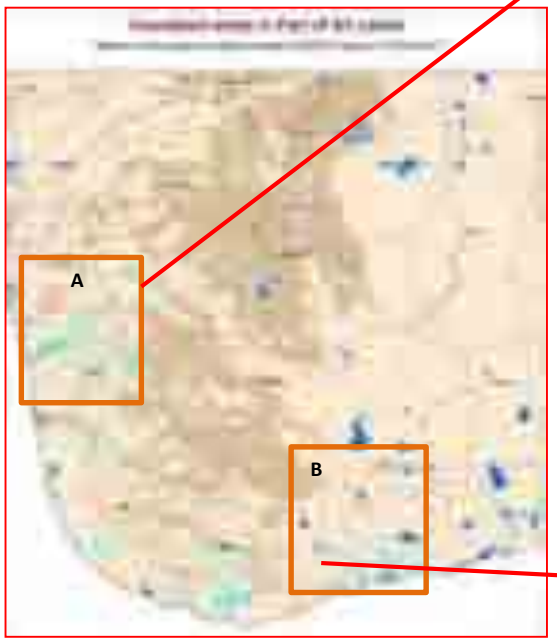
- The island nation of Sri Lanka has experienced its worst torrential rains during last week of May 2017 causing heavy flooding and landslides, affecting 15 districts in southern Sri Lanka.
- DSC/NRSC has acquired & analysed Indian Remote Sensing satellite (IRS) data of RESOURCESAT-2 AWiFS data of 27- May-2017 and RESOURCESAT-2A AWiFS & LISS-IV Mx data of 30-May-2017.
- The flood inundation was observed in Colombo, Galle, Kalutara, Matara, Hambantota and Ratnapura districts as on May 27,2017.

Sri Lanka

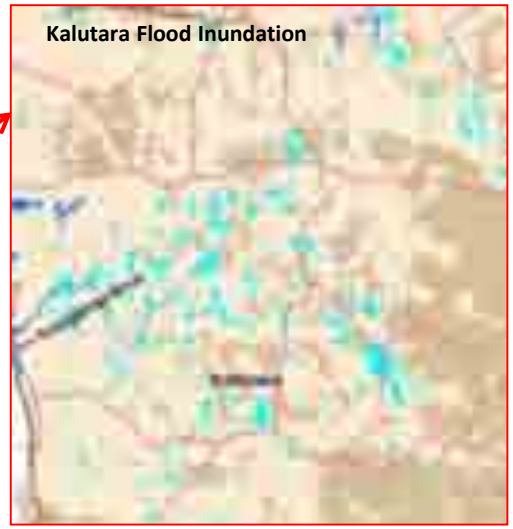
Resourcesat-2 AWiFS data of 27-May-17



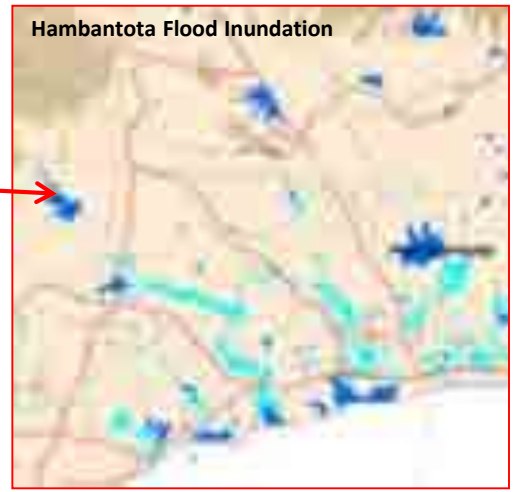
Flood Inundation Map



Kalutara Flood Inundation



Hambantota Flood Inundation



Legend

- District Boundary
- Road Network
- Normal River /Water bodies
- Flood Inundation

Support to SAARC – ISRO initiative through Sentinel Asia

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Emergency requests responded during 2016

Support to SAARC countries during 2008-2015

List of Disasters supported for SAARC countries during 2008-2015

- Sri Lanka Floods, January 2011
- Nepal Flash Floods, May 2012
- Nepal Landslide, May 2015
- Bhutan Floods, June 2015
- Pakistan Floods, July 2015
- Bangladesh Floods, Sep 2015
- Pakistan Earthquake, Nov 2015
- Pakistan Landslide, Apr 2016
- Sri Lanka Floods, May 2016
- Bangladesh Floods, Aug 2016
- Bhutan Floods, Aug 2016
- Nepal Flash Floods, Dec 2016
- Nepal Flash Floods, Apr 2017

Support to SAARC – ISRO initiative through Sentinel Asia

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Bangladesh Floods-2015

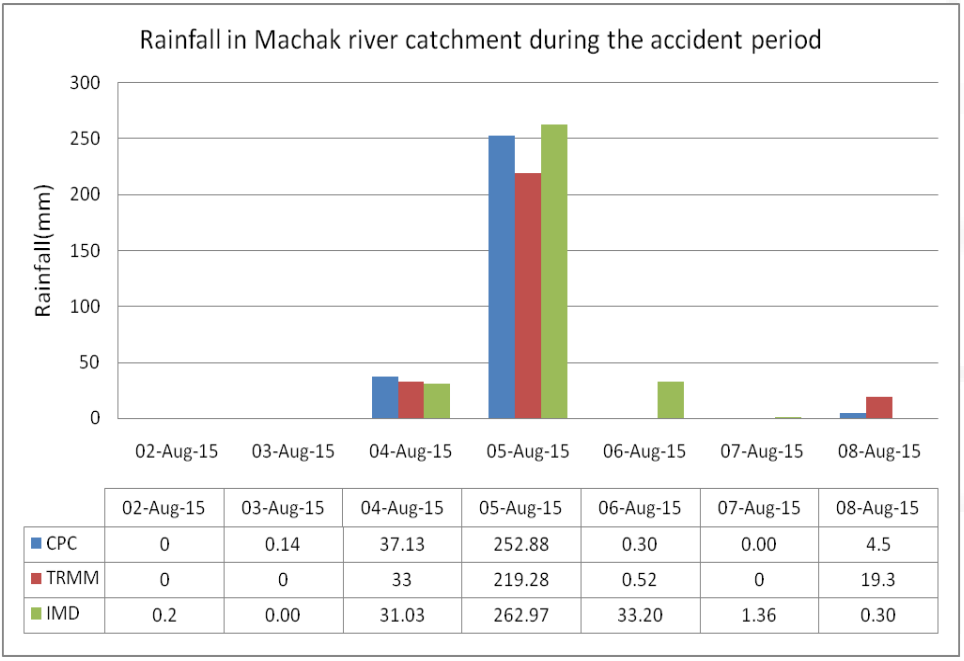
Resourcesat-2 AWiFS Sep 07,2015

MYANMAR FLOODS - 2016

RISAT-1 CRS data of Sep 07, 2016

Case Study
Machak River

Machak River Floods (MP State) – A Hydrological and Hydrodynamic Simulation Study

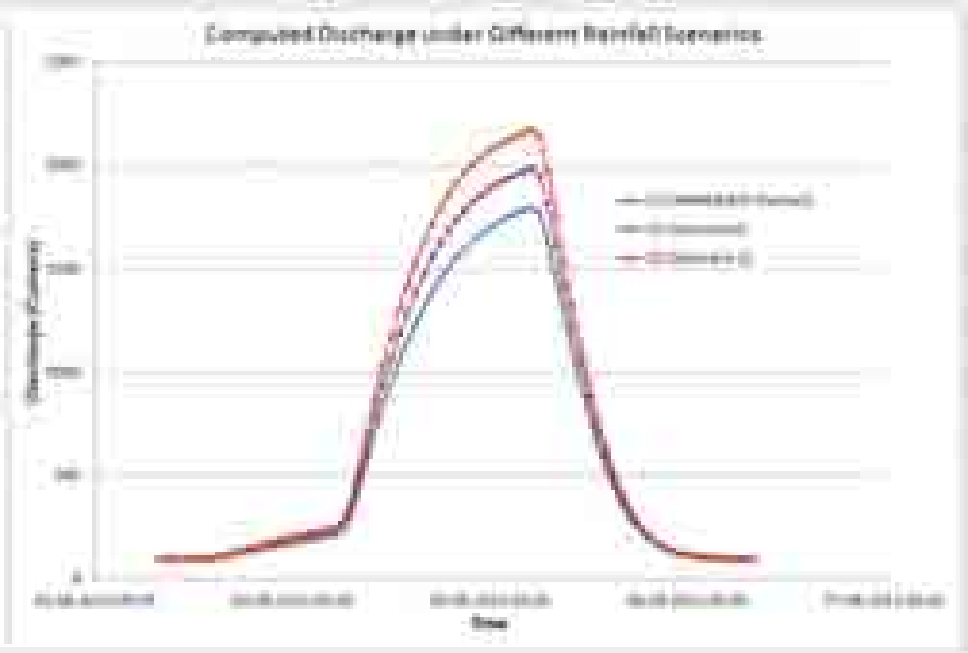


	02-Aug-15	03-Aug-15	04-Aug-15	05-Aug-15	06-Aug-15	07-Aug-15	08-Aug-15
CPC	0	0.14	37.13	252.88	0.30	0.00	4.5
TRMM	0	0	33	219.28	0.52	0	19.3
IMD	0.2	0.00	31.03	262.97	33.20	1.36	0.30

