EO Data for Disaster Management Support : *NRSC Contributions*

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Indian Context

- India/SE Asia as a natural disaster prone country/region

- Elaborate Government & Organizational Framework for Disaster Management
  - NDMA (NDRF), MHA, Local Government,
  - MOES(incl IMD), Min Water Res (CWC), GSI, Min Agric,

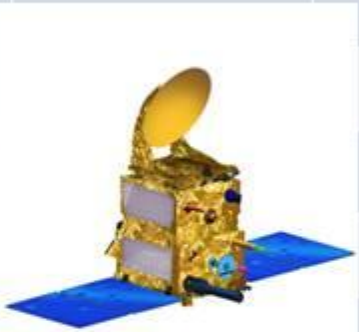
- ISRO/ Space Technology (inl. EO)
  - ISRO Disaster Management Support Program (ISRO-DMSP)

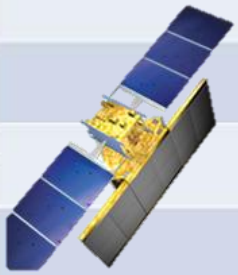
ISRO-DMSP *(Disaster Management Support Program)*

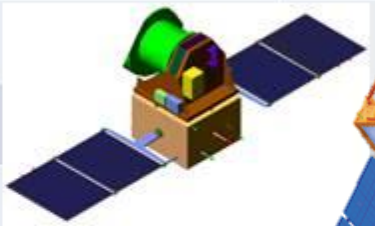
- **Comprehensive approach for use of space technology inputs for disaster management. Components include**
  - **Communication Support**
  - **Weather Monitoring Satellites**
  - **Earth observation satellites & products from their data**
    - **Decision Support Centre (DSC) at National Remote Sensing Centre**
  - **Early Warning Research with space inputs**
  - **Aerial survey (Rapid surveys, High resolution terrain products)**
  - **Geospatial Support (WebGIS, mobile-geospatial, etc)**
    - **National Database for Emergency Management (NDEM)**
    - **BHUVAN Geo-portal (www.bhuvan.nrsc.gov.in)**
  - **Support disaster management at global level**
    - **International Charter, Sentinel Asia, UNESCAP, UN-SPIDER**

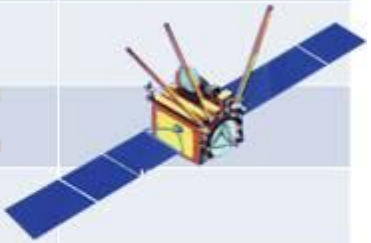
Satellites & Sensors

INSAT-3D	SARAL	RISAT-1	Megha-Tropiques	Resourcesat-2	Oceansat-2
26-7-2013	25-2-2013	26-4-2012	12-10-2011	20-4-2011	23-9-2009
Imager Sounder	ALTIKA	C-SAR	(MADRAS) SAPHIR SCARAB ROSA	AWiFS, LISS III, IV	Scatterometer, OCM, ROSA
Geo	Polar	Polar; 6am-6pm	Equatorial	Polar	Polar; Noon









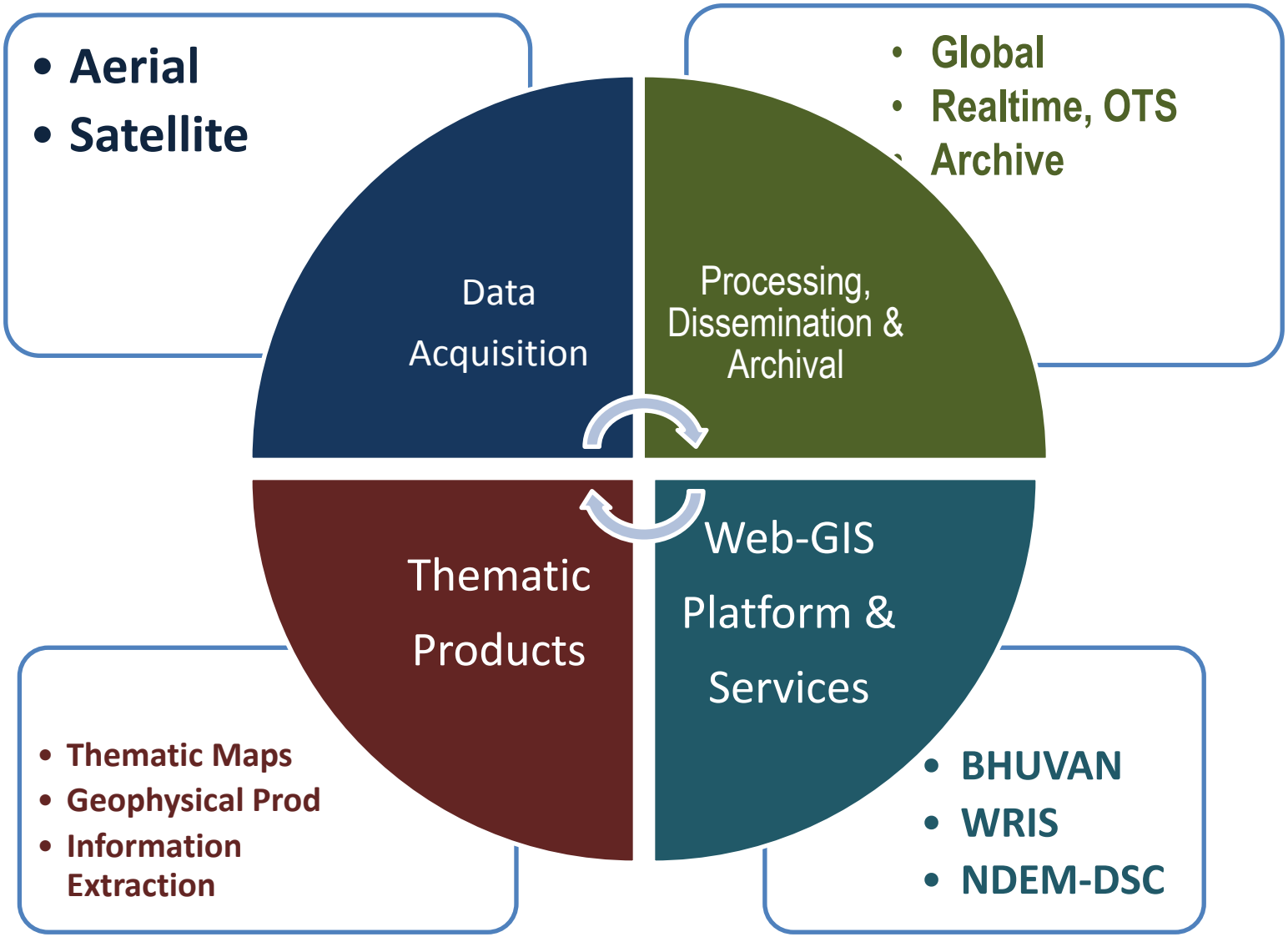
+ Kalpana

National Remote Sensing Centre (ISRO)

- Estd 1974, *National Remote Sensing Agency (Dept. Sci & Technol.)*
  - ***Aerial Surveys, Training (Indian Photo-interpretation Institute), Landsat Ground Station, 1979***
- 1980-2008
  - **EO Data Acquisition, Processing & Sales, RS Application Projects for Ministries, R&D, Training, Aerial Survey Projects for Users**
- **2008-**
  - Converted as NRSC, a ISRO Centre on Sep 1, 2008; Regional Centres (West, Central, East, South)
  - **Re-engineered EO Data Acquisition, Processing & Archival, Global EO data acquisition, Antartica Ground Station, National Programs on Natural Resources, Disaster Information Services, Aerial Surveys with ALTM, LFDC**

- Six campuses, HYDERABAD, Shadnagar (Ground Station), and *Regional Centres* at Jodhpur, Kolkata, Nagpur and Bangalore

NRSC Geospatial Activities



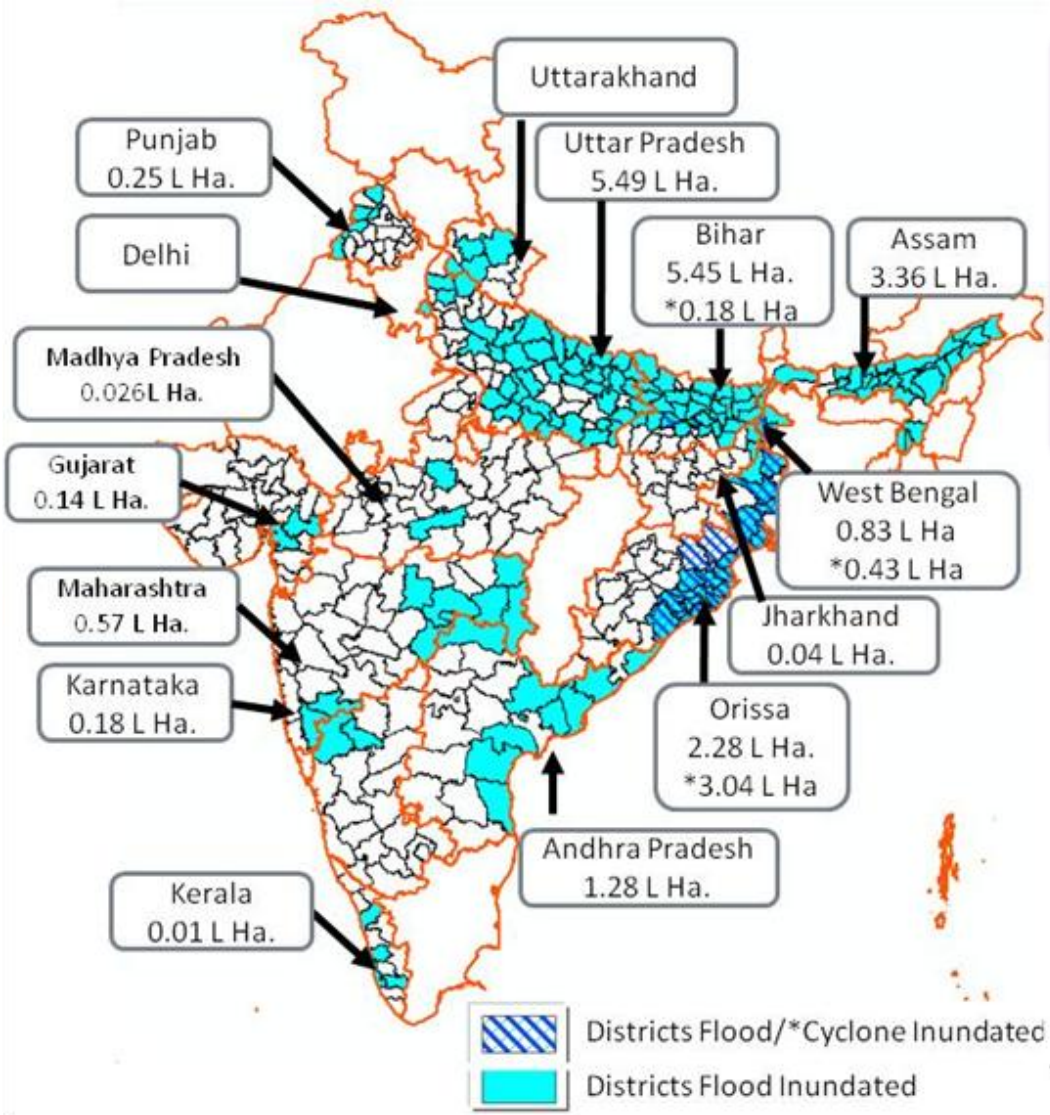
Activities in Flood Management

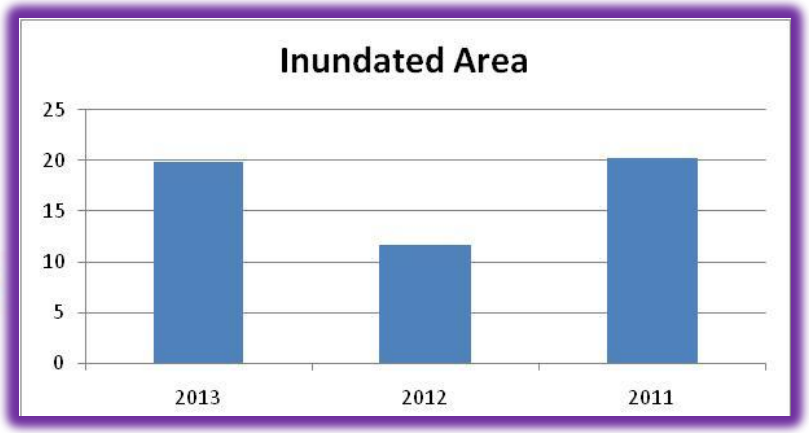
- Produce duration of inundation maps and merge with terrain to provide Depth Class of Inundation
  - Experimental
- Use multiyear inundation to estimate Satellite-based cumulative flooded area
  - Only Flood in plains preliminary estimate ~ 10 Million ha (1998-2013)
- Use multi-year flood inundation to produce 'Flood Hazard Zonation'
  - Assam and Bihar released (available on www.bhuvan.nrsc.gov.in)
- Use models with inputs from current stage, forecast of rain to produce 'flood prediction'
  - Demonstrated in Godawari
- Use stage & flow of flood prediction for spatial prediction of flood.

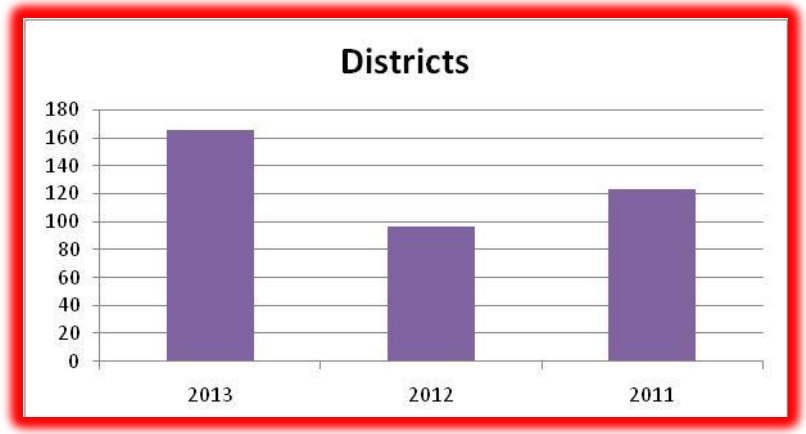
Flood Inundation Mapping - 2013

nrsc

15 States -19.91 L ha.-165 Districts - 144 Maps





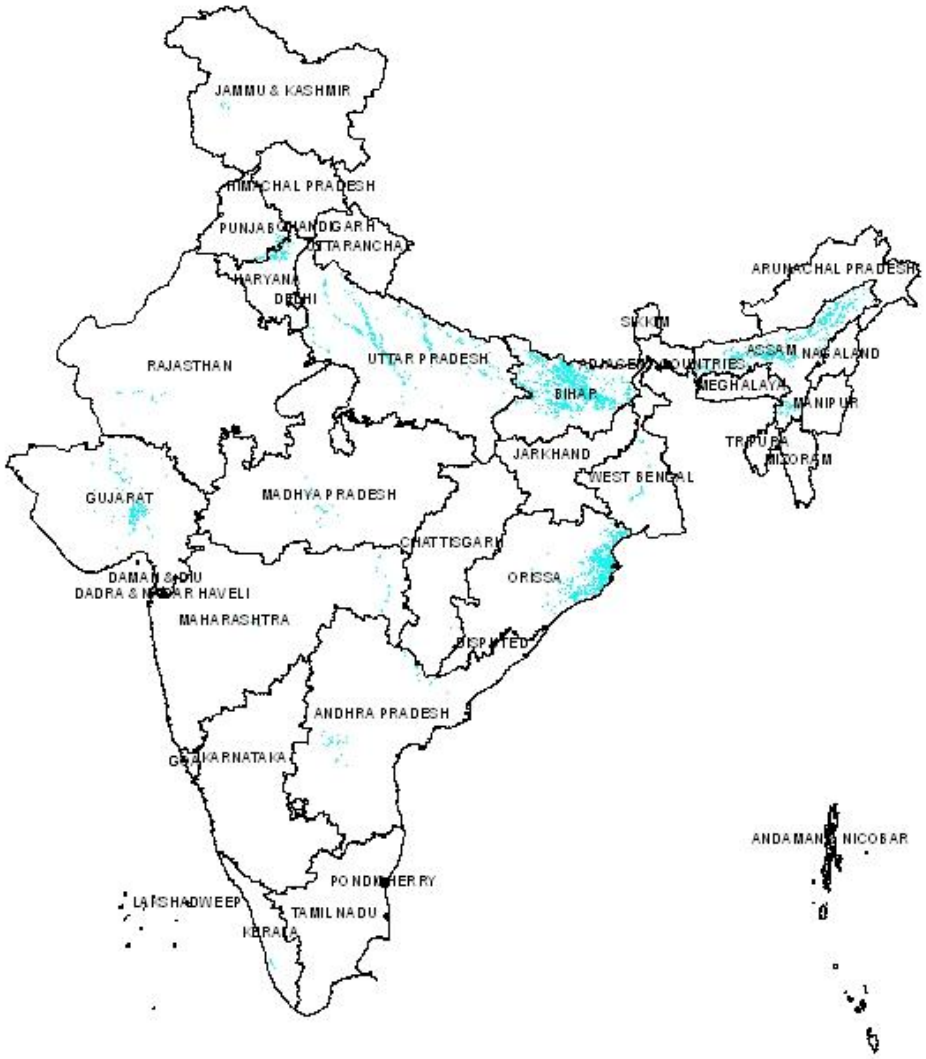


Users:
- **Ministry of Home Affairs**
- **State Relief Commissioners**
- **IMD, CWC, NDMA**

Flood Prone Area Assessment

Flood Prone Area (Ver. 1.0)

1. Satellite Data - 10 years (2003-12)
2. Layer preparation (plains) based on
   - CWC HFL info for major rivers
   - NRSC Flood info for other areas
3. Layer being finalised (21 States)

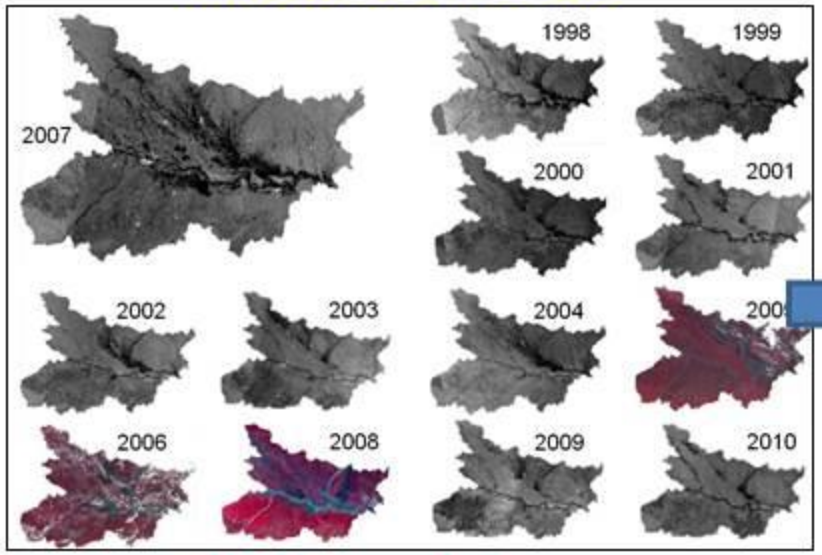


Next Steps

- Hilly regions are to be included (which are not included in version 1.0)
- This will be addressed using Carto-DEM / ACE-SRTM and CWC HFLs

Bihar Flood Hazard Atlas

13 Years (1998-2010)
128 satellite datasets



Broad Methodology

- Generation of flood layers from satellite data
- Preparation of annual flood layers (13 years)
- Integration and classification of flood layers of various flood hazard categories

Information Provided

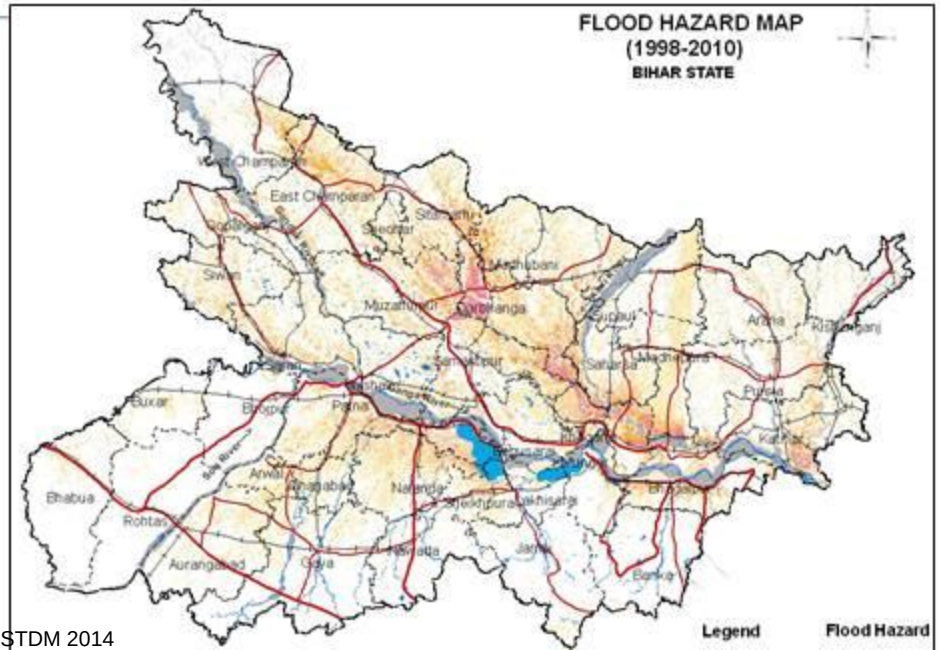
A Flood Hazard Atlas showing

- District-wise Flood Hazard Area,
- List of villages in high & very high flood hazard categories,
- Flood hazard index for all districts

Flood Hazard Index

∑ (Hazard Category (Hw)
X Hazard Area (Aw))
X Intra Annual Variations (IAVw)

Hw = Weightage for Hazard Category
Aw = Weightage for % Hazard Area
IAVw = Weightage for intra annual variation



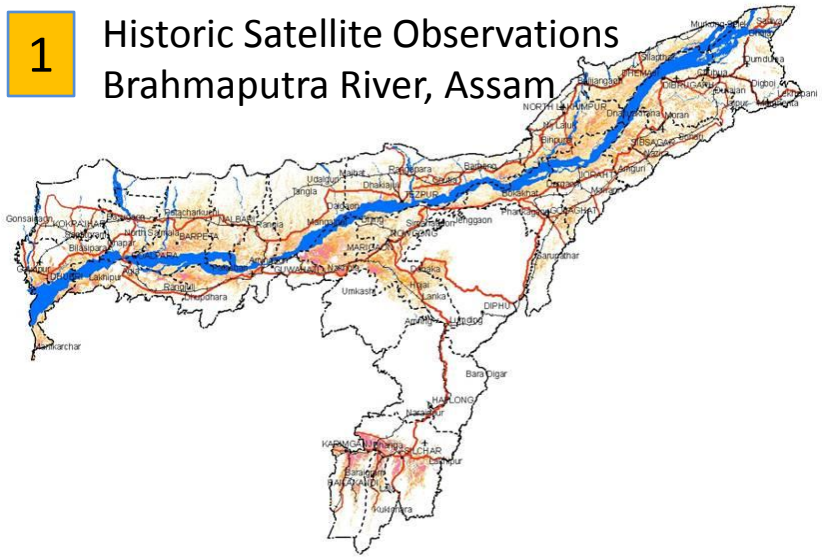
Flood Prone Area Assessment

Methods of Assessment

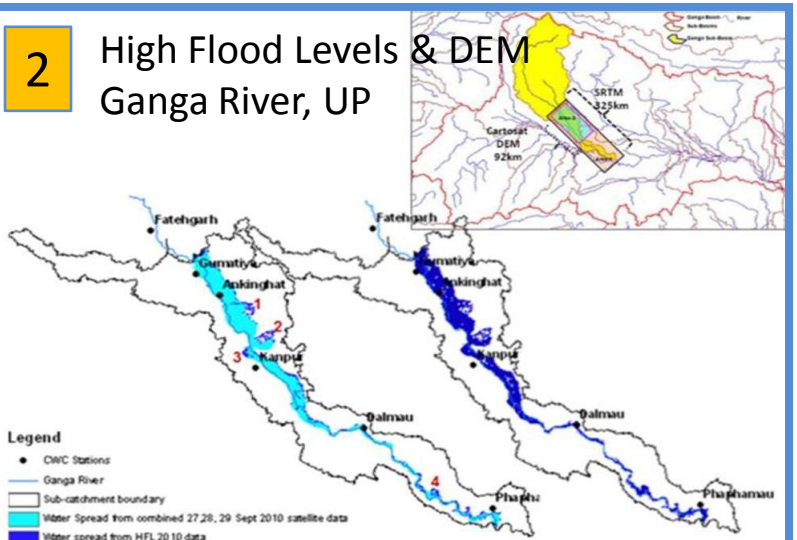
1. **Historic Satellite Observations**
2. **Integration of Flood Level with DEMs**
3. **Hydraulic Modelling**

DSC is in the process of bringing out the flood inundated area of the country based on satellite data of 2003-2012, as a first step towards flood prone area assessment

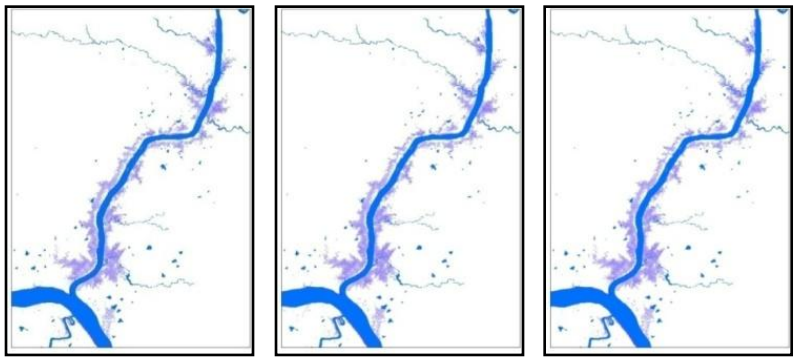
1 Historic Satellite Observations
Brahmaputra River, Assam



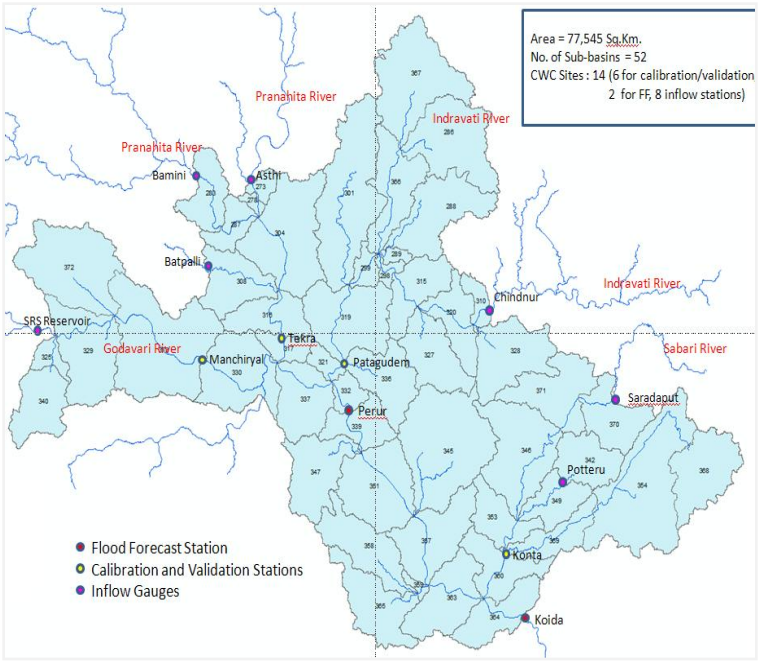
2 High Flood Levels & DEM
Ganga River, UP



3 Hydraulic Modelling, Sabari River



Flood Forecast Model for the Godavari Basin & Real-time Simulations



Static Data

- Landuse/landcover, Soil texture, DEM

Derived Parameters:

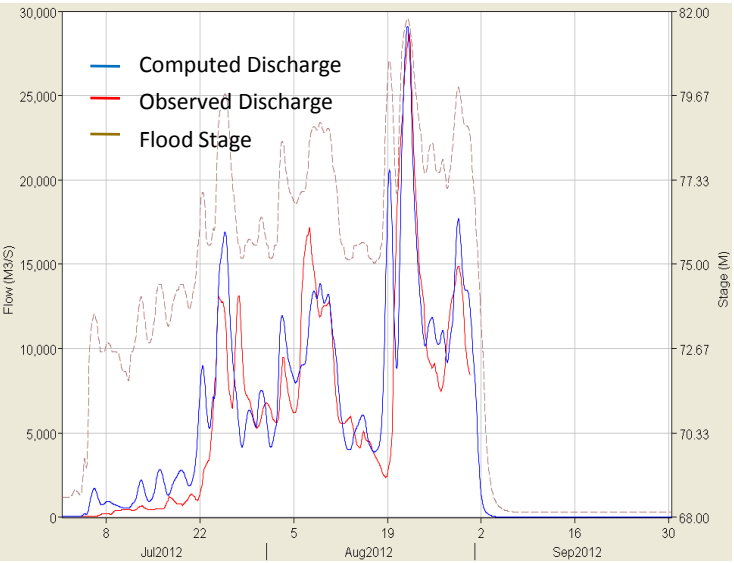
Topographic and Hydraulic Parameters of sub-basins and Channels

Dynamic Data

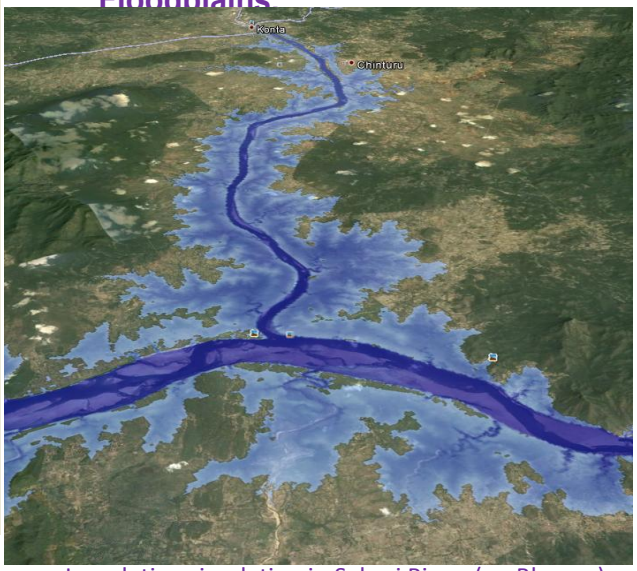
- Real-time 3 hr. Rainfall and discharge data (during 2010&11 from CWC)
- Daily Rainfall Data in near real-time from IMD of 2012.
- Rainfall forecast grids at 3 hr frequency from IMD, New Delhi
- Monthly ET data, and Rating curves

Real-time validation at CWC, Hyderabad

- The model was calibrated, validated and operationally used in 2010 and 2012 using real-time hydro- met. data obtained from CWC and IMD.
- Flood alerts were given to CWC and DMSP during the 2012 monsoon season.
- Inundation simulations were done using ALTM DEM of Sabari Floodplains



Flood Forecast Hydrograph at Perur



Inundation simulation in Sabari River (on Bhuvan)

Modelling Environment:

HEC-HMS, HEC-Geo HMS, HEC-RAS, HEC-Geao RAS (public domin softwares)

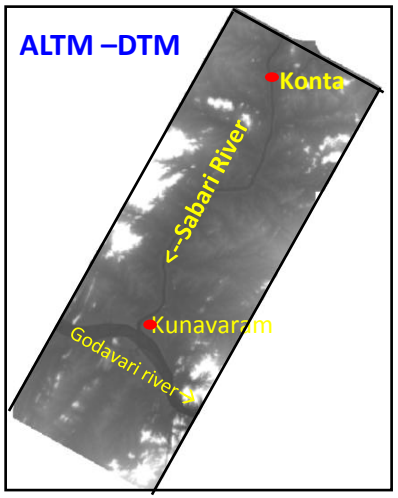
Flood Inundation Modelling

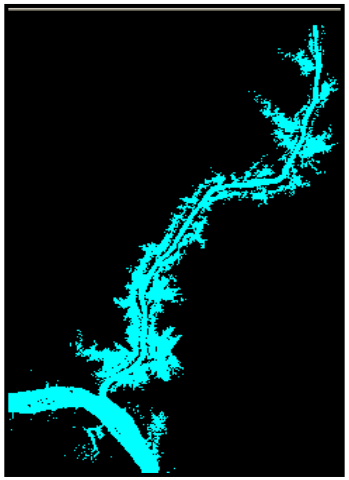
Input data: ALTM-DTM, Hydrological data LU/LC data, Contour interval -0.5m

Objective:
To simulate flood inundation for part of Sabari river in Godavari River basin using HEC Hydraulic model using ALTM DTM and to validate the results with Satellite data.