Unprecedented Rainfall Situation

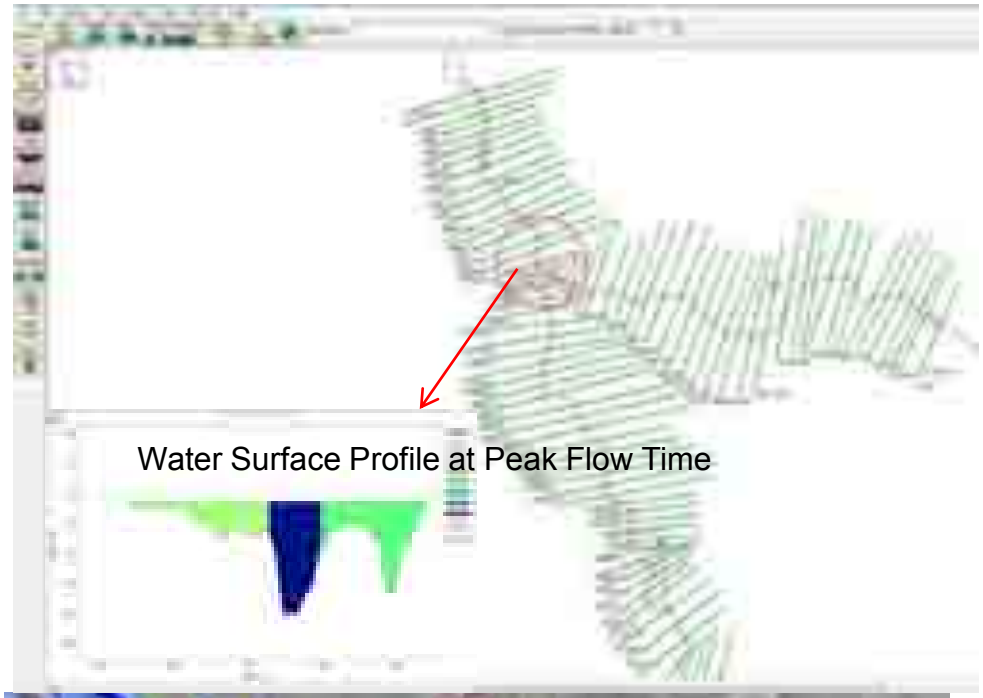
Machak River Catchment (743.15 sq.km)

- Peak rainfall on 05 Aug 2015 : 263 mm
- Antecedent rainfall : 37 mm
- Peak flood discharge : 2300 m^3/sec



Computed Flood Hydrographs (in different Scenarios)

Flood Inundation Simulations (10m CARTO DEM)



Results:

- Peak Flood discharge: 2300 m^3/sec
- Velocity of flow : 0.75 to 3.0 m/s
- Depth of flood :8 to 9 m (at rail arch bridge)

Conclusions:

- High intensity of rainfall
- Sudden change in slopes from up-stream to down-stream.
- Single went arch bridge could not accommodate flood discharge
- Unprotected embankments
- Role of soil properties in that area has to be examined.

Suggestions:

- Proper flood alarming is required
- Catchments should be gauged (rainfall & discharge)
- Embankments should be protected

Chennai Floods

Chennai Floods 2015

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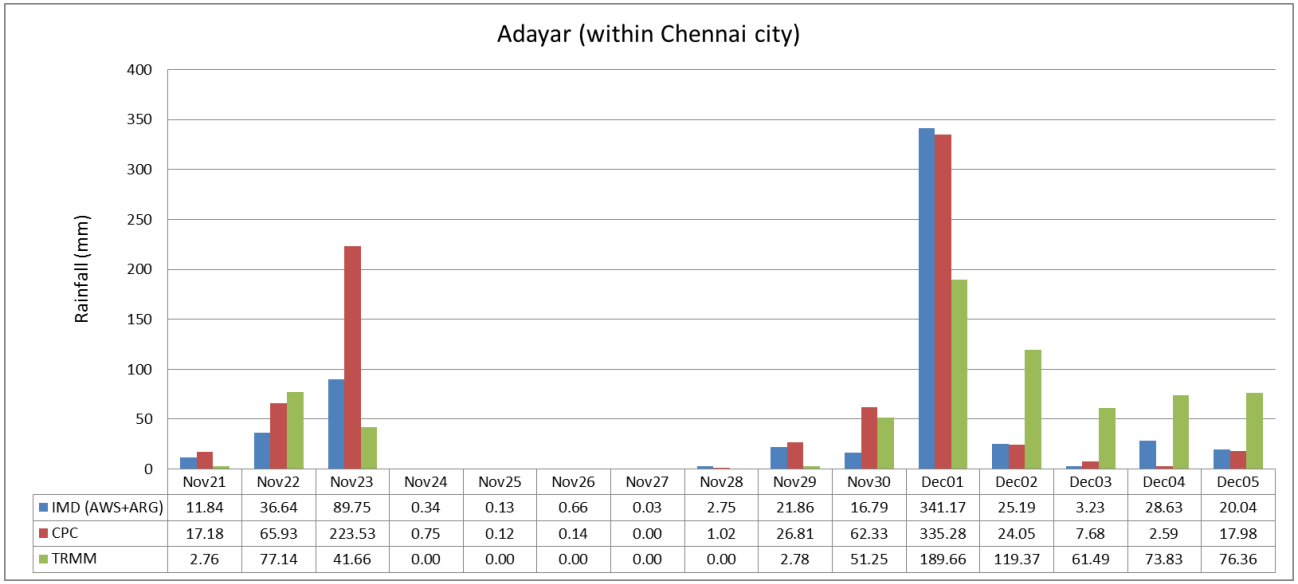
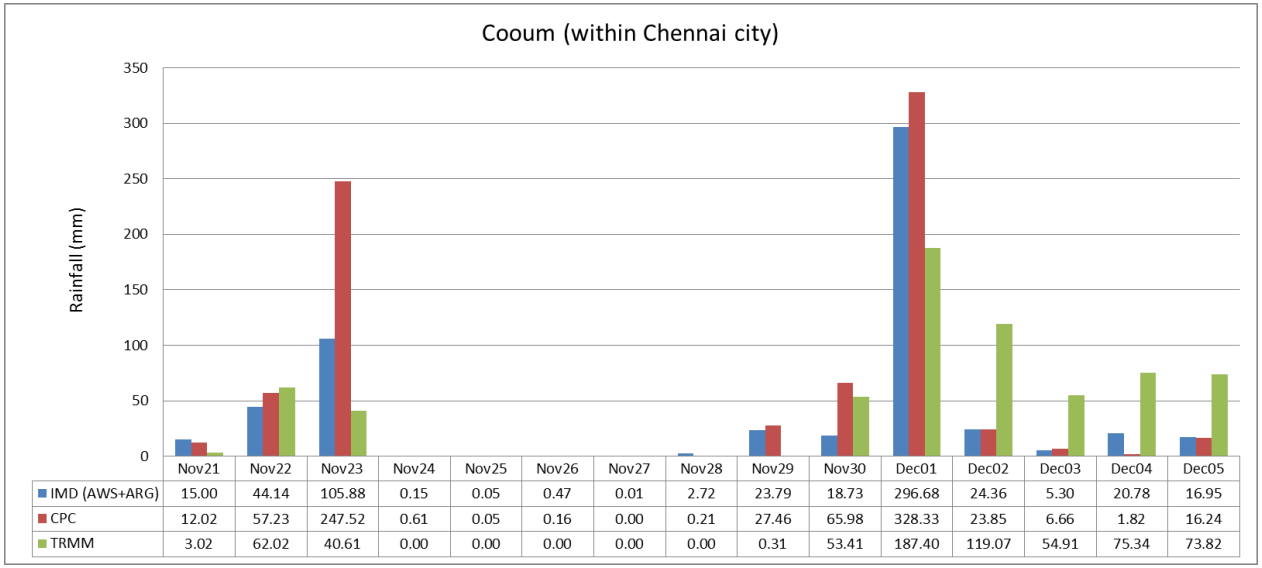
Rainfall Scenario in the Catchments (CPC, TRMM, and IMD)

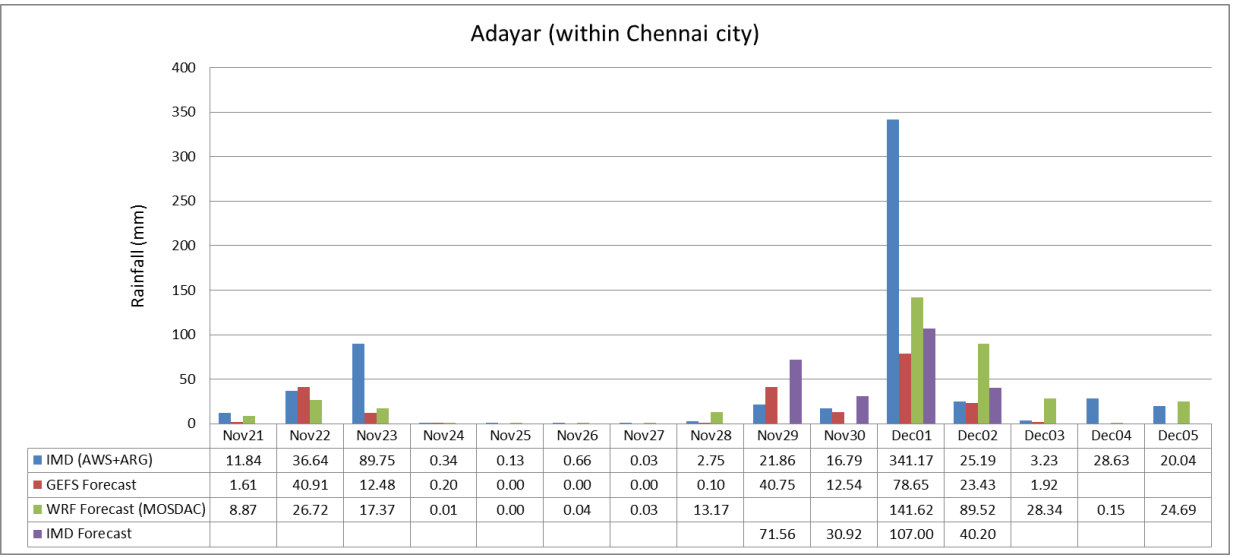


	Nov21	Nov22	Nov23	Nov24	Nov25	Nov26	Nov27	Nov28	Nov29	Nov30	Dec01	Dec02	Dec03	Dec04	Dec05
IMD (AWS+ARG)	11.84	36.64	89.75	0.34	0.13	0.66	0.03	2.75	21.86	16.79	341.17	25.19	3.23	28.63	20.04
CPC	17.18	65.93	223.53	0.75	0.12	0.14	0.00	1.02	26.81	62.33	335.28	24.05	7.68	2.59	17.98
TRMM	2.76	77.14	41.66	0.00	0.00	0.00	0.00	0.00	2.78	51.25	189.66	119.37	61.49	73.83	76.36

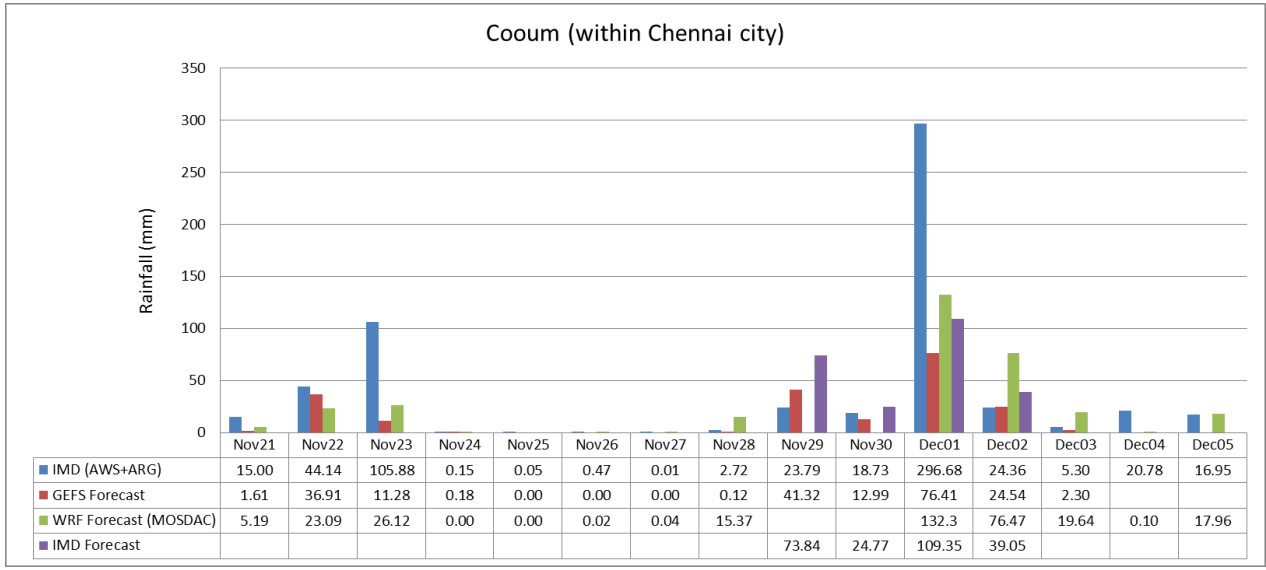


	Nov21	Nov22	Nov23	Nov24	Nov25	Nov26	Nov27	Nov28	Nov29	Nov30	Dec01	Dec02	Dec03	Dec04	Dec05
IMD (AWS+ARG)	15.00	44.14	105.88	0.15	0.05	0.47	0.01	2.72	23.79	18.73	296.68	24.36	5.30	20.78	16.95
CPC	12.02	57.23	247.52	0.61	0.05	0.16	0.00	0.21	27.46	65.98	328.33	23.85	6.66	1.82	16.24
TRMM	3.02	62.02	40.61	0.00	0.00	0.00	0.00	0.00	0.31	53.41	187.40	119.07	54.91	75.34	73.82

Chennai Floods 2015



	Nov21	Nov22	Nov23	Nov24	Nov25	Nov26	Nov27	Nov28	Nov29	Nov30	Dec01	Dec02	Dec03	Dec04	Dec05
IMD (AWS+ARG)	11.84	36.64	89.75	0.34	0.13	0.66	0.03	2.75	21.86	16.79	341.17	25.19	3.23	28.63	20.04
GEFS Forecast	1.61	40.91	12.48	0.20	0.00	0.00	0.00	0.10	40.75	12.54	78.65	23.43	1.92		
WRF Forecast (MOSDAC)	8.87	26.72	17.37	0.01	0.00	0.04	0.03	13.17			141.62	89.52	28.34	0.15	24.69
IMD Forecast									71.56	30.92	107.00	40.20			



	Nov21	Nov22	Nov23	Nov24	Nov25	Nov26	Nov27	Nov28	Nov29	Nov30	Dec01	Dec02	Dec03	Dec04	Dec05
IMD (AWS+ARG)	15.00	44.14	105.88	0.15	0.05	0.47	0.01	2.72	23.79	18.73	296.68	24.36	5.30	20.78	16.95
GEFS Forecast	1.61	36.91	11.28	0.18	0.00	0.00	0.00	0.12	41.32	12.99	76.41	24.54	2.30		
WRF Forecast (MOSDAC)	5.19	23.09	26.12	0.00	0.00	0.02	0.04	15.37			132.3	76.47	19.64	0.10	17.96
IMD Forecast									73.84	24.77	109.35	39.05			

NOTE: Gap areas in the graph indicates the non-availability of the concerned rainfall data

Chennai Floods 2015

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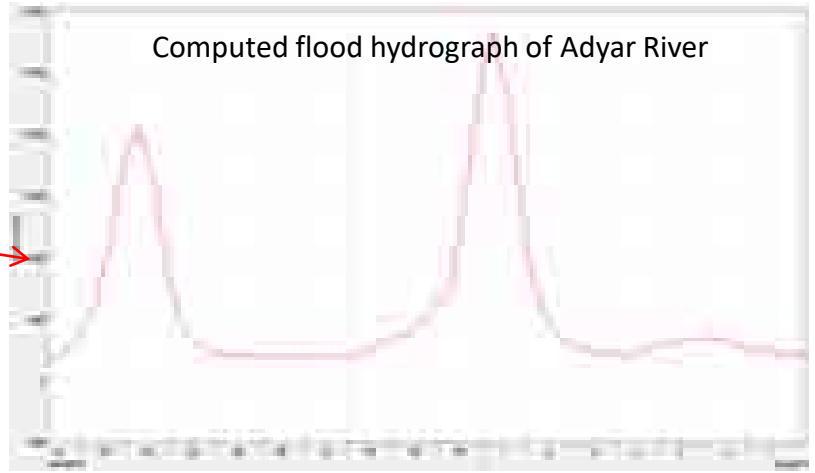
Hydrological Simulation Study of Chennai Floods