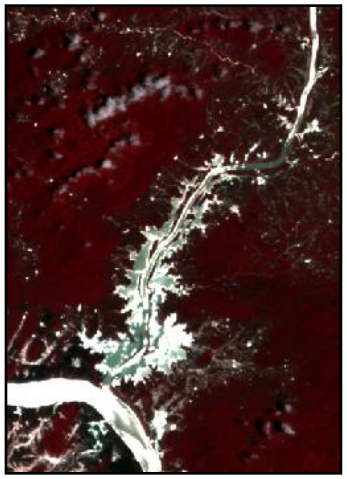
Study area : Sabari tributary from Konta to Kunavaram (35 km) stretch.

Study area

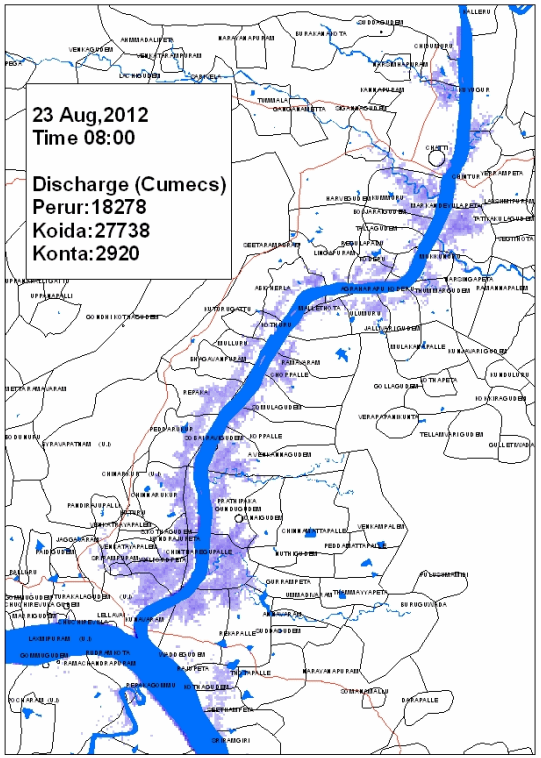




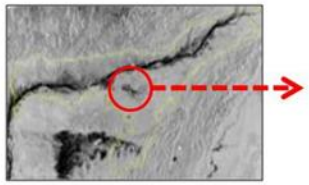
Simulation Results
23 Aug,2012
Time 06:00



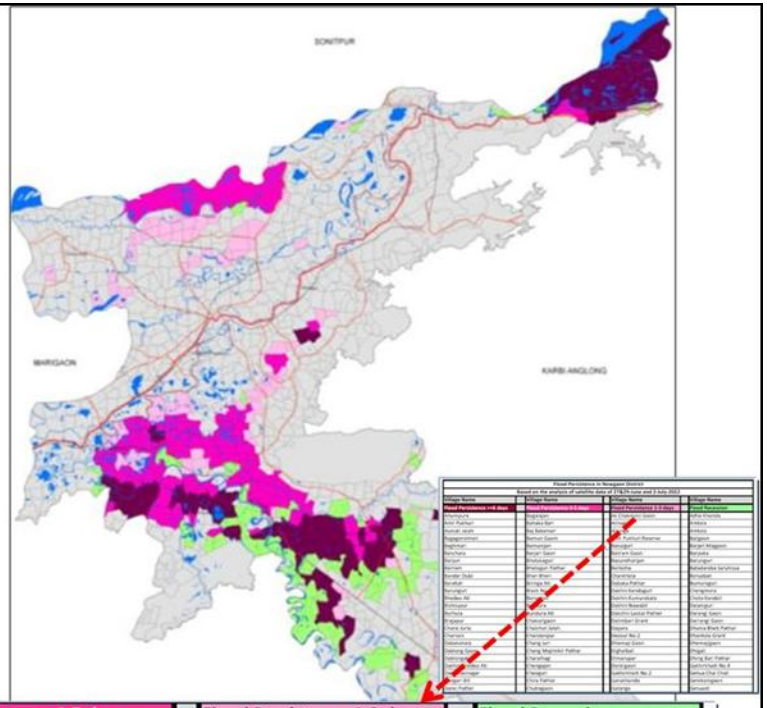
Resoursesat-2
23 Aug,2012
Time 10:30



FLOOD STUDIES : MORE PARAMETERS



This map shows the flood persistence in different villages of Nowgong district. This is derived based on the analysis of satellite data of 27&29-Jun and 02-Jul, 2012

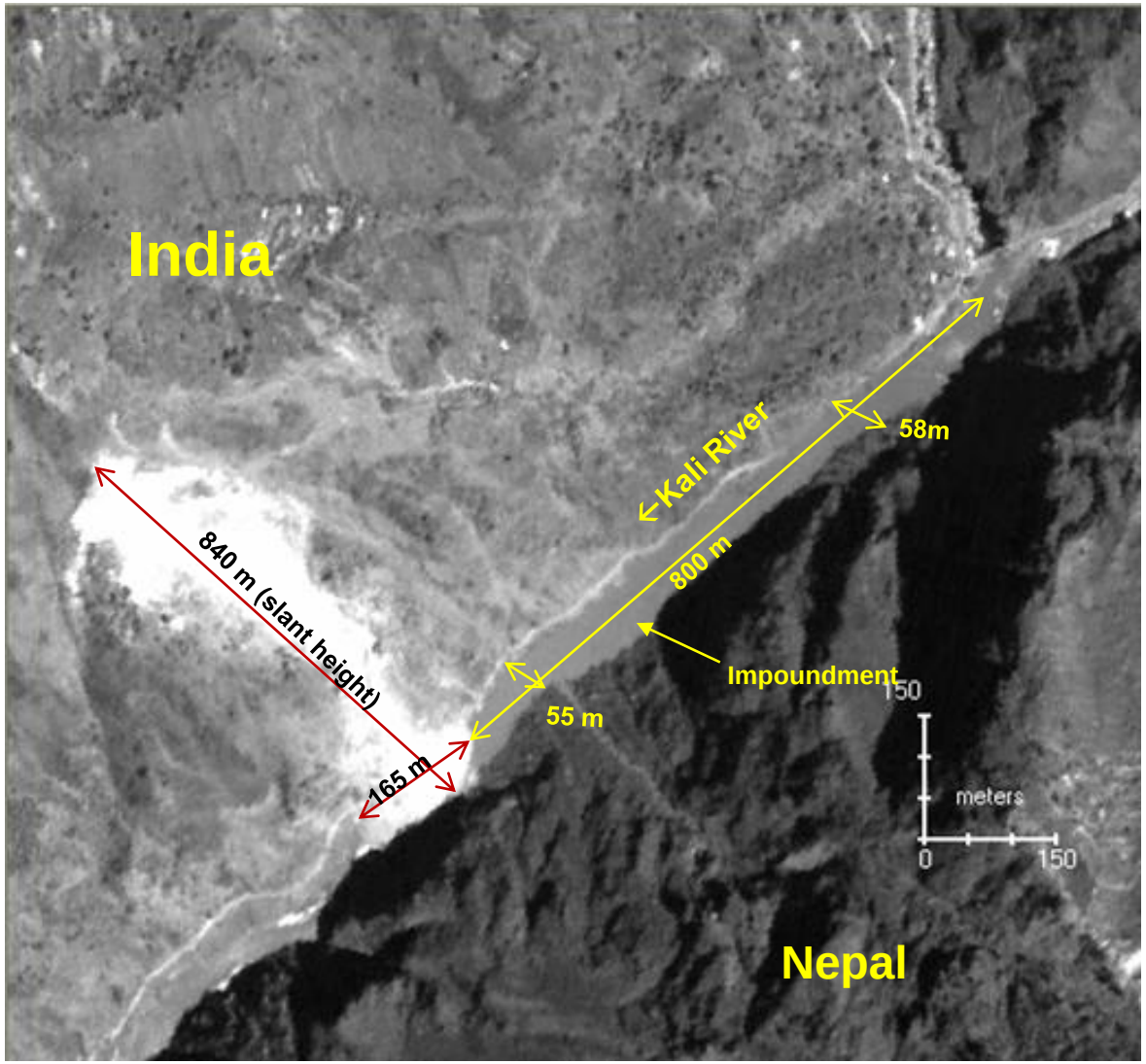


Flood Persistence >=6 days	Flood Persistence 4-5 days	Flood Persistence 1-3 days	Flood Recession
Ahumpura	Bagalajan	Ak Chakmikir Gaon	Adha Khonda
Amli Pukhuri	Bahaka Bari	Alinagar	Amtola
Auniati Jalah	Baj Batamari	Alisinga	Amtola
Bagagoroimari	Bamun Gaom	Amli Pukhuri Reserve	Baligaon

FLOOD PERSISTENCE

FLOOD DEPTH

Landslide studies

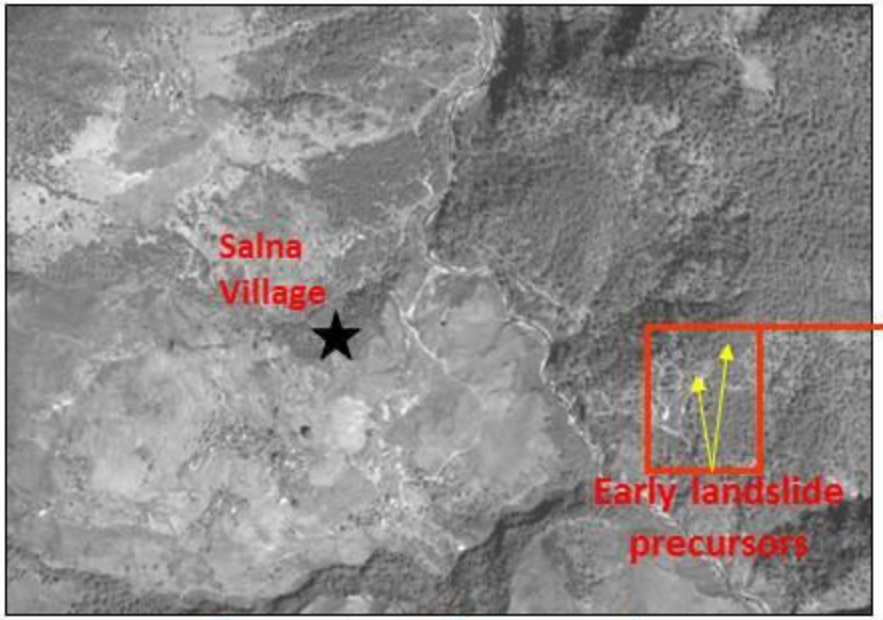


- Landslide inventory
- Hazard Zonation
- Risk assessment
- Transport corridors: monitoring
- Early Warning

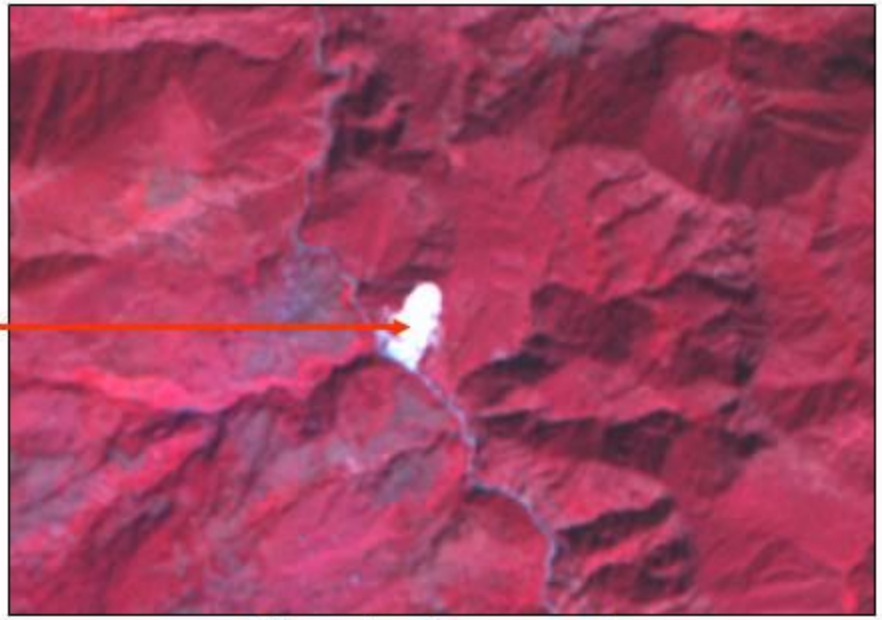
Landslide on Kali River
In Pithoragarh District,
Uttarakhand
Cartosat-1 (April 11, 2009)

Landslide detection

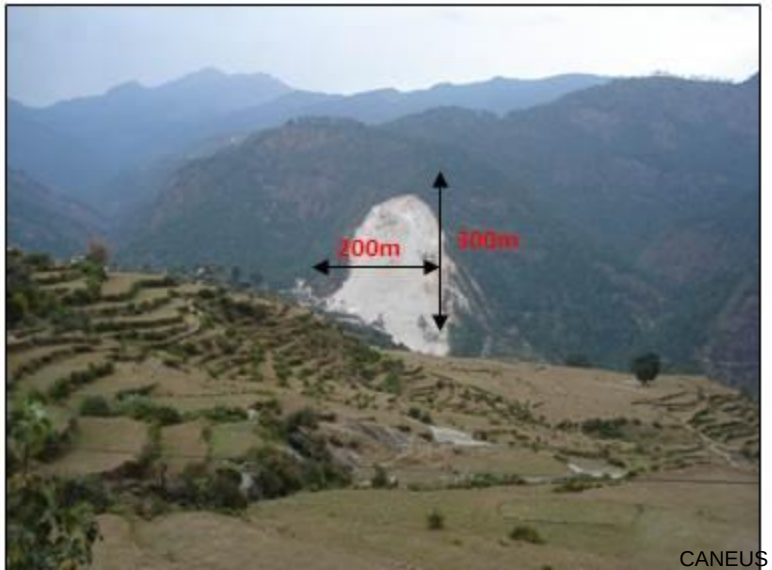
Pre Landslide cartosat -1 image



Post Landslide Resourcesat -1/LISS III image



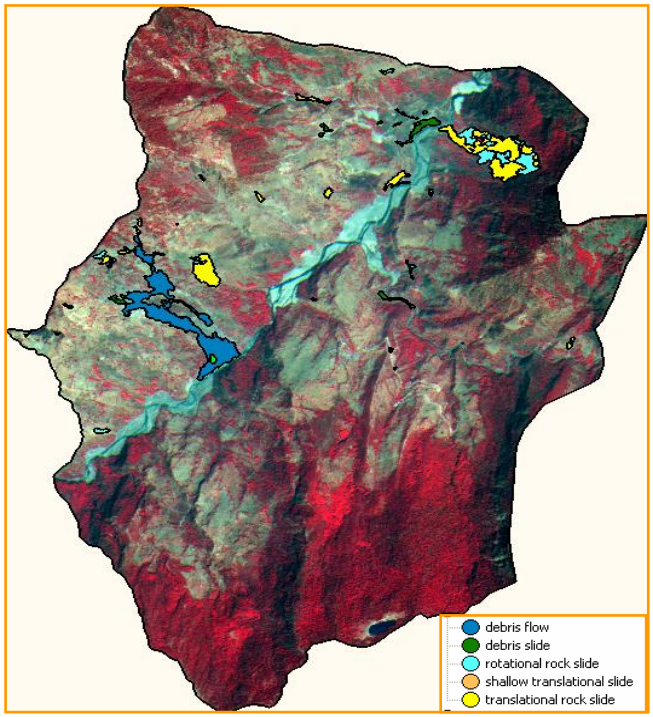
Panoramic view from ground

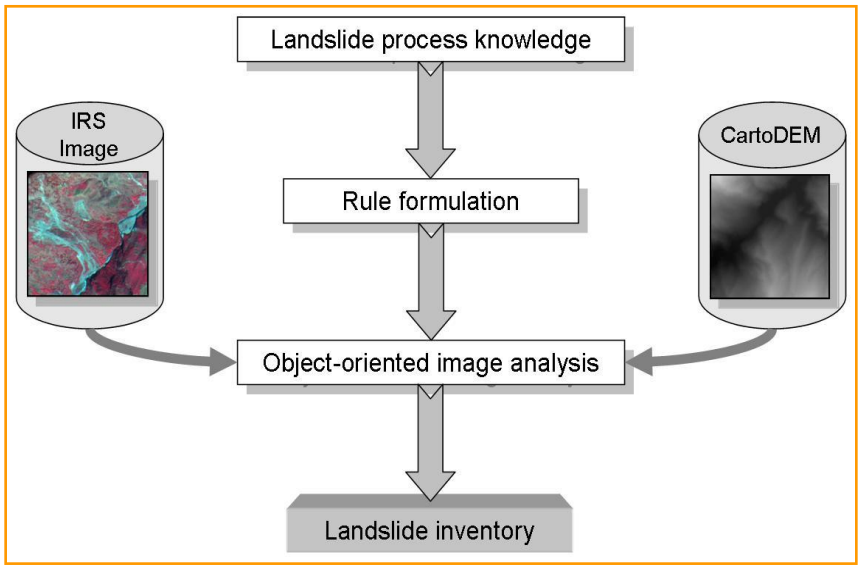


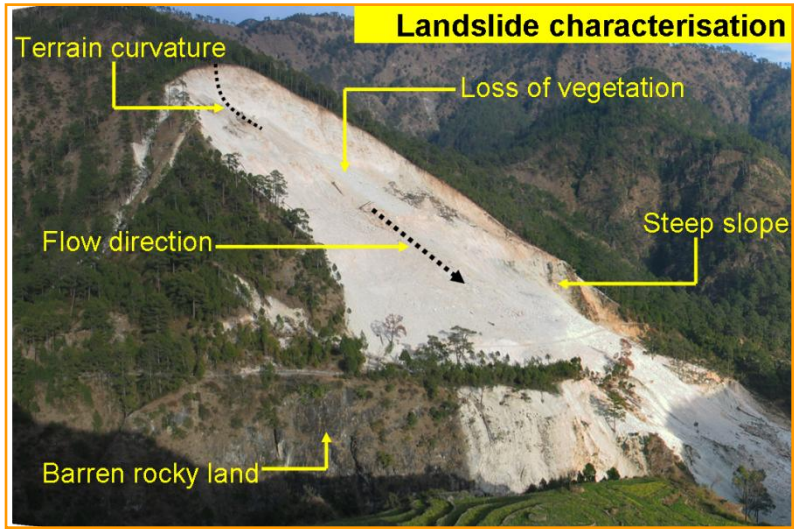
Close view from ground

Landslide Characterization & Inventory

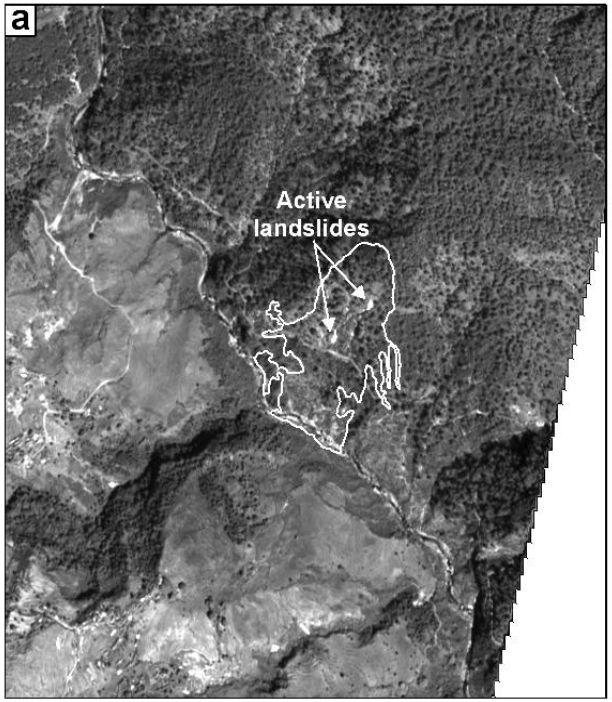
- **Semi-automated EO data analysis**
  - Image analysis is done in an object-based environment.
  - Knowledge based spectral-spatial-morphometric method is used.
  - IRS-P6 LISS IV Mx is used for characterisation of landslides.
  - CartoDEM is used for classification of landslides.

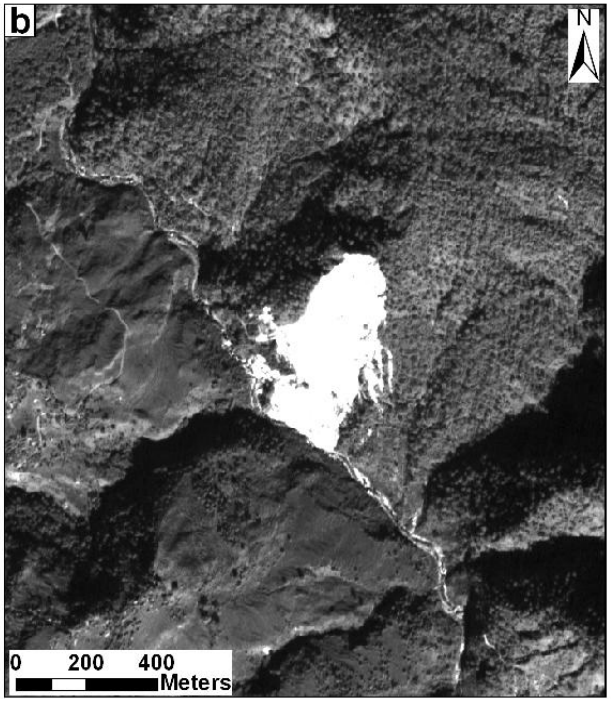


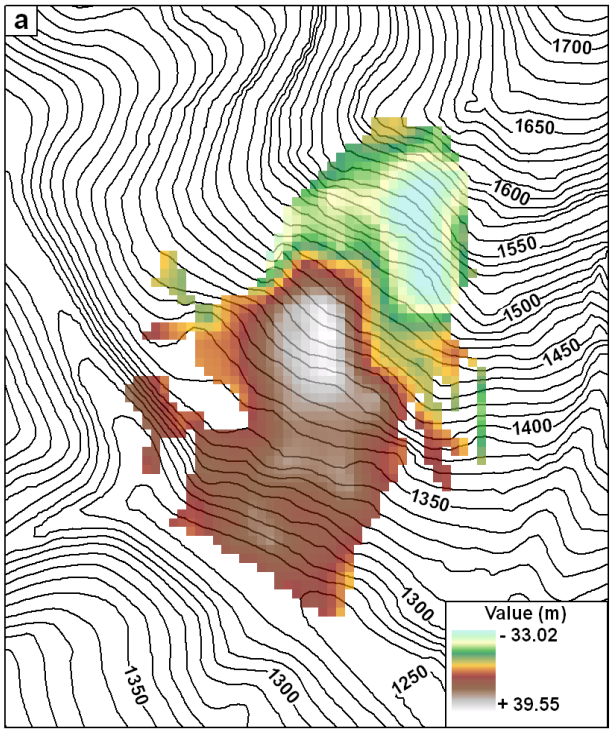


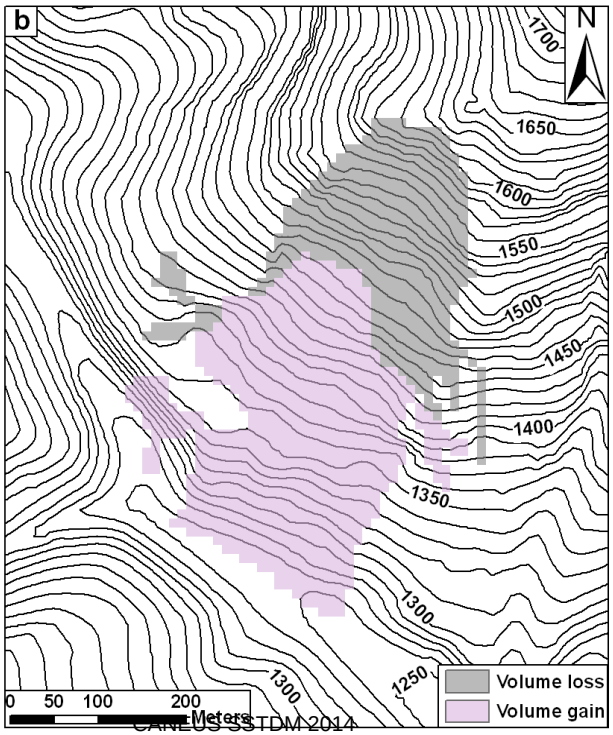


Estimation of landslide volume from CartoDEM



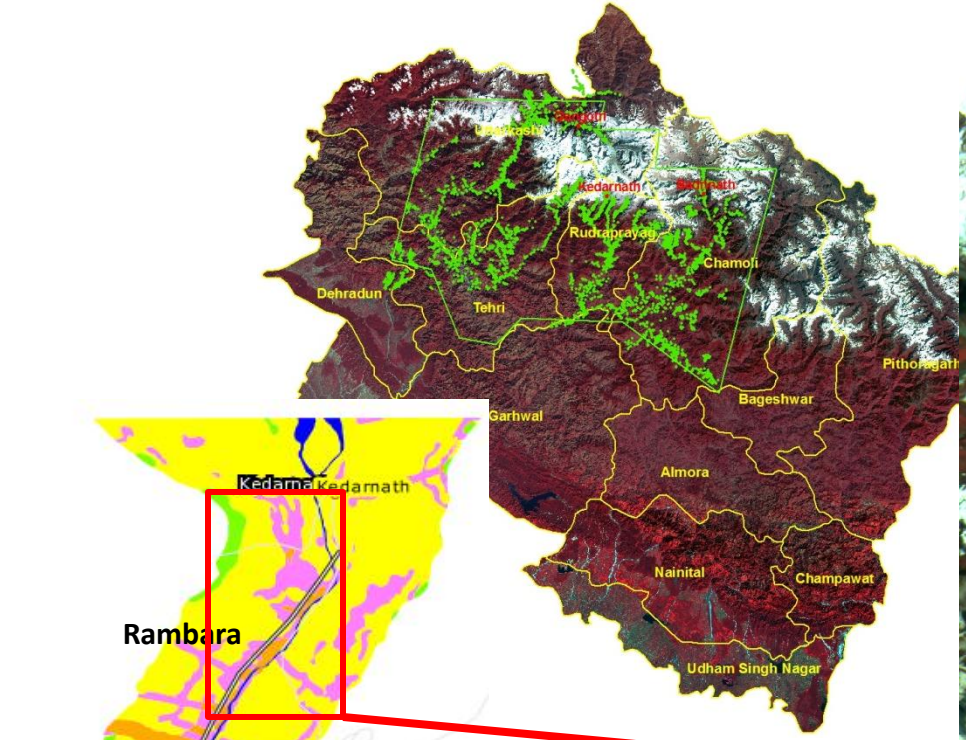




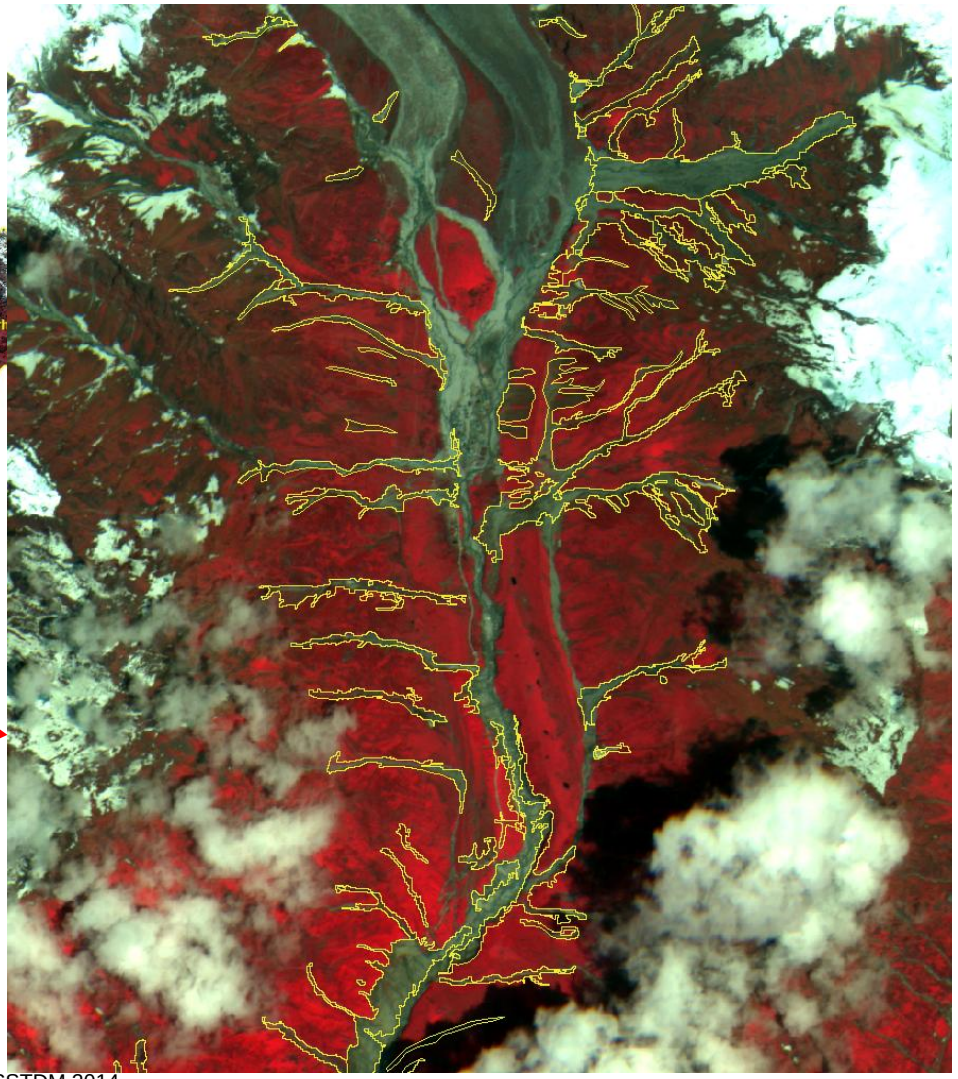


Landslide Inventory

- Landslide Inventory post high rain event carried out. More than 5,000 landslides affecting 12,500 sq km are mapped.