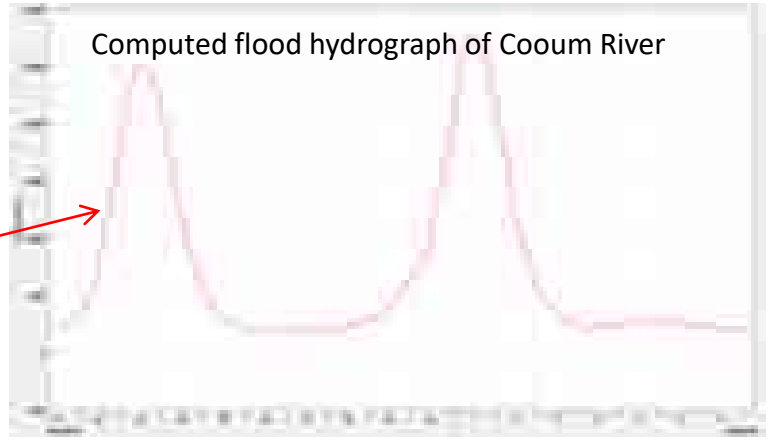
Rainfall Data Analysed

- Max. Rain: 338 mm in Adyar River
  248 mm in Cooum River

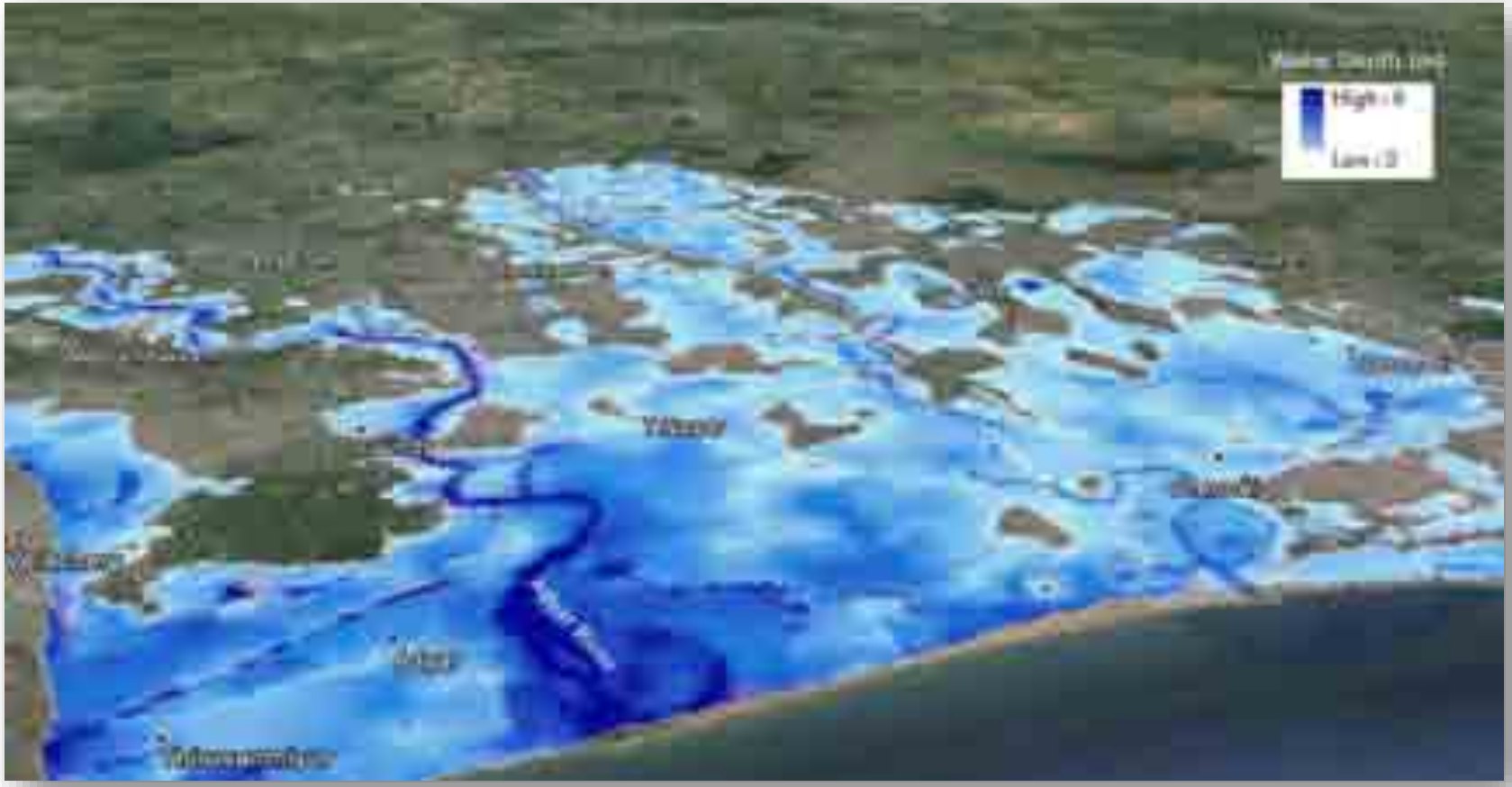
Data Used:

Landuse, 10m CARTO DEM, and Soils





Spatial Inundation Simulations (using 10m CARTO DTM)



	Adyar River	Cooum River
Rainfall (29 Nov to 03 Dec)	406 (total) 341 (max.)	362 (total) 296(max.)
Discharge (01 Dec 2015)	2850 cumecs	2800 cumecs
Depth of flood	0.5 to 5.0 m	0.5 to 2.5 m
Velocity of flow	0.25 to 2.25 m/sec	0.2 to 1.6 m/sec

Flood Response: 2015

Heavy Rains in Tamilnadu – Nov-Dec, 2015

Introduction

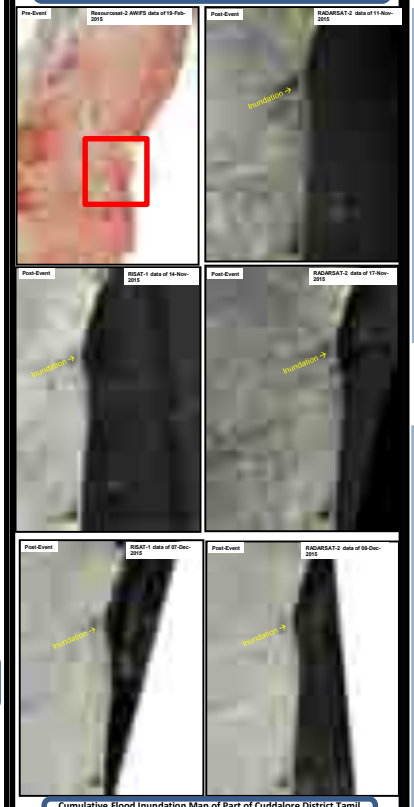
Heavy rains were reported in Tamil Nadu State under the influence of cyclonic circulation over southwest Bay of Bengal during November - December, 2015. Several areas have been submerged in flood waters in Cuddalore, Kancheepuram, Thoothukudi districts.

Chennai city has witnessed unprecedented floods inundating vast areas in the city. Communication including road, rail traffic has been hit hard in Chennai city. DSC kept a close watch and acquired satellite images from RISAT-1 & Radarsat-2 over the coastal districts of Tamil Nadu and High resolution data over Chennai city and its surroundings. RISAT-1 CRS/MRS data was planned at 12 hrs interval using both ascending and descending passes over Tamil Nadu for continuous monitoring.

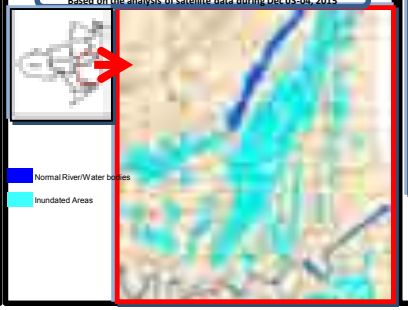
International Charter was activated for having more coverages over the affected areas

Flood Recession Map in Part of Tamil Nadu State
Based on the analysis of satellite data during Dec 03-04, 2015

Daily Monitoring of the event



Cumulative Flood Inundation Map of Part of Cuddalore District Tamil Nadu State
Based on the analysis of satellite data during Dec 03-04, 2015



Inundation Situation in surroundings of Chennai City , Tamil Nadu

Cumulative flood map of Chennai City
Based on the analysis of RISAT-1 data of 03, 04 &06-Dec,2015

Zoomed View of Chennai City and its surroundings

Chennai Floods 2015

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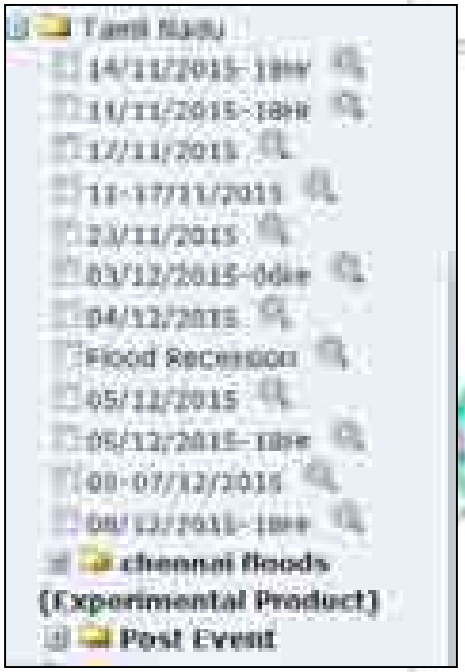

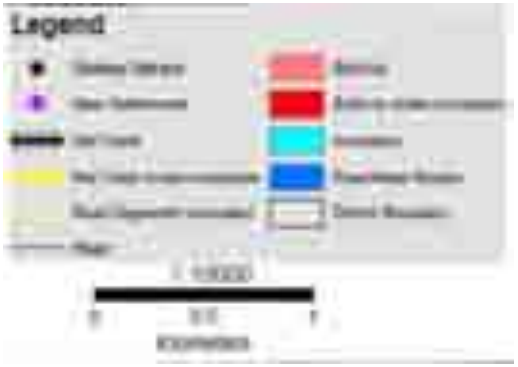

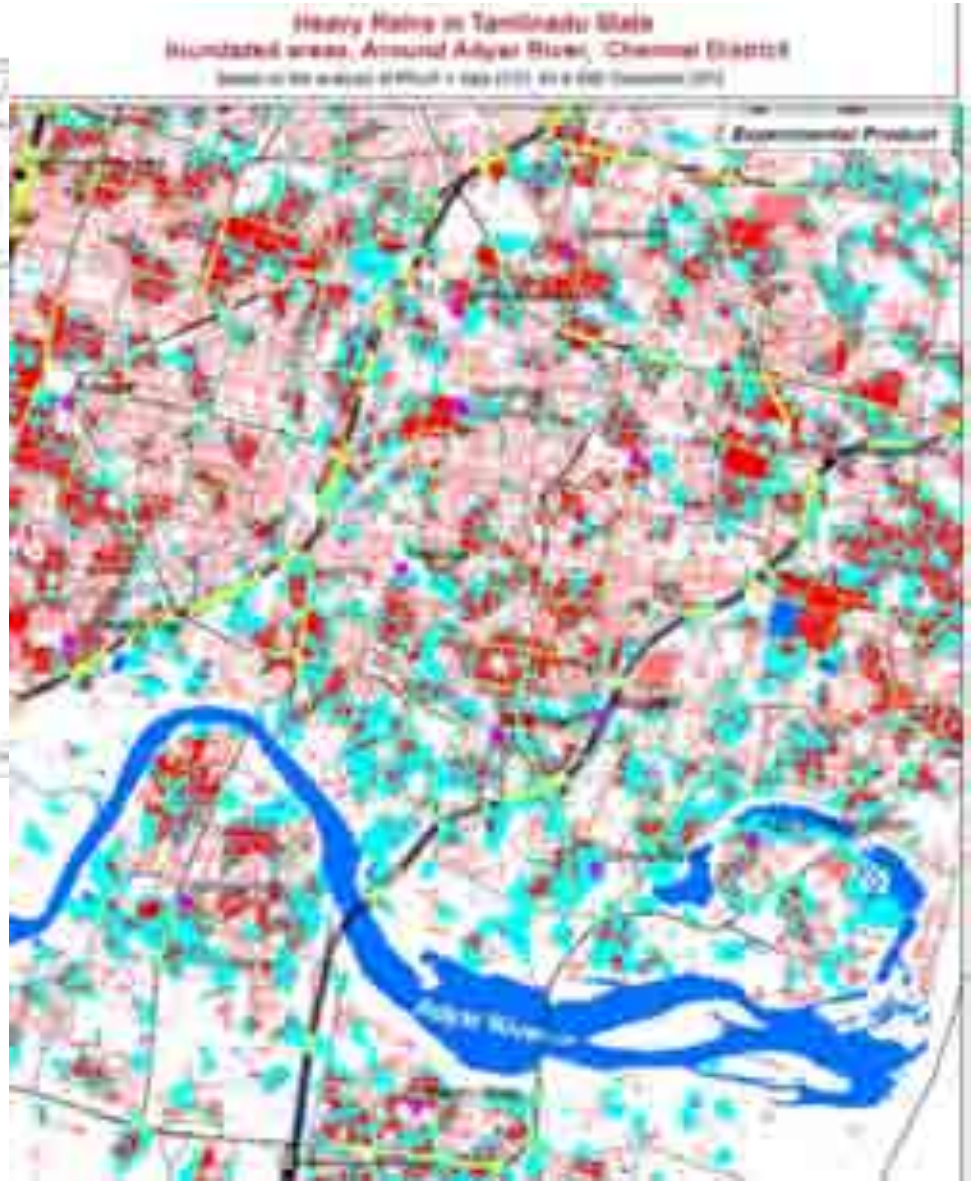

High Resolution Cartosat-2 Images of 4-Dec-2015 showing Inundation in surroundings of Kulukkarai, Tamilnadu

Kashmir Floods

Himalayan Disasters: J&K – Sep, 2014

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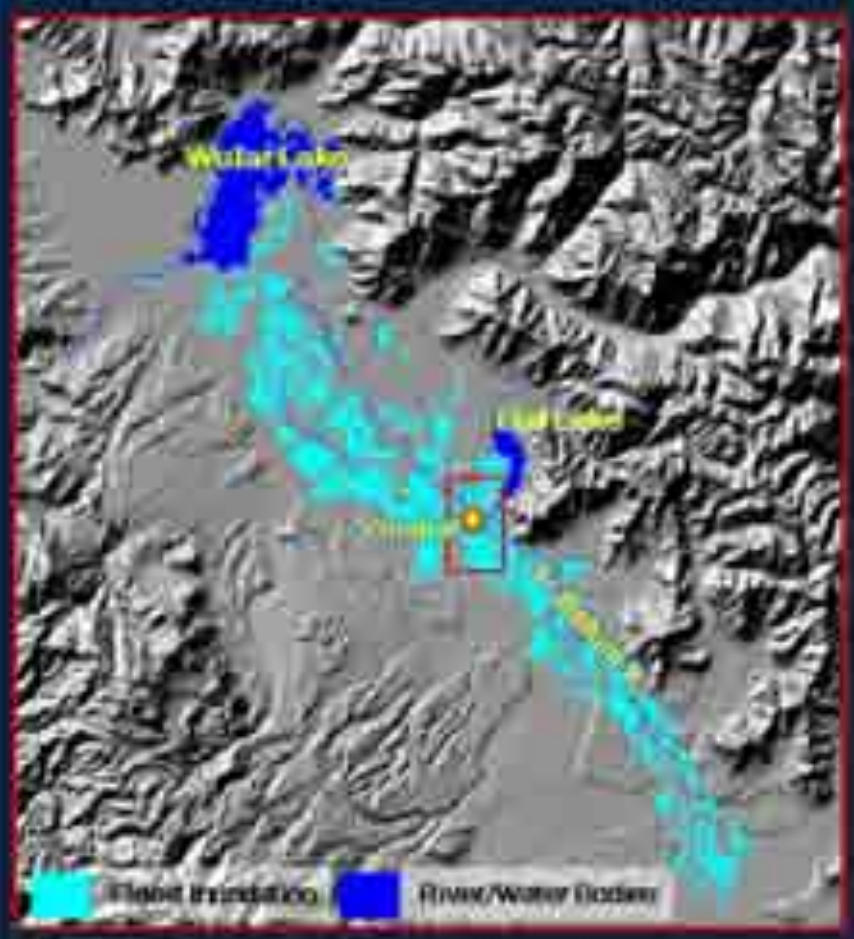

Jammu & Kashmir, Floods - 2014

- Jammu & Kashmir experienced one of the worst floods in the past 60 years during September 2014.
- NRSC closely monitored the floods and inundation information was disseminated in near real time to State Govt. and also uploaded to Bhuvan geo portal.

End Use

- Used by state agencies for relief operations.

Ministry Info

- MHA, NDMA & Govt. of J & K

Location Info

- Jammu & Kashmir

Sensor Info

- RISAT-1, Resourcesat-2, Cartosat-2, Pleiades

Himalayan Disasters: J&K – Sep, 2014

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Submerged Srinagar City

Inundation observed in parts of Srinagar City

Jammu & Kashmir, Floods - 2014

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Exit Use

- Used by state agencies for relief operations.

Ministry Info

- MHA, NDMA & Govt. of J & K

Location Info

- Jammu & Kashmir

Sensor Info

- RISAT-1, Resourcesat-2, Cartosat-2, Pleaides

Himalayan Disasters: J&K – Sep, 2014

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Inundation around Assembly Complex

Inundation observed around Assembly Complex and J&K High Court Complex

Jammu & Kashmir, Floods - 2014

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End Use

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Ministry Info

- MHA, NDMA & Govt. of J & K

Location Info

- Jammu & Kashmir

Sensor Info

- RISAT-1, Resourcesat-2, Cartosat-2, Pleaides

Himalayan Disasters: J&K – Sep, 2014

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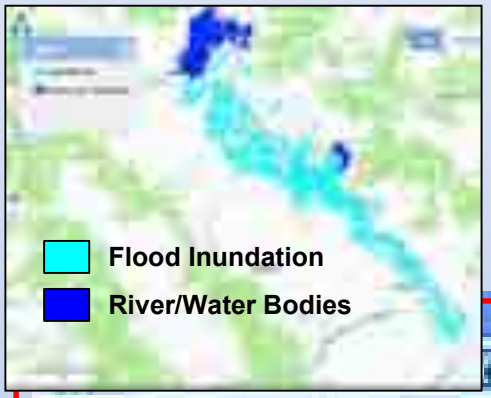