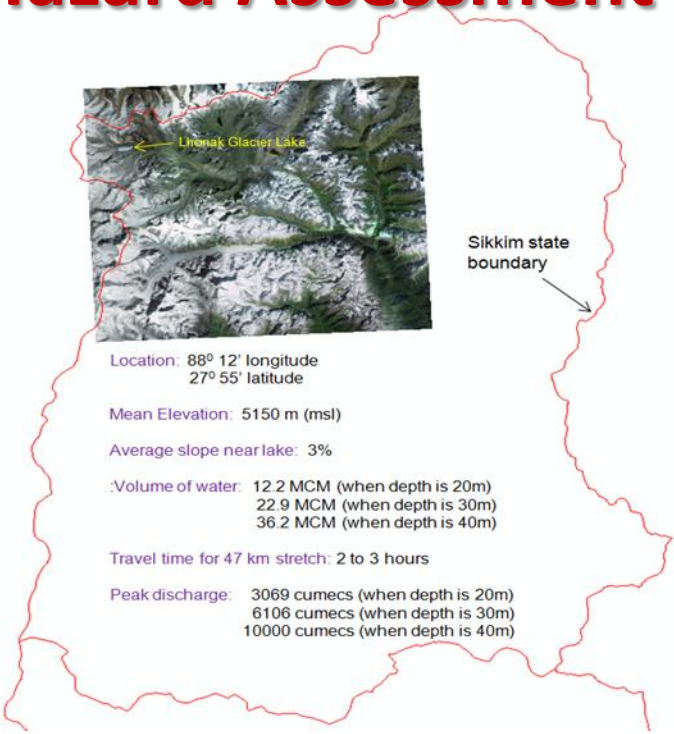


LHZ map prepared in 2001

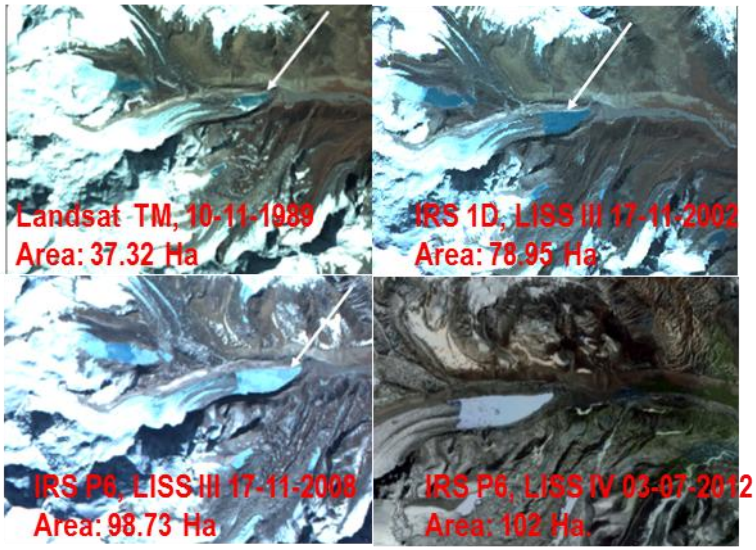


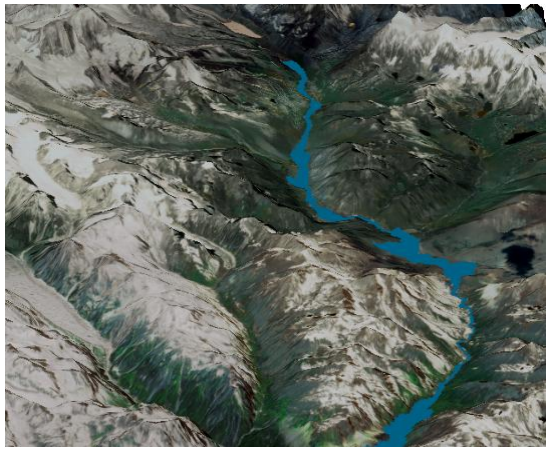
South Lhonak Lake (Sikkim) : Hazard Assessment

- **Approach : Earthen Dam/Embankment Breach Analysis (Froehlich Method)**
  - Breach Parameters: Avg Breach Width, Time to Peak, Peak Flow, Vol. water stored, etc.
  - Topographic parameters computed: River cross section profiles (CARTODEM), manning's roughness parameters (using LULC of 2010)
  - Hydraulic parameters computed: Velocity of flow, water level, and discharge of flow at every cross section, flood hydrographs for different scenarios (for assumed possible depth of water in the lake), and flood inundation simulations under different scenarios.
- **Results**
  - Depth of inundation varies from 3 to 5 m when the discharge is 10,000 m 3/s
  - Peak discharge will occur within one hour in case of sudden failure of the earthen dam



Growth of the lake as viewed by RS Satellites



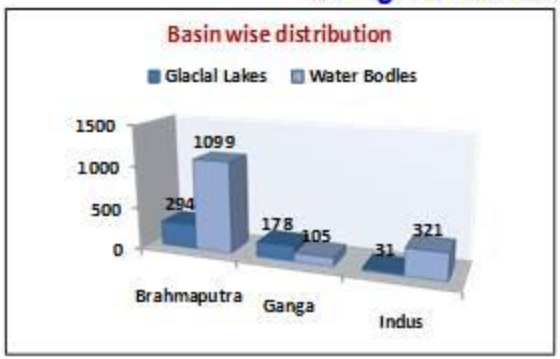


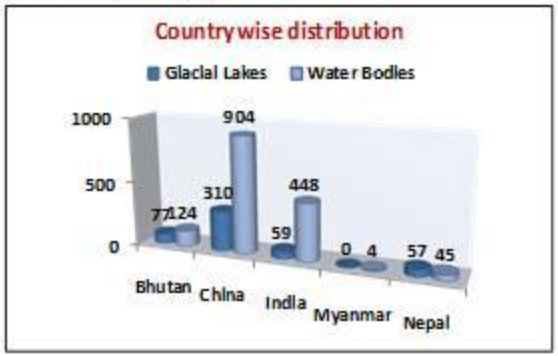
Possible flood inundation simulation in case of Sudden failure of the earthen dam (at 10000 m ^{3}/s)

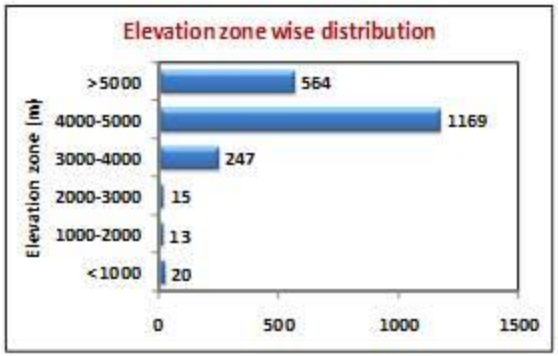
Inventory, monitoring of glacial lakes & water bodies in Himalayan region

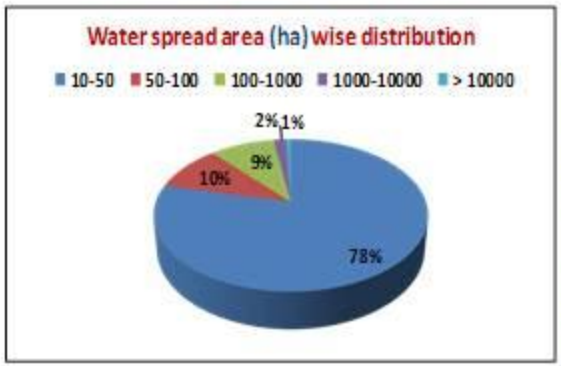
- Inventory of glacial lakes/water bodies in the Himalayan region of Indian River basins using satellite data (spatial extent > 10ha)
- Monitoring the spatial extent changes of the lakes/water bodies (> 50ha) on monthly basis during June to October months for 5 years, succeeding the inventorying year

Inventory of glacial lakes/water bodies - 2009
Using Resourcesat-1 AWiFS Data









Status of glacial lakes/water bodies - 2011

Month	No. of GL/WB monitored	Water Spread Area		
		Increase	Decrease	No Change
Jun	178	49	20	109
Jul	125	36	17	72
Aug	153	73	23	57
Sep	243	93	56	94
Oct	360	114	97	149
Jun-Oct	391	218	35	138

Total Monitored - 433

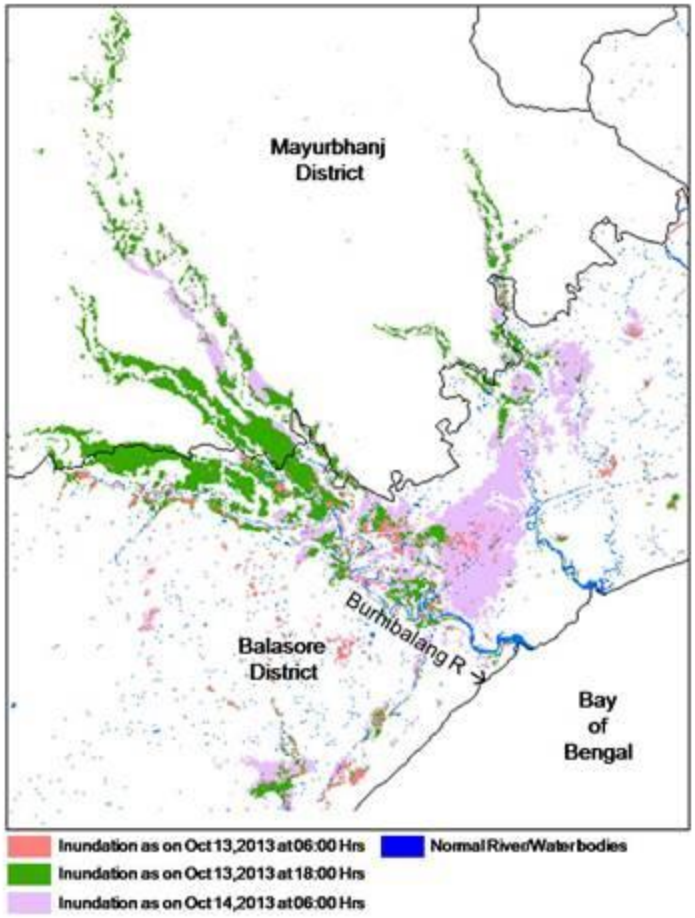
Status of glacial lakes/water bodies - 2012

Month	No. of GL/WB monitored	Water Spread Area		
		Increase	Decrease	No Change
Jun	267	40	126	101
Jul	217	48	73	96
Aug	240	16	128	96
Sep	305	5	200	100
Oct	370	15	228	123
Jun-Oct	391	88	110	190

Total Monitored - 409

EO Data Applications post PHAILIN Landfall

- Monitoring of inundation
- Detection of damage to structures
- Crop damage
  - Inventory of inundated rice crop



1-Central Warehousing Corporation - Godowns

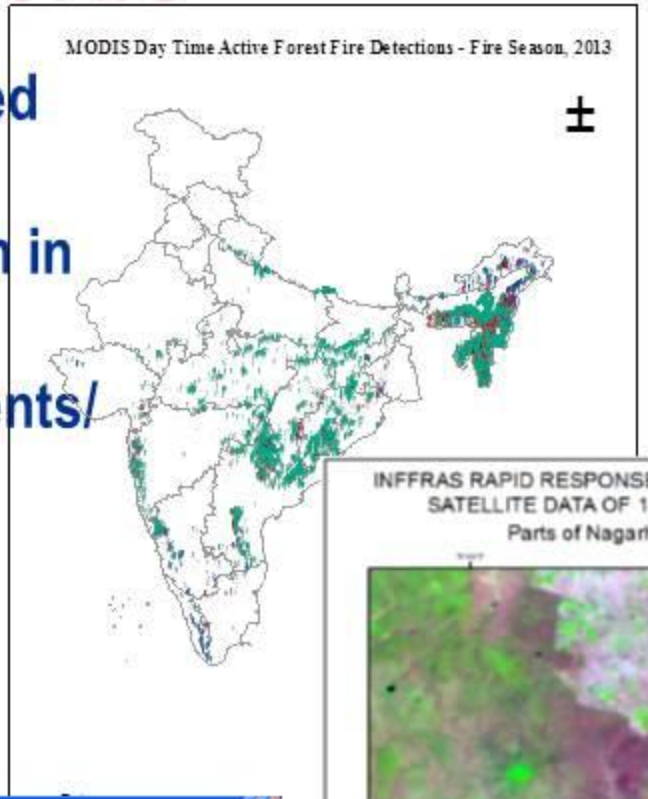
Arrow ( ) indicates damaged roof tops

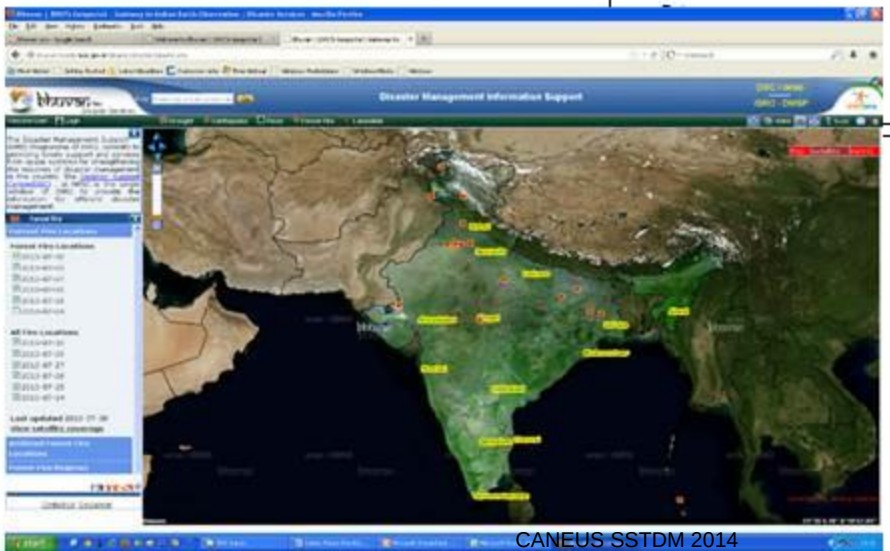
Forest Fire

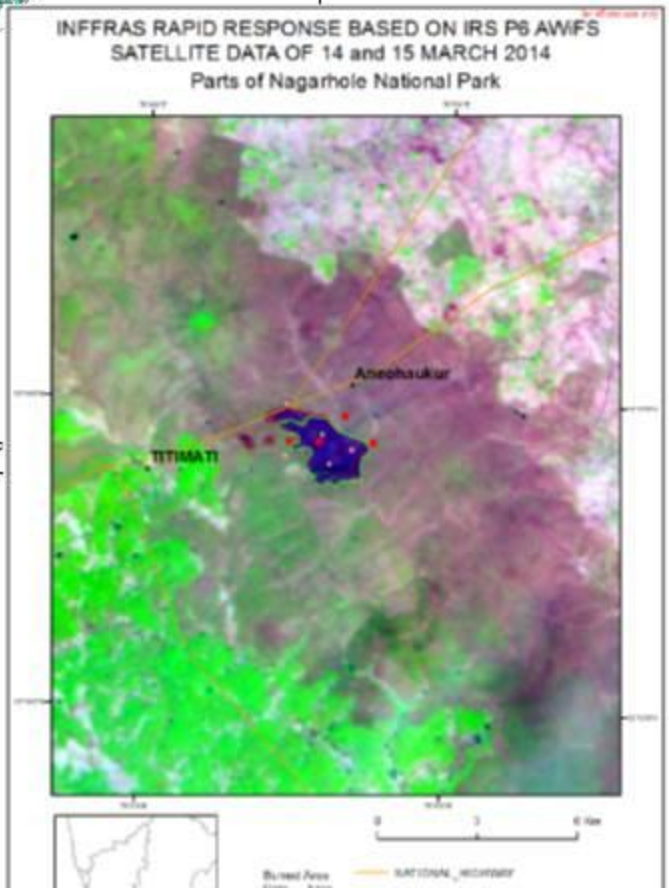
- Use of RS for near real time fire detection (< 30 min of acquisition of MODIS, 4 times/ 24 h
- Rapid dissemination to FSI/field managers
- Research studies on burnt area mapping (post facto analysis)
- Fire regimes, fire hazard zonation