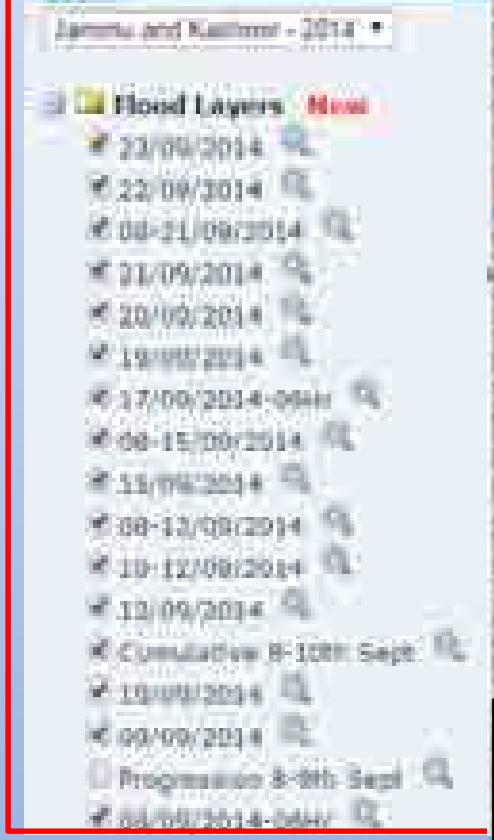

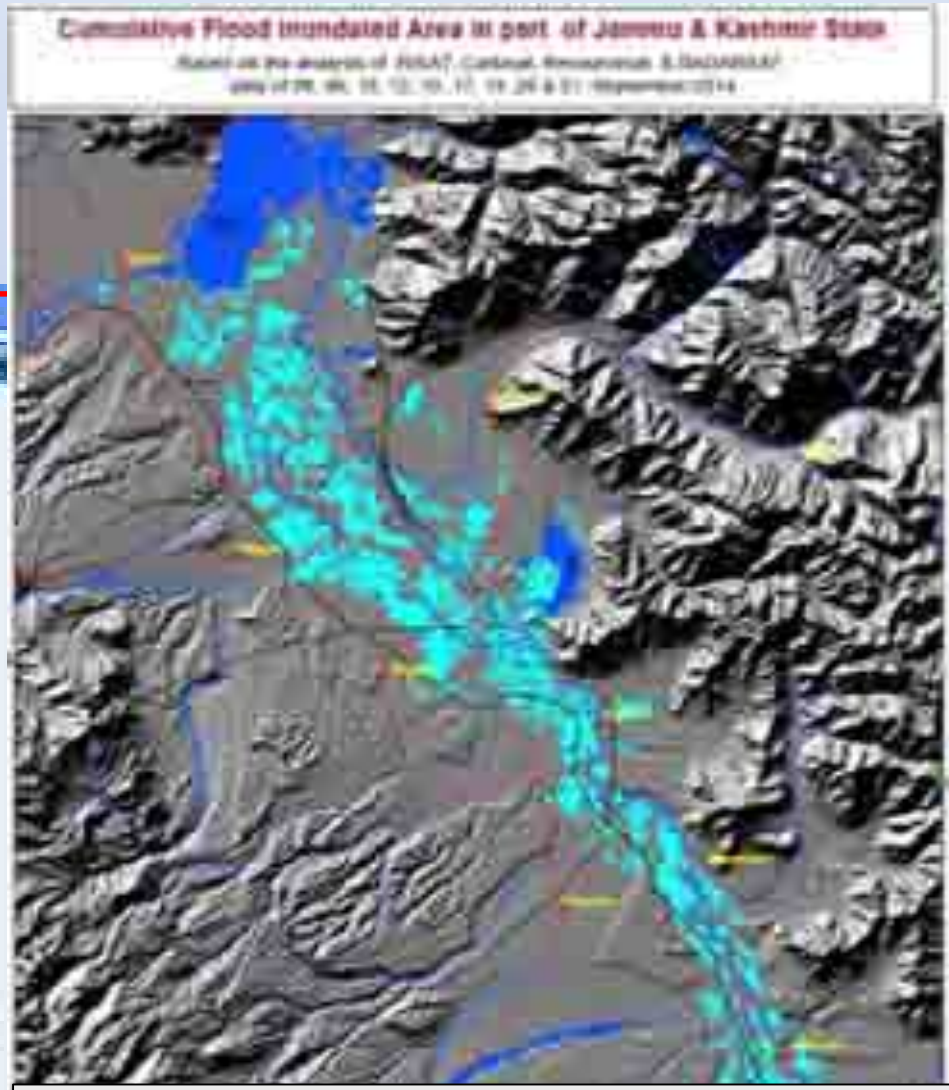

50 Flood inundation maps disseminated in near real time to MHA, NDMA, Govt. of J&K to help in relief and rescue operations.