Forest Fire

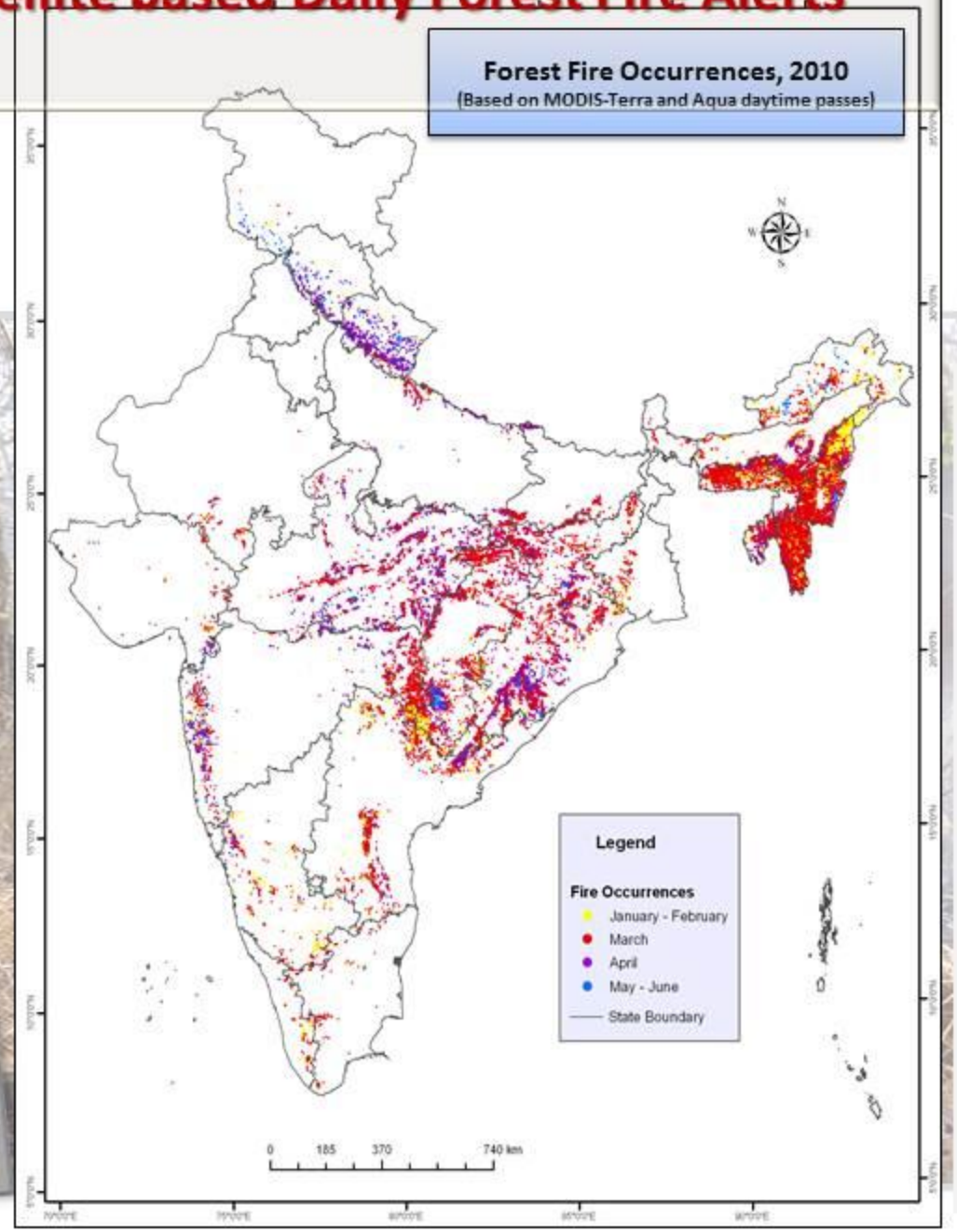
- Active Fire Detection by automated workflow (30min)
- Forest Fire location dissemination in near-real time through sms
- Burnt Area Mapping for major events/ on requesT
- Forest Fire Regime : Web tool on BHUVAN



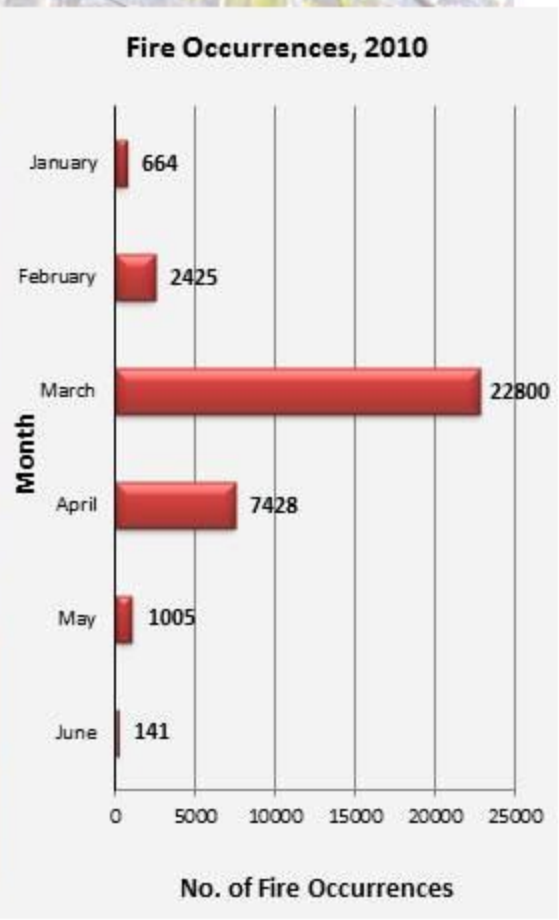




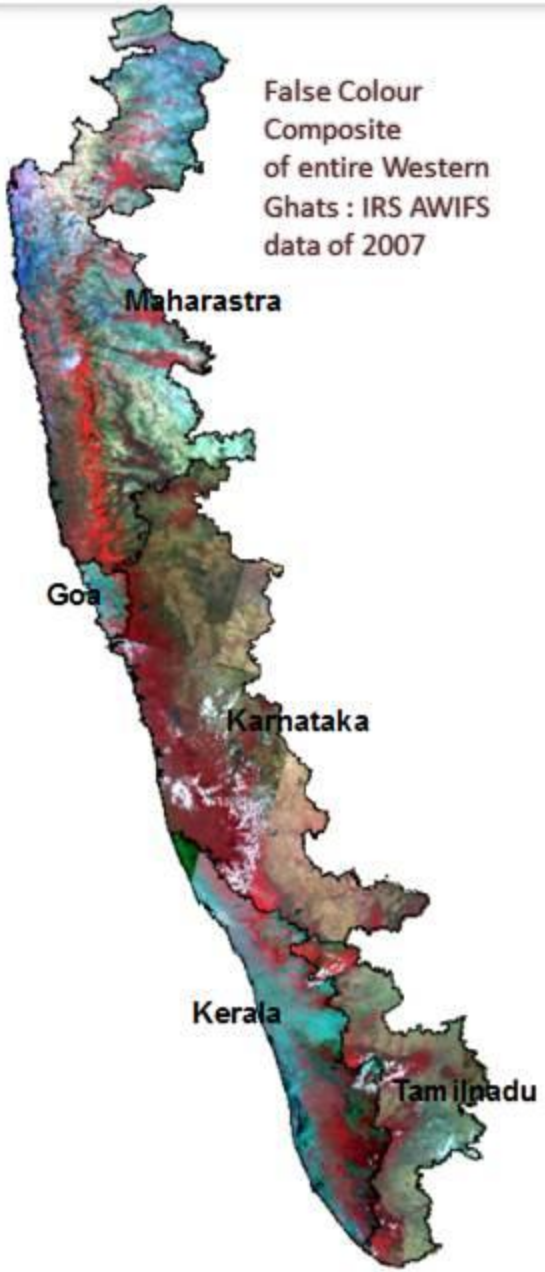
Satellite based Daily Forest Fire Alerts



- MODIS – Terra & Aqua based daily fire alerts generated and transmitted within 1 hr of over pass
- 600 field duty officers receives by e-mail
- Also posted on NRSC website and BHUVAN

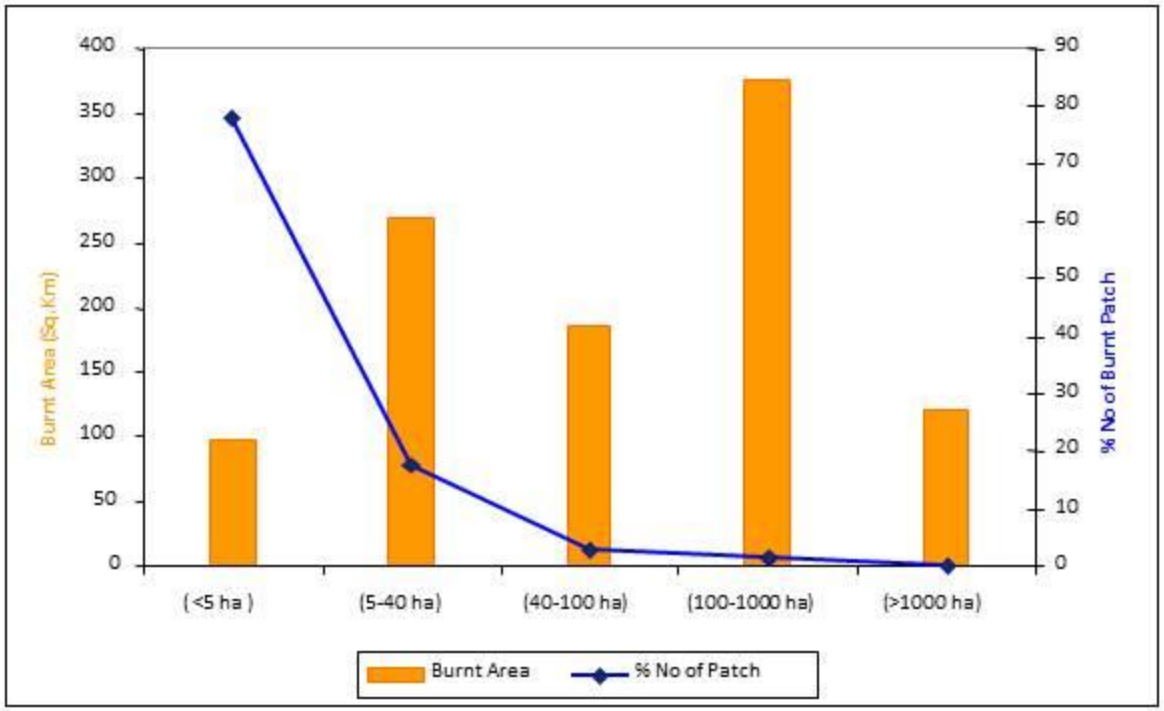


Burnt area characteristics – Case study Western Ghats



False Colour Composite of entire Western Ghats : IRS AWIFS data of 2007

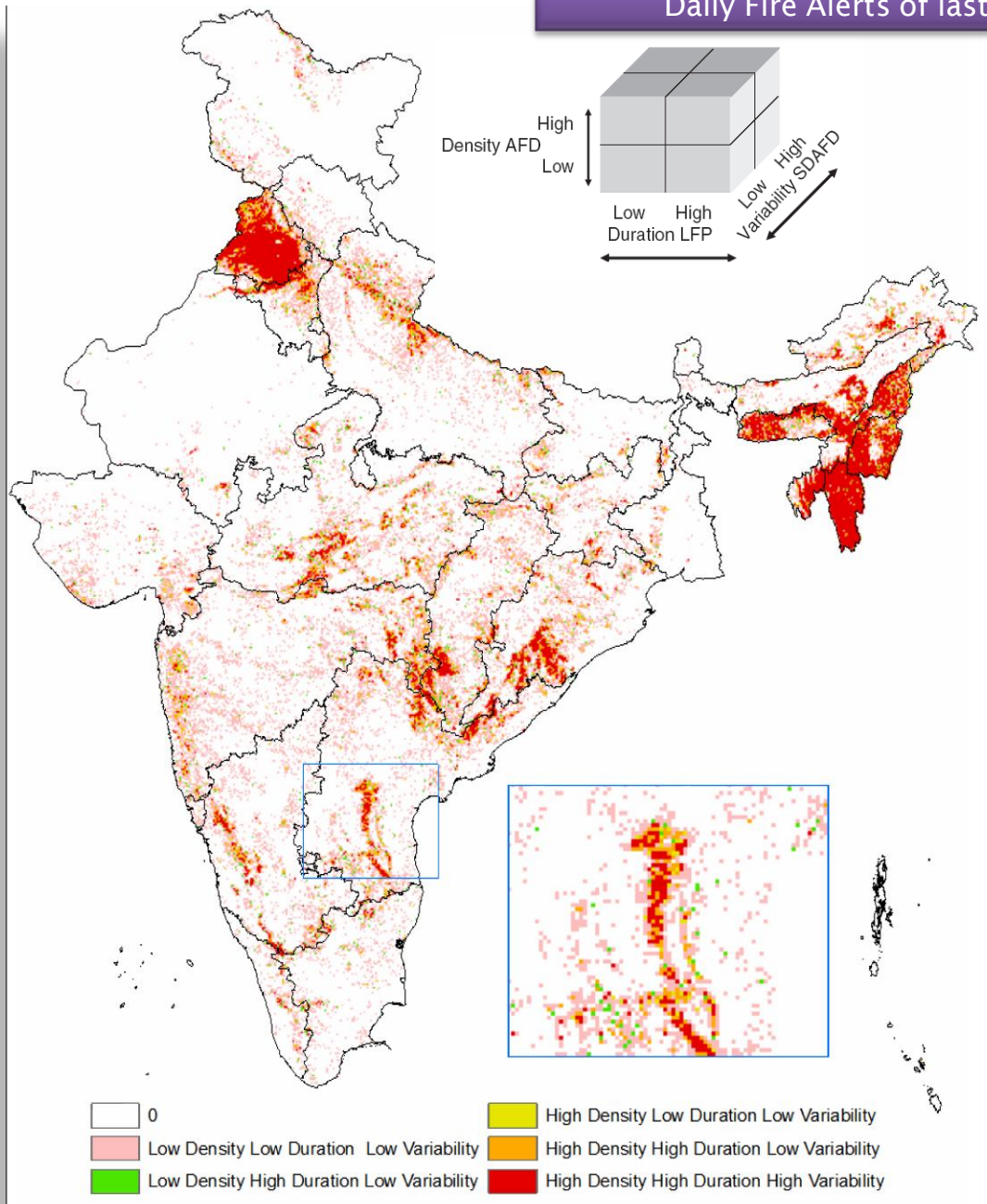
Total Burnt area – 1,060 sq.km
Total Forest area – 7,1461 sq.km



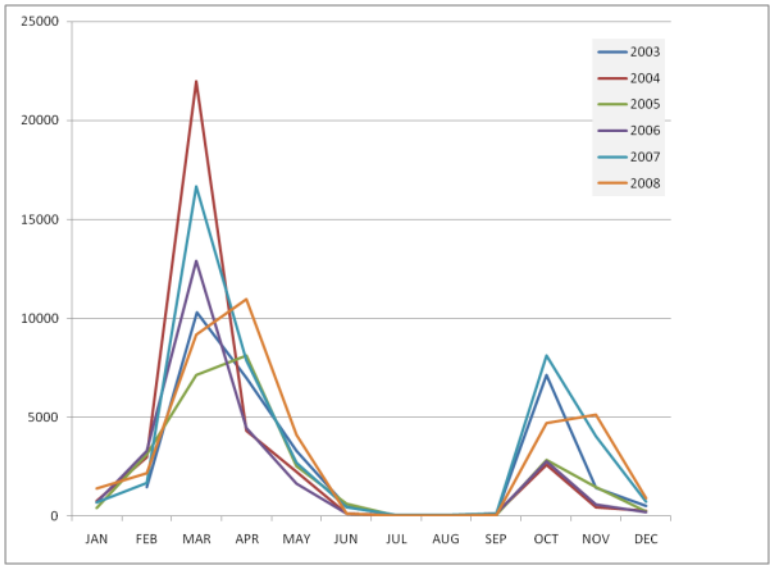
- 50% of the burnt area is composed of patches less than 100 ha (90% of the total patches)
- 60% of the burnt areas are in deciduous forest and 20% on the scrub forest.

Fire Regimes across India

Daily Fire Alerts of last 8 years



Temporal Patterns

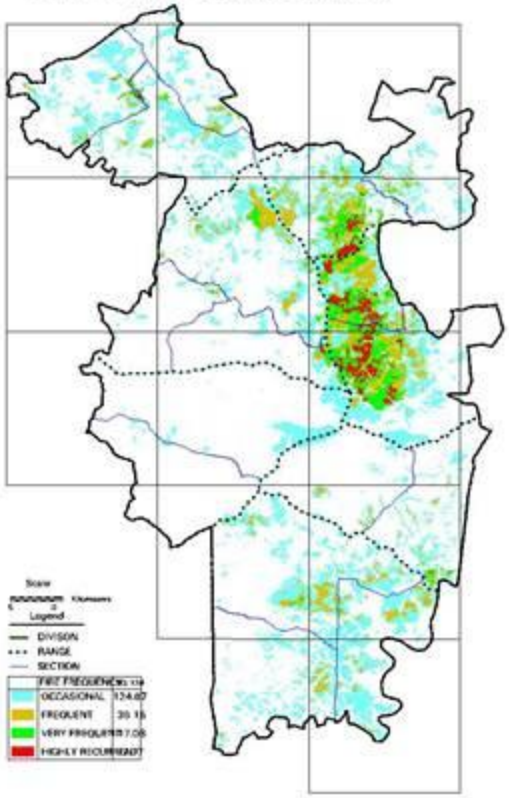


Fire regimes are analyzed in conjunction with forest cover, type, topography, climate and socioeconomic status

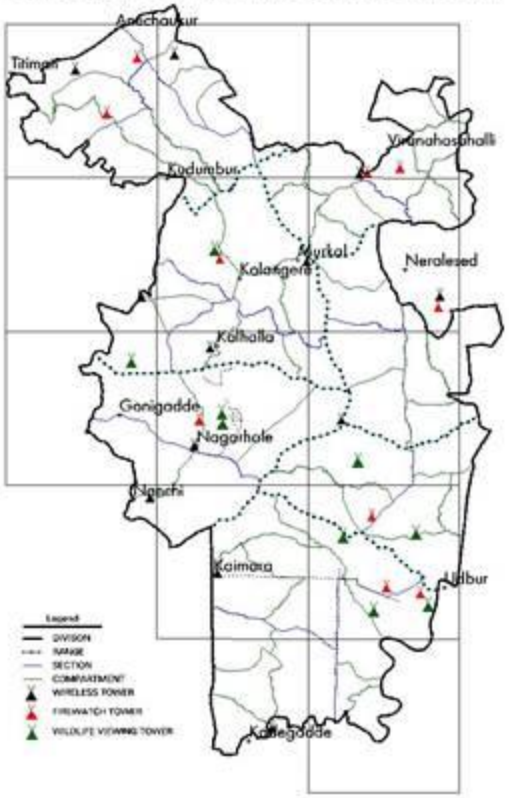
- Forest Fire Vulnerability
- Fire early warning system
- Ecological Damage Assessment
- Phenology
- Climate
- Ecosystem models

FOREST FIRE WATCH TOWERS VISIBILITY ANALYSIS

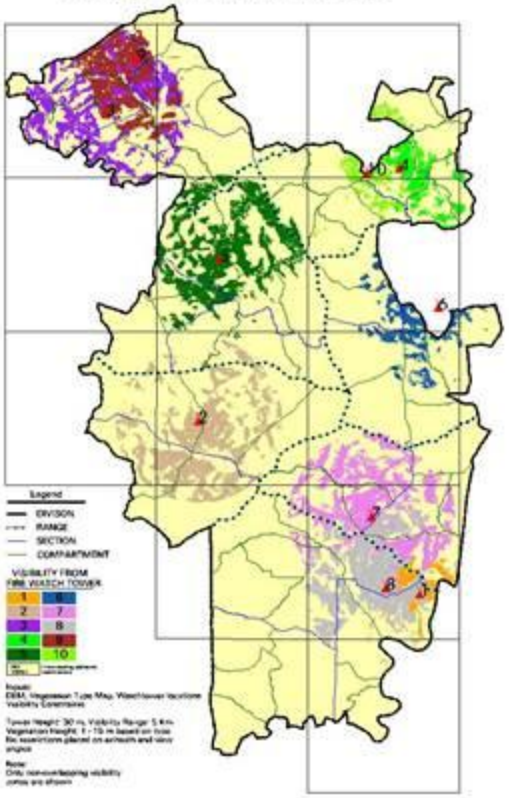
FIRE FREQUENCY MAP



FIRE DETECTION INFRA-STRUCTURE



VISIBILITY ANALYSIS



National Agricultural Drought Assessment & Monitoring System - NADAMS

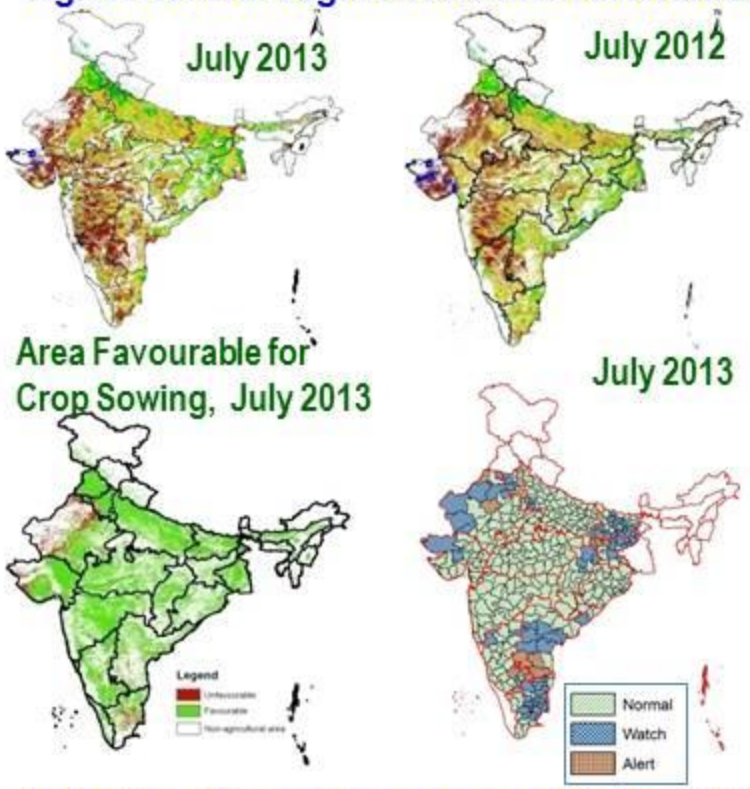
NADAMS

Operational project: since 1989
Season : kharif
Objective: prevalence, intensity and persistence of agricultural drought at district/sub-district level
Data: Multiple indices

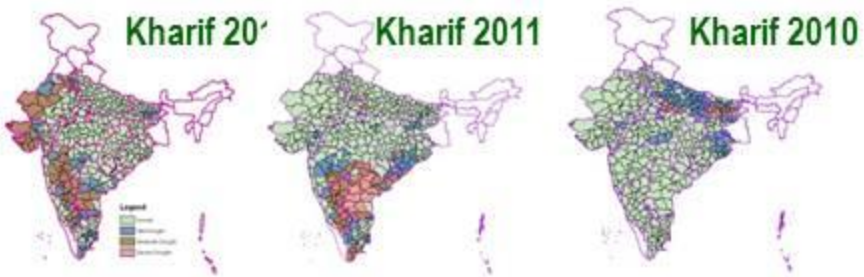
Institutionalization of NADAMS project

NADAMS project was transferred to **Mahalanobis National Crop Forecasting Centre (MNCFC), DAC/ Min Agric (GOI) in May 2012**

Agricultural drought assessment in kharif 2013



Agricultural drought assessment in kharif 2012



Initiatives

NADAMS Software
Automation of satellite data analysis

India Drought Monitor
Improved soil moisture products, Drought Response Modelling

Agricultural Drought Vulnerability
Composite Index & map of vulnerability map

Future

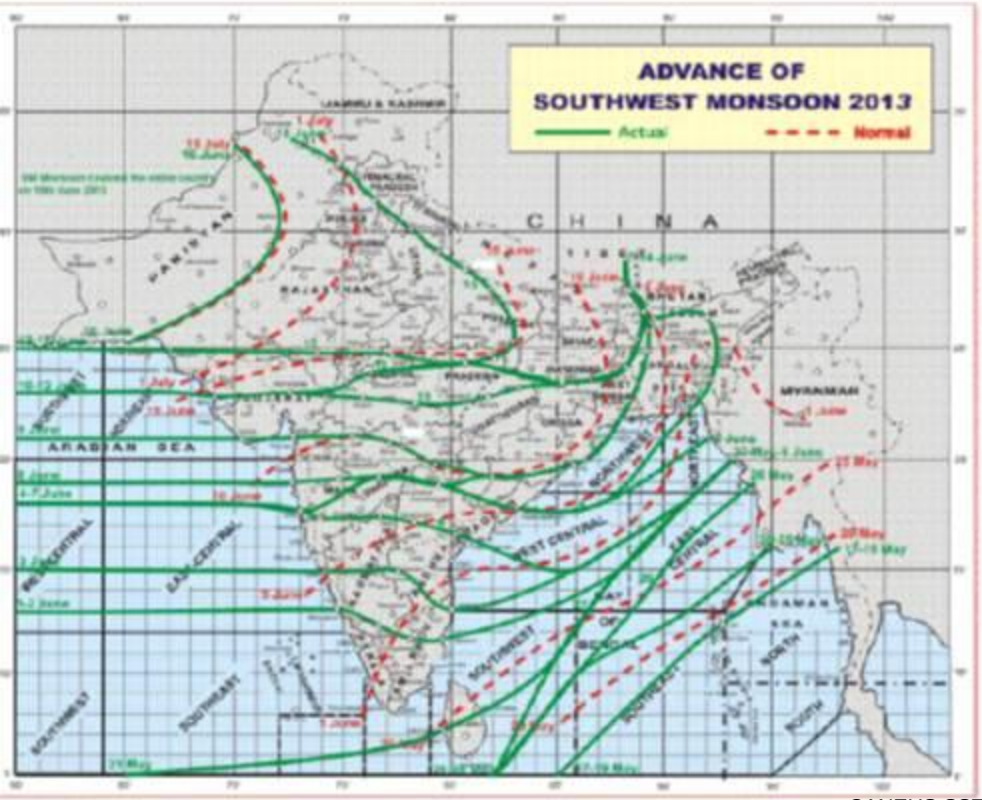
Crop specific drought monitoring, impact assessment, developing crop insurance products

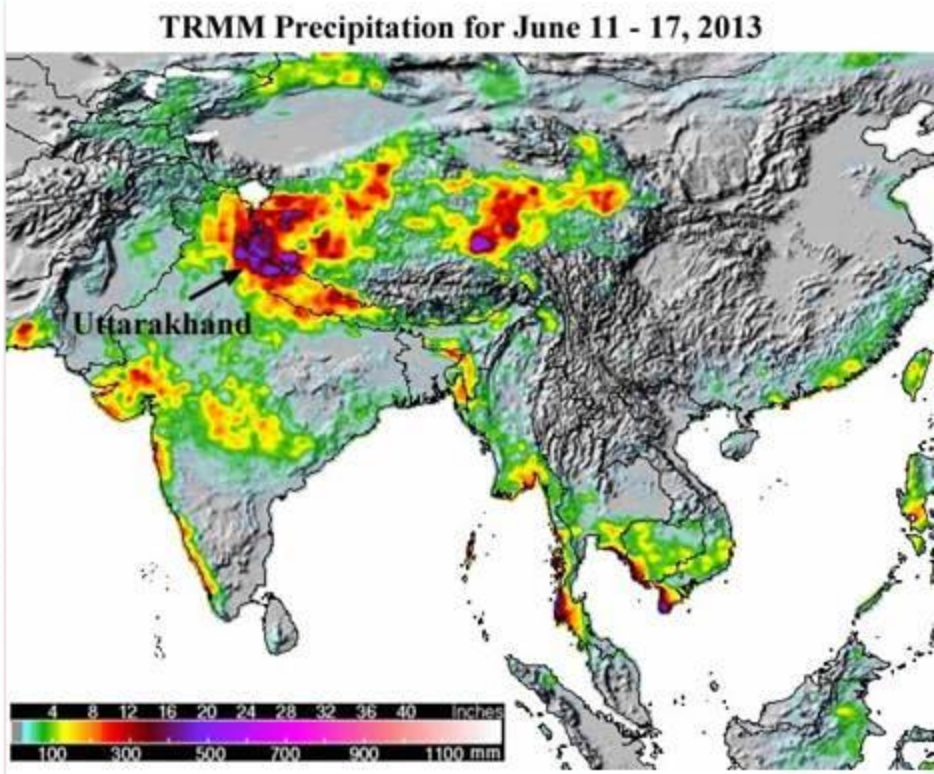
(An operational and user oriented project successfully institutionalized in 2012)

Kedarnath 2013 Disaster

Kedarnath : Multiple causes of disaster

- Early monsoon advance, special atmospheric conditions
- Heavy snowfall (9-11 June), heavy immediate rainfall (14-16 June)
- Flash floods (entire village washed away)
- Debris flow and landslides
- High-altitude lake formation & burst
- Massive road infrastructure & house damage affecting rescue