Himalayan Disasters: J&K – Sep, 2014

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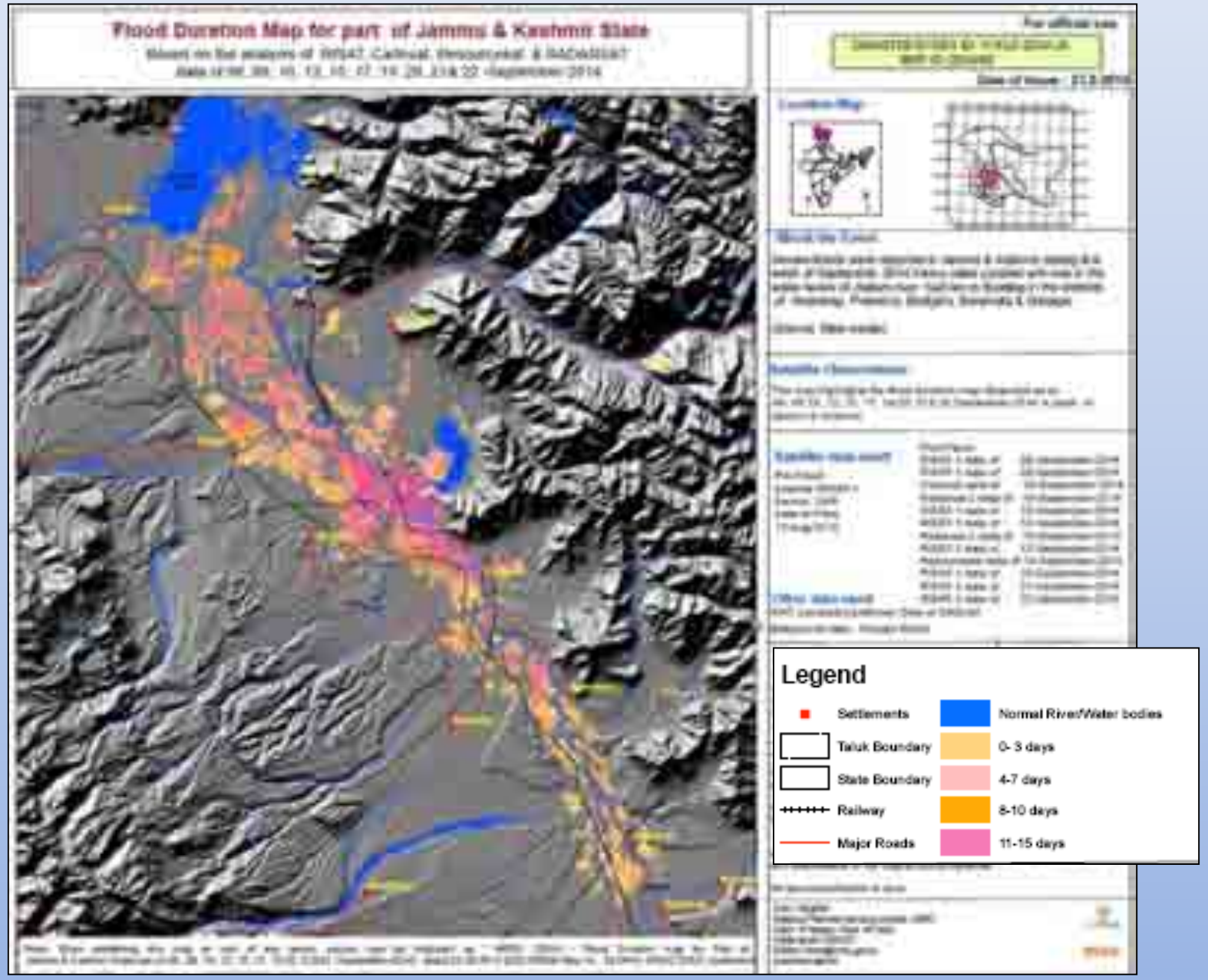
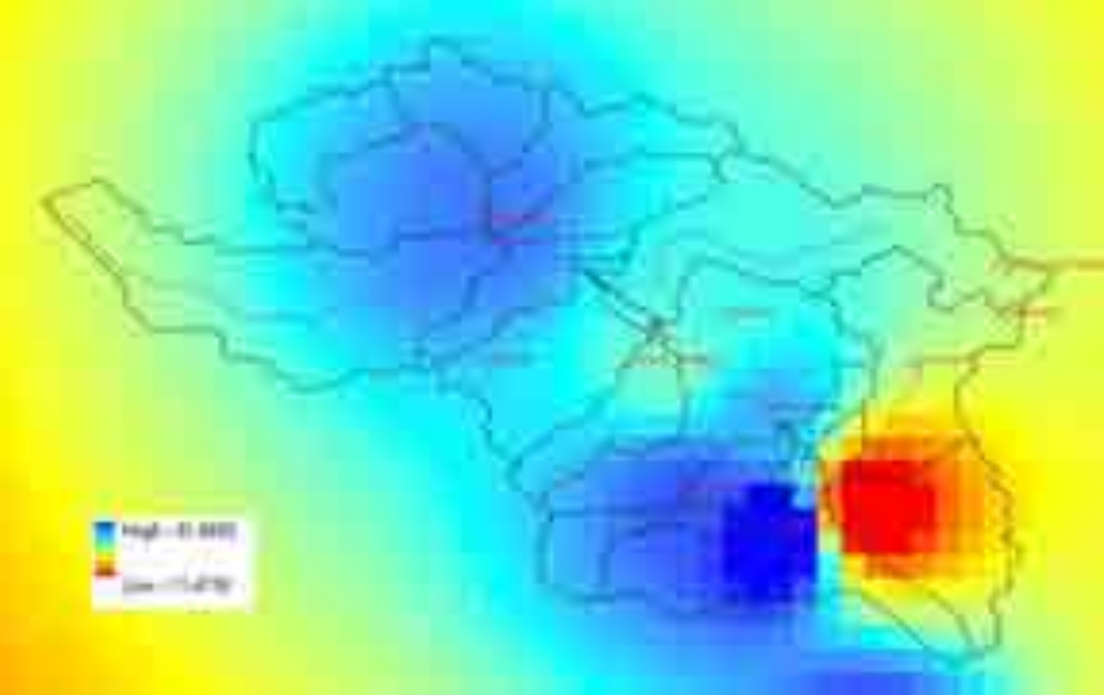
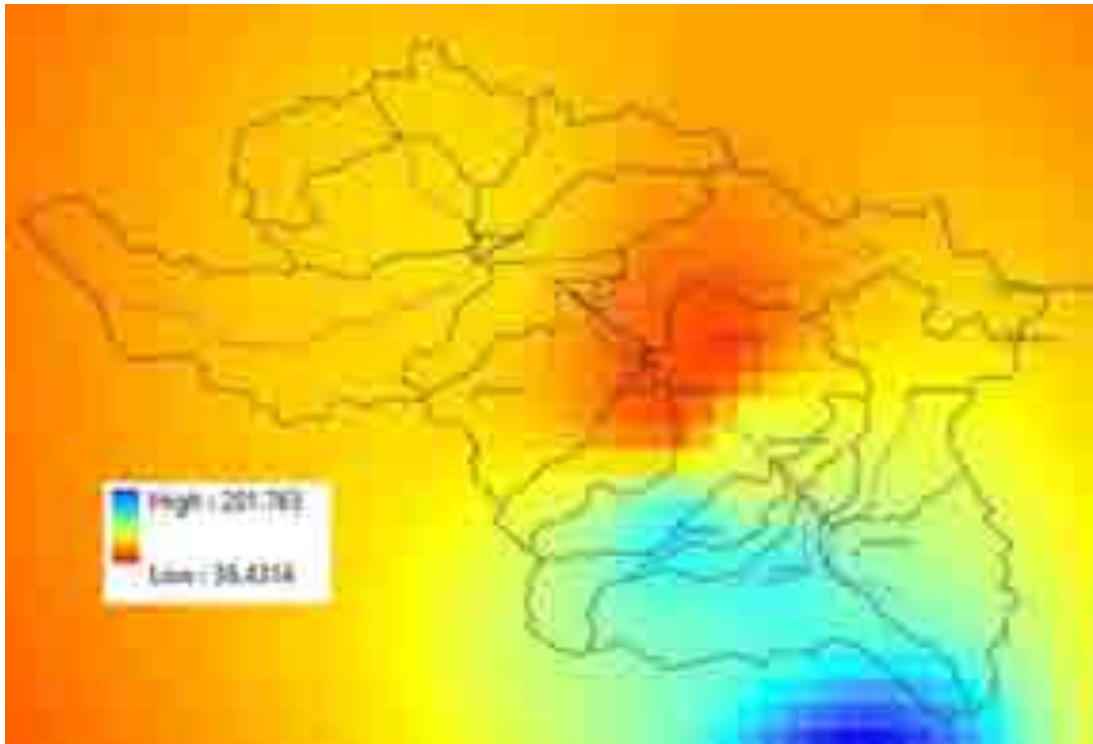




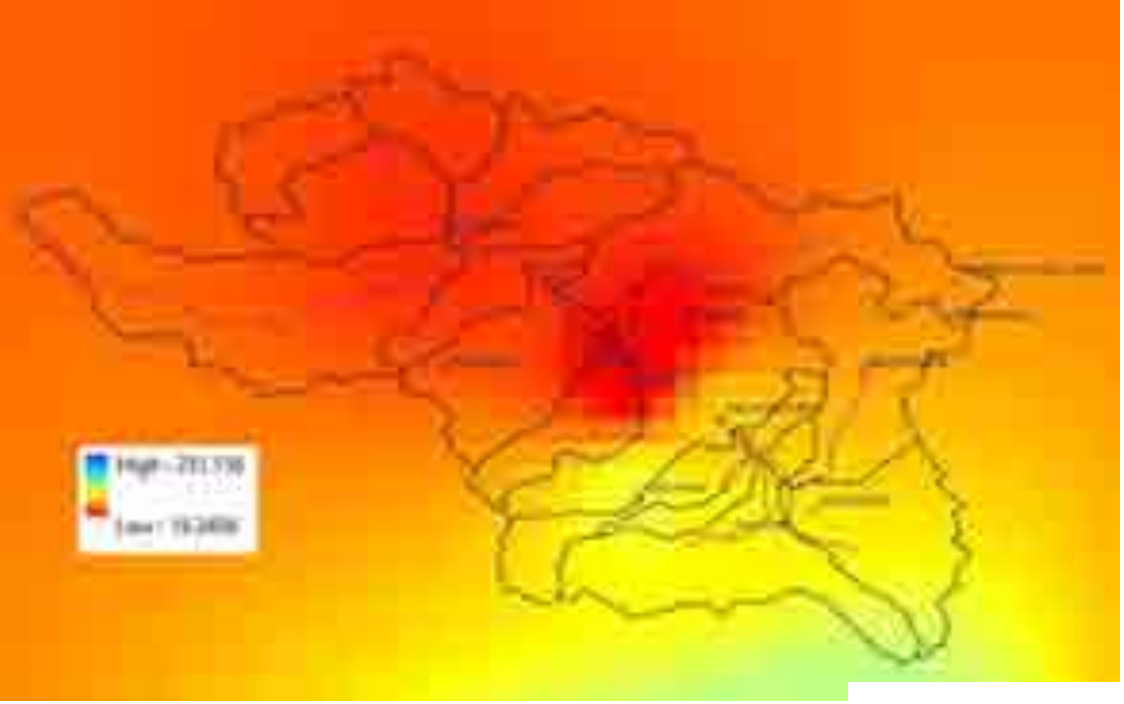
Spatial Variation of Rainfall on 3rd Sep, 2014 in mm.(Point data Source: IMD)

Input Data Used:

- IMD Rainfall grids
- DEM
- Landuse/landcover
- Soil Texture



Spatial Variation of Rainfall on 4th Sep, 2014 in mm.(Point data Source: IMD)



Spatial Variation of Rainfall on 5th Sep, 2014 in mm. (Point data Source: IMD)

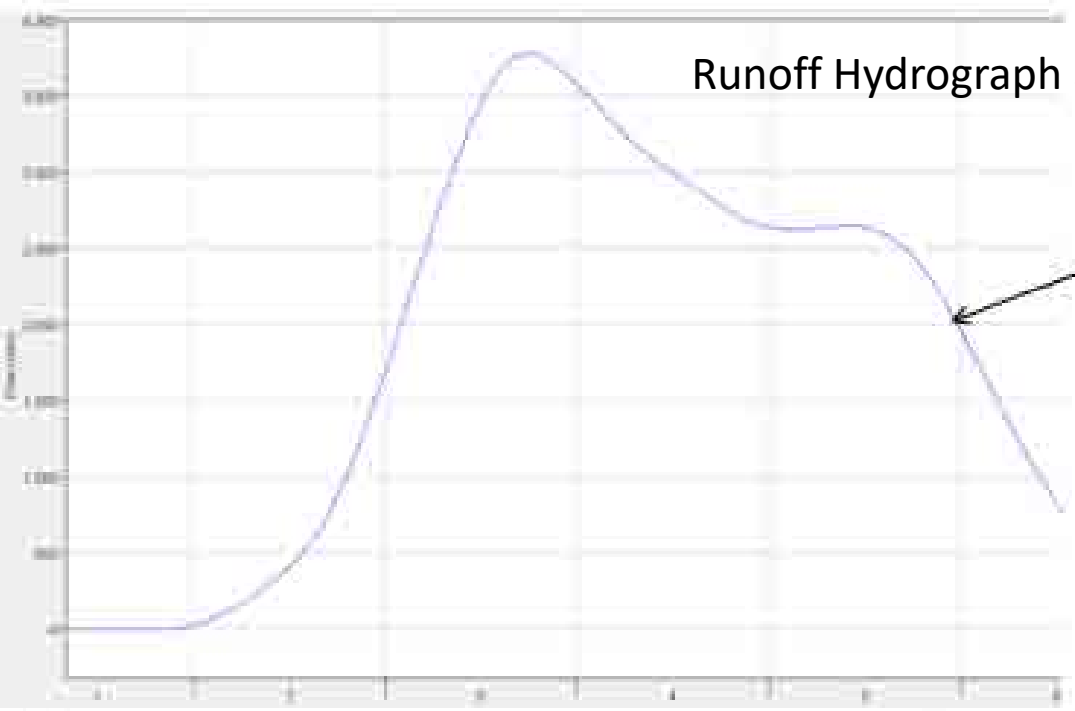
Accumulated Rainfall (3rd to 5th Sep , 2014) in each sub-basin (in mm)