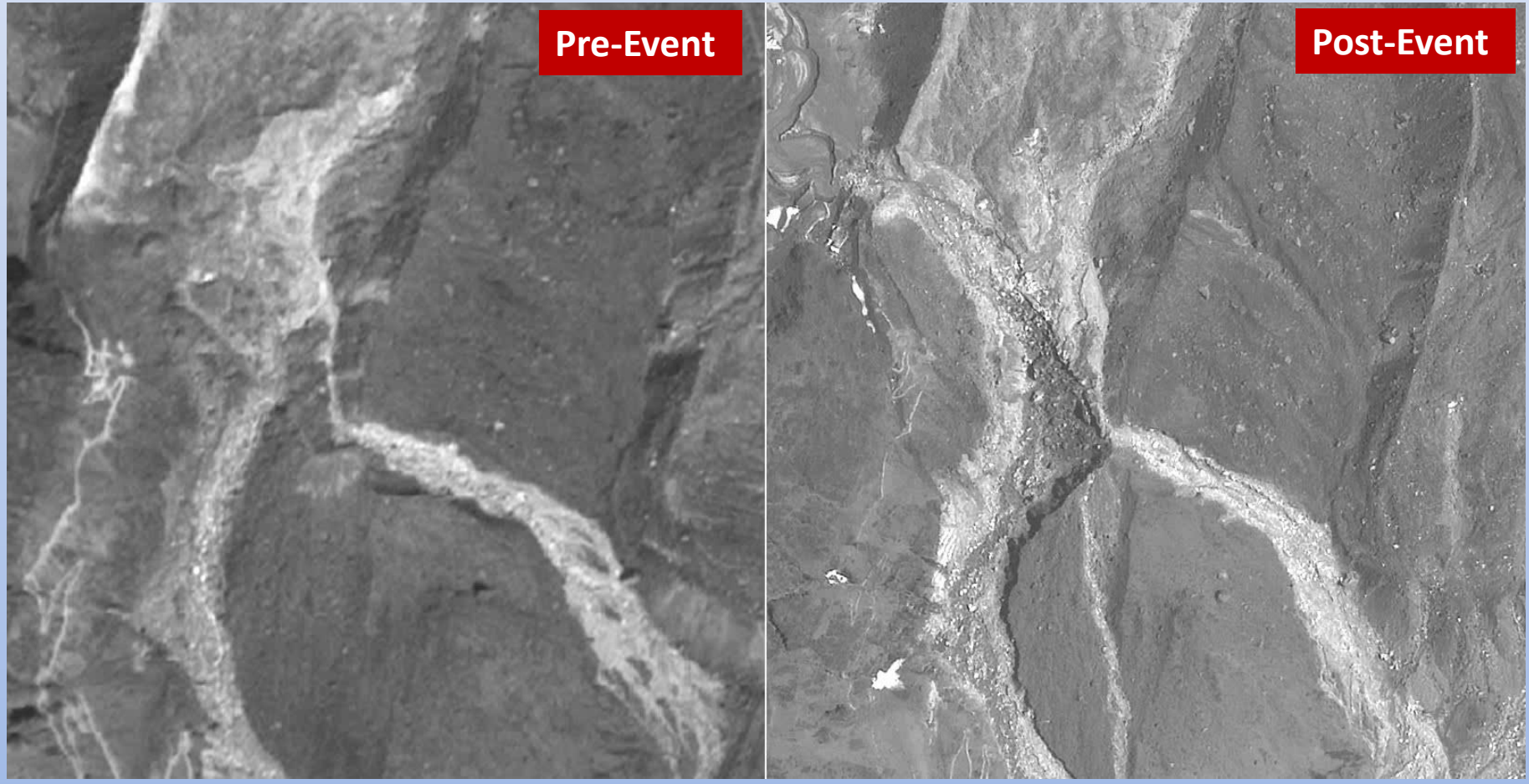


Kedarnath: Magnitude of disaster

- Due to heavy rains (14-17 June, 2013) and associated phenomena, worst natural disaster since Dec 2004 tsunami in India
- 4200 villages affected (580 dead, 5400 missing 'presumed dead'), during event 170,000 people stranded in high mountains (70,000 tourists/ pilgrims)
- One of the largest emergency evacuation effort "Surya Hope", airforce (23,775), army (38,750), ITBP (33,000), NDRF (9,000), civil helicopters (13,000) evacuated by air and land
- 730 Mt of essential commodities air dropped

Chaurabari Lake burst – Kedarnath tragedy (2013)

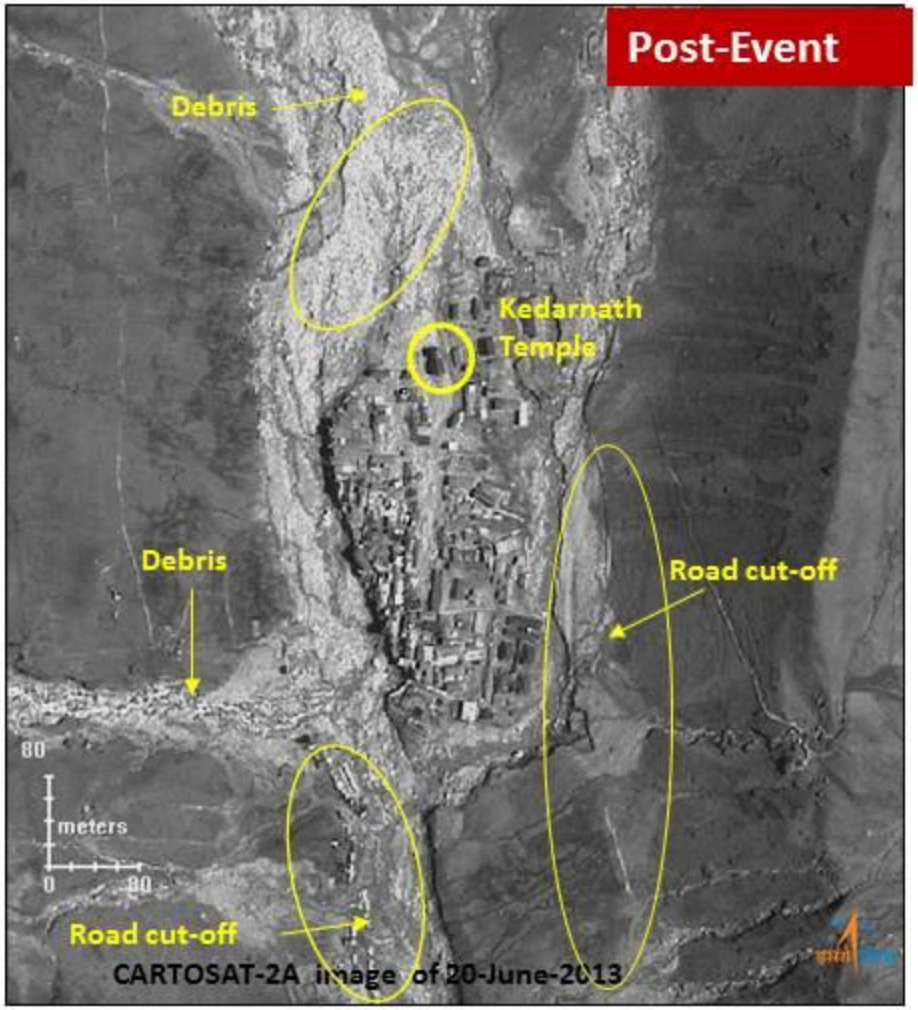
Uttarakhand Floods–Kedarnath–Video



Uttarakhand Floods– Damage to Kedarnath

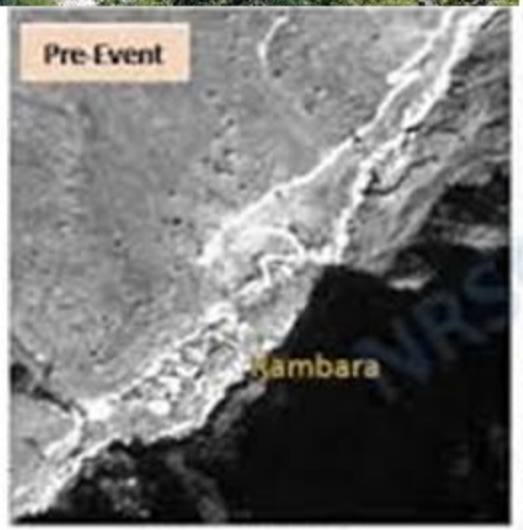
nrsc

- Information Provided – Flood Inundation, Damaged Roads, Landslides
- Observation Period – June, 17 to till date
- Information Dissemination – NDEM – VPN, Bhuvan Portal



Kedarnath : View from Space and Ground

Downstream Impacts



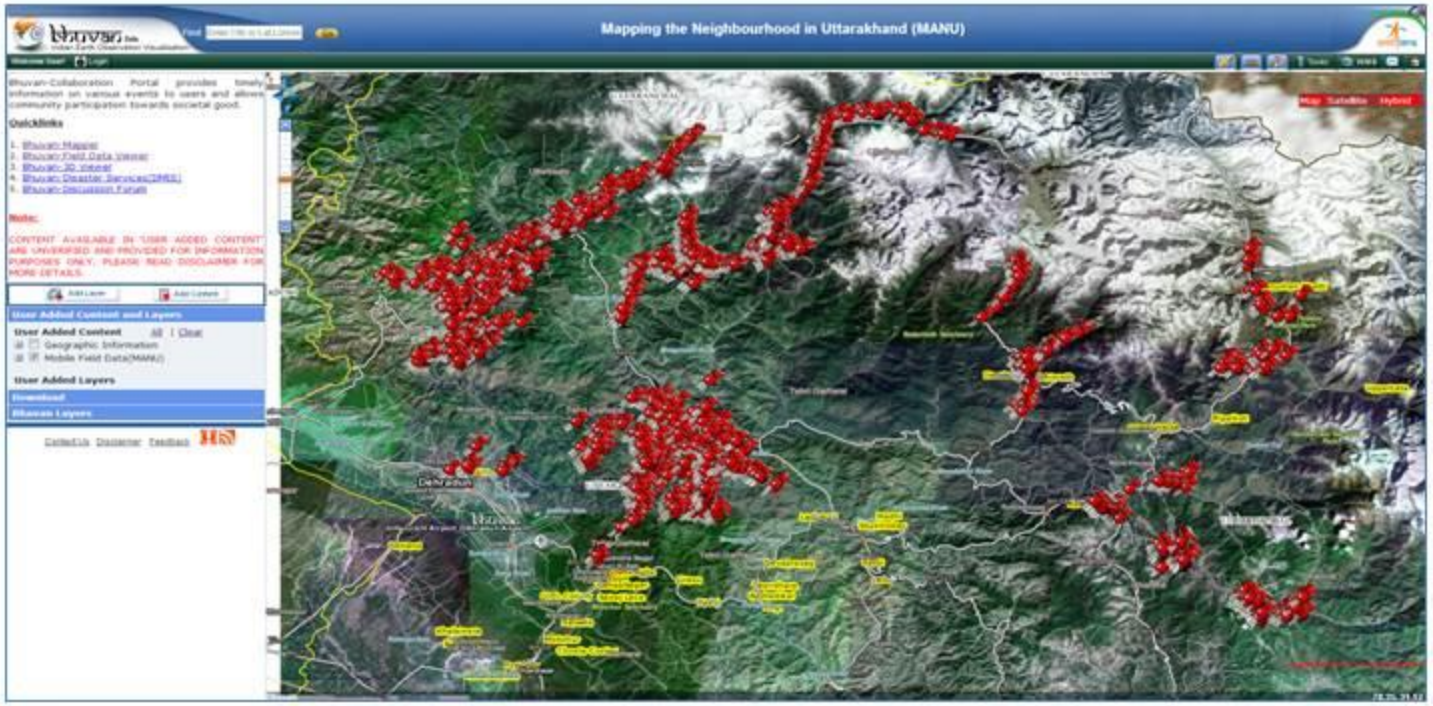
Cartosat-1 data of 2011

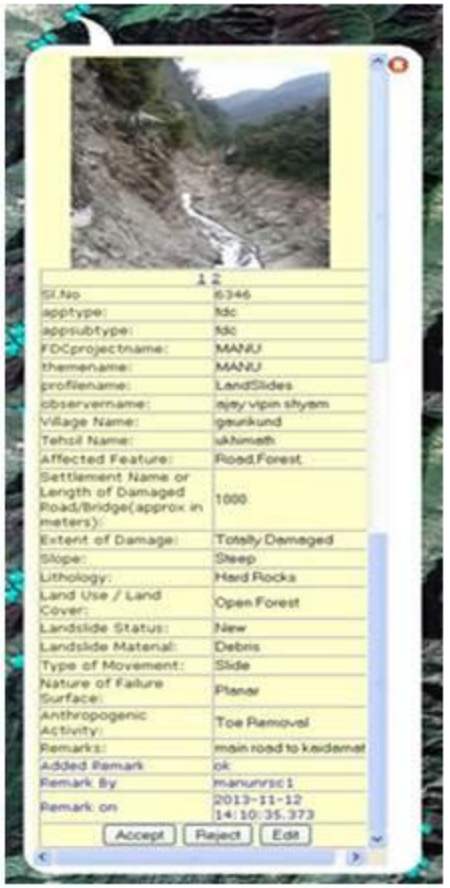
Cartosat-2A data of 20-Jan-2013

Rambara Village

Crowdsourcing

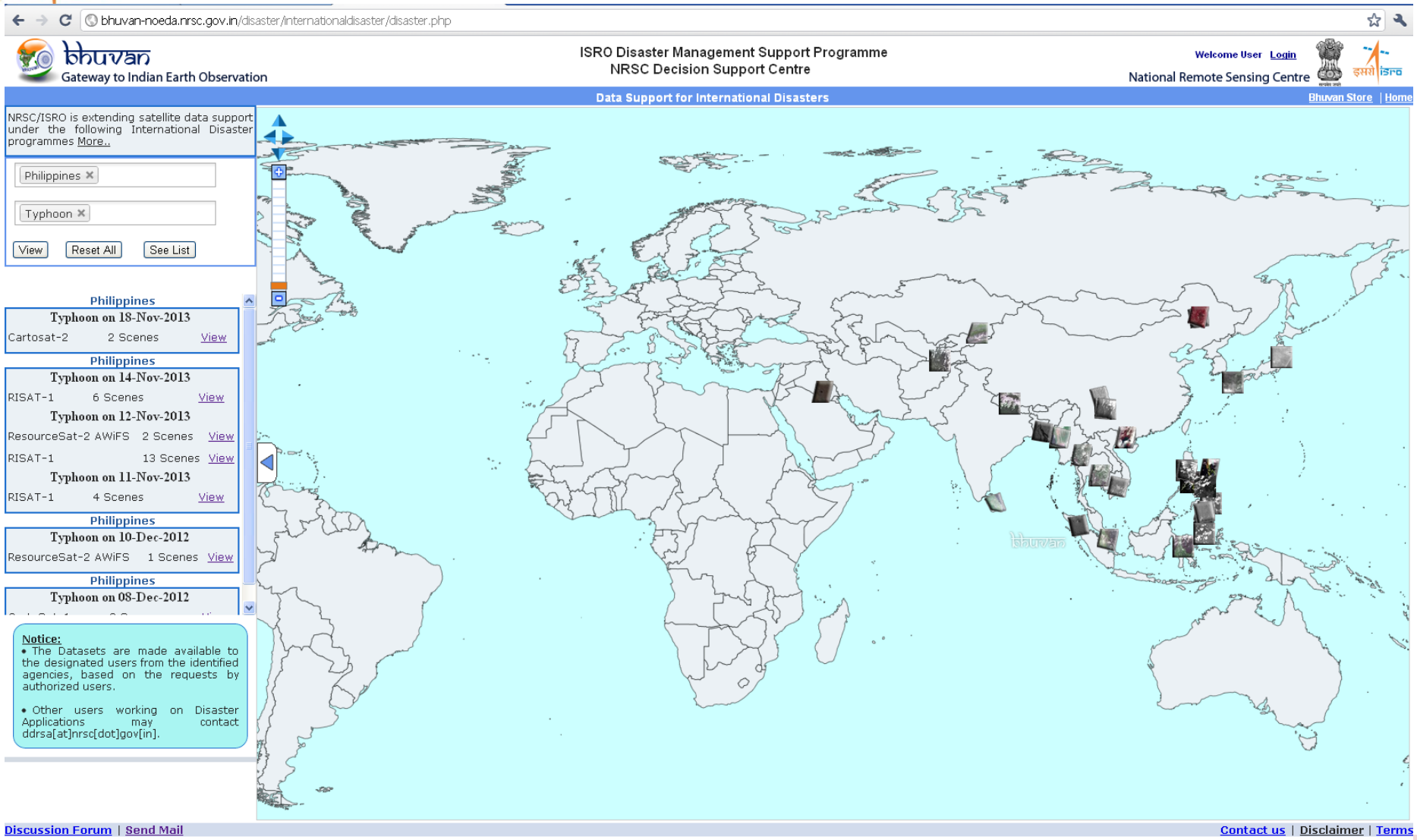
- BHUVAN geo-portal adopted for crowd-sourcing for damage assessment and use in reconstruction planning
  - 150 Students were trained for mobile-based field data collection
- Being made accessible on BHUVAN for various uses





19,799 geo-located information Collected (11-Oct-13 to 18-Feb-14)

Data Support for International Disaster



"27 events – 102 Data sets including HRS and MRS data"

Latest – Philippines – Typhoon – Haiyan
RISAT – 23 Scenes
Cartosat- 2 Scenes
Resourcesat – 2 Scenes

Thank You

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http://bhuvan.nrsc.gov.in

http://www.nrsc.gov.in

http://www.isro.gov.in