Sub-watersheds of the Basin

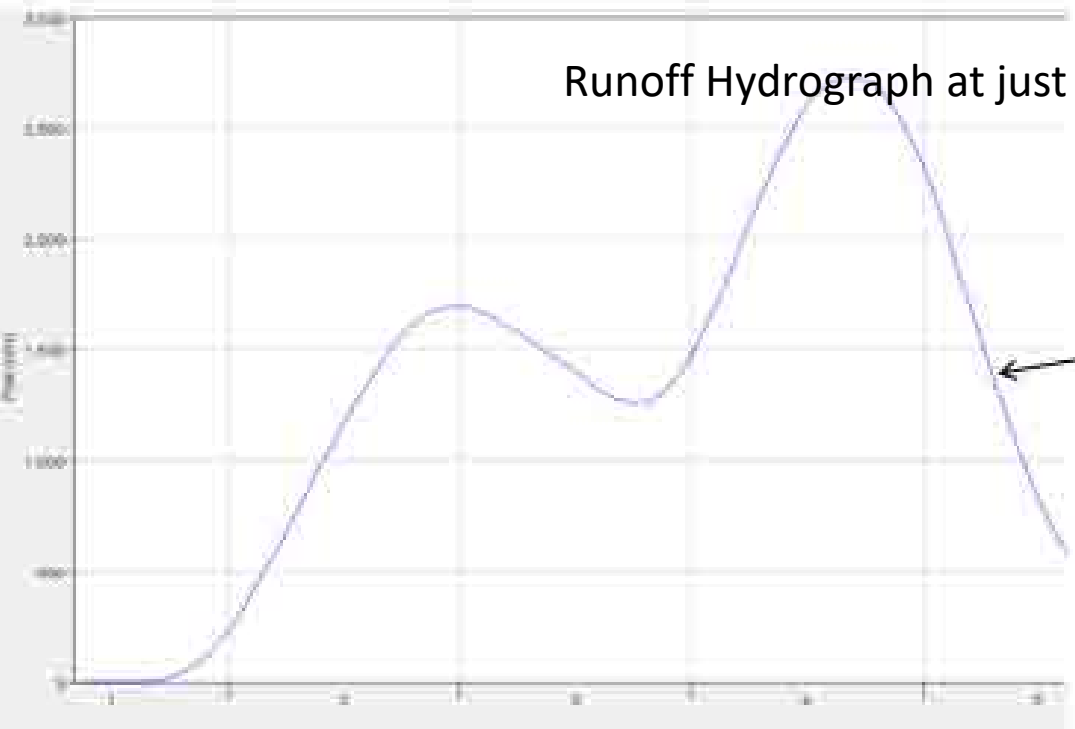
Comparison of IMD, CPC, and TRMM Rainfall

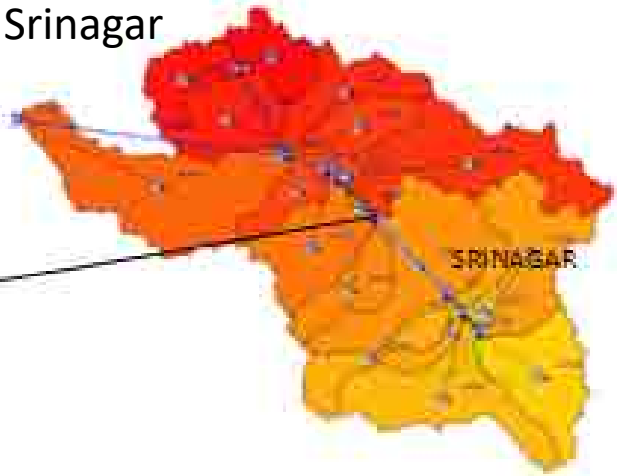
		Sep-03			Sep-04			Sep-05			Sum(3 TO 5 SEP)					
NAME	AREA(Sq.km)	CPC	TRMM	IMD	CPC	TRMM	IMD	CPC	TRMM	IMD	CPC	TRMM	IMD	CPC	TRMM	IMD
W220	522.6687	17.488	12.54	60.582	26.154	18.69	80.251	21.063	4.78	31.316	64.705	36.01	172.149	33819.3	18821.3	89976.9
W230	505.683	22.511	10.113	57.093	29.727	28.193	77.918	22.671	4.238	33.924	74.909	42.544	168.935	37880.2	21513.8	85427.6
W240	792.9009	33.834	15.936	62.125	26.725	45.731	81.913	26.553	5.314	30.452	87.112	66.981	174.49	69071.2	53109.3	138353
W250	647.757	30.465	22.652	59.477	17.196	27.651	77.747	16.534	8.146	31.782	64.195	58.449	169.006	41582.8	37860.7	109475
W260	1571.5782	21.305	32.114	51.261	62.757	98.861	69.413	100.572	11.966	38.739	184.634	142.941	159.413	290167	224643	250530
W270	503.091	37.148	22.268	57.406	25.065	33.299	71.804	25.459	8.197	31.376	87.672	63.764	160.586	44107	32079.1	80789.4
W280	446.0994	38.386	21.808	61.076	45.317	38.128	77.136	43.306	6.922	29.132	127.009	66.858	167.344	56658.6	29825.3	74652.1
W290	0.0648	33.834	15.936	62.125	26.725	45.731	81.913	26.553	5.314	30.452	87.112	66.981	174.49	5.64486	4.34037	11.307
W300	0.0486	36.121	15.601	54.569	56.195	56.51	76.716	39.554	8.495	36.876	131.87	80.606	168.161	6.40888	3.91745	8.17262
W310	2011.0437	36.121	15.601	54.569	56.195	56.51	76.716	39.554	8.495	36.876	131.87	80.606	168.161	265196	162102	338179
W320	30.0186	30.355	21.93	55.794	52.584	39.78	66.261	55.685	4.95	29.158	138.624	66.66	151.213	4161.3	2001.04	4539.2
W330	899.2377	47.213	27.156	57.838	97.185	51.65	78.63	68.805	10.719	36.242	213.203	89.525	172.71	191720	80504.3	155307
W340	49.5234	29.875	21.93	54.94	66.768	39.78	64.135	67.028	4.95	27.523	163.671	66.66	146.598	8105.54	3301.23	7260.03
W350	543.4209	49.15	32.076	55.438	111.728	56.181	77.188	90.181	15.637	39.086	251.059	103.894	171.712	136431	56458.2	93311.9
W360	1528.3728	30.096	26.921	56.979	77.883	58.816	78.371	106.598	14.135	42.836	214.577	99.872	178.186	327954	152642	272335
W370	1101.1545	15.816	35.954	46.362	72.359	110.189	86.063	155.236	30.474	52.126	243.411	176.617	184.551	268033	194483	203219
W380	321.3351	21.503	31.602	55.317	64.745	75.915	100.001	154.646	26.601	61.629	240.894	134.118	216.947	77407.7	43096.8	69712.7
W390	514.2123	51.282	34.84	63.321	119.011	63.306	120.092	137.15	22.984	73.525	307.443	121.13	256.938	158091	62286.5	132121
W400	1231.2	57.985	31.284	64.829	180.359	68.556	134.882	147.222	38.707	79.621	385.566	138.547	279.332	474709	170579	343914
W410	103.1535	28.172	31.44	42.34	75.554	67.65	104.715	150.539	28.74	64.439	254.265	127.83	211.494	26228.3	13186.1	21816.3
W420	965.4228	44.204	33.033	29.19	128.181	61.612	119.651	119.328	51.62	75.275	291.713	146.265	224.116	281626	141208	216367
	14287.9869													2792961	1499708	2687305
												WT.AVERAGE		195.476	104.963	188.081

Runoff Hydrograph at final outlet



Runoff Hydrograph at just D/S of Srinagar





Innovation !!
(survival instincts…)

What Can Help ?

- A reliable rainfall forecast system
- A robust network of gauge and discharge data over rivers.
- Sensitisation
- Technological interventions (structural and non structural measures)
- Respect mother nature.