Satellite Remote Sensing & GIS Applications in Water Resourcess

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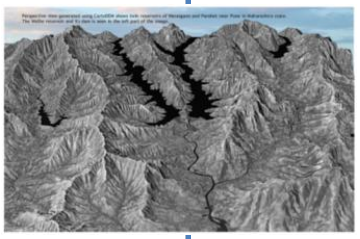
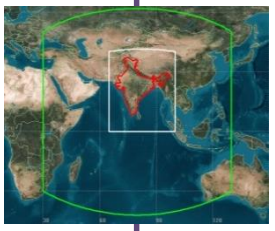
Space Technology Inputs

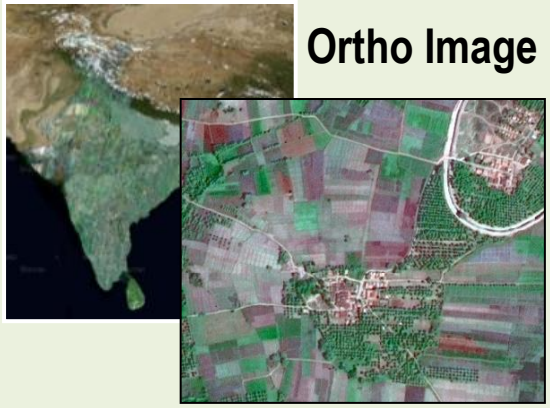
Digital Elevation Model



Optical & Microwave
Multi-Spectral
Multi-Spatial, Multi-Temporal

Geo-Positioning





In-situ Sensors

DCPs

Mobile Data Collection

Geo-Platforms

Suite of Applications

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Satellite Data - Derivatives

Optical/
Thermal/
Microwave/
Altimeter
/Gravity

Sensor
Satellite
Data

- Surface water extent
- Snow & Glacier extent
- River configuration
- Flood inundation
- Water quality
- Agricultural/Irrigated crop extent & condition
- Land use / Land cover
- Land/Crop/Vegetation Surface & Bio-physical parameters (Surface Temperature, Emissivity, Albedo, NDVI, LAI, …)
- Surface soil moisture
- Spatial Precipitation
- Snow cover depth, snow water equivalent
- Reservoir/River water elevation
- Total Water Storage

High resolution Satellite Data

- Water Infrastructure

Stereo Satellite Data

Radar Interferometry data

- Terrain profile
- Digital Surface/Terrain models
- Watershed & Stream definition

Applications in Water Resources

- Surface Runoff
- Snowmelt Runoff
- Water Budgeting & Water Balance
- Water Resources Availability
- Inventory - Water bodies/Glacial Lakes/

- Irrigation Performance Evaluation
- Surface Water Logging
- Soil Salinity/Alkalinity
- Near-real-time inputs
- Irrigation scheduling

- Interlinking of rivers
- Canal alignment &
- Land irrigability
- Ranking of hydropower sites
- Reservoir submergence
- Catchment treatment
- Flood Hazard Zone mapping

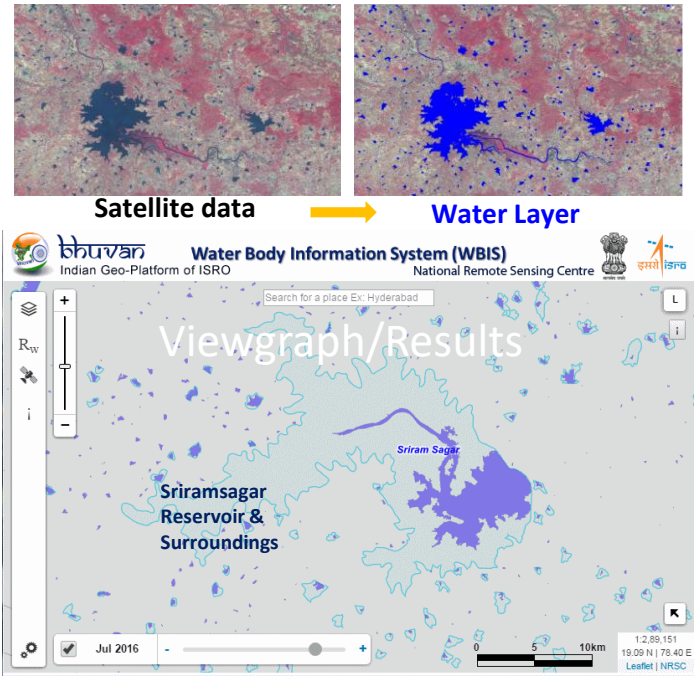
- Reservoir Sedimentation
- Flood Forecasting
- Inundation Simulation
- Flood Mapping & Damage
- Water Demand / Use
- Surface water resources *(Lakes/water bodies/snow cover)*

- Rehabilitation & Relocation Studies
- Irrigation Infrastructure Mapping & Assessment of Potential Created

Water Resources Availability

Water Bodies Information System (WBIS)

- Surface Water bodies dynamics for the entire country derived from multi-sensor satellite data and hosted on a Web enabled Water Bodies Information System (WBIS)



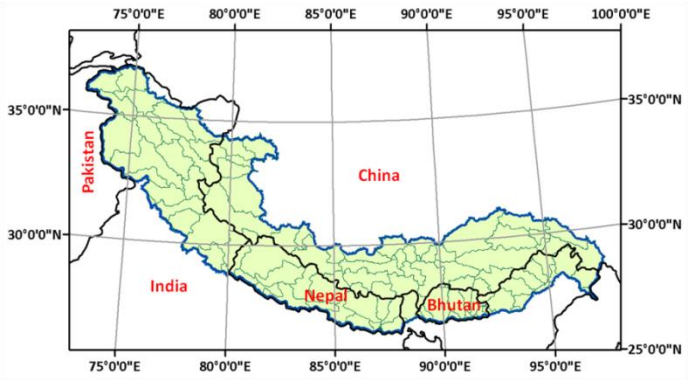
- *Surface Water bodies dynamics derived from satellite data is provided through Water Bodies Information System (WBIS) and Bhuvan*
- *Visualisation & Analytics provided for at Individual water body & Region level*
- *Water Bodies are monitored*
  - *Once in 5 Days (for size > 50Ha)*
  - *Once in a Month (for size > 2 Ha)*
  - *Once in a Season (for size > 0.25Ha)*

Surface water bodies information is useful for

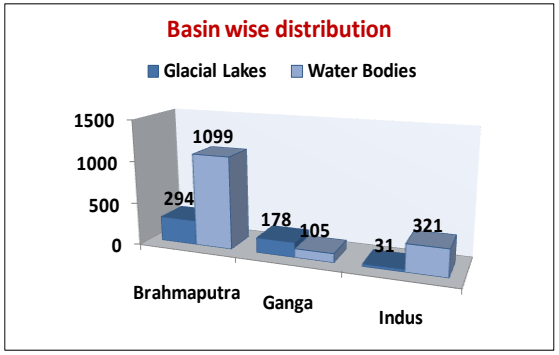
- ✓ ***Supporting Blue Revolution leading to integrated development of fisheries***
- ✓ ***Hydrological Drought Assessment***
- ✓ ***Surface Storage Quantification***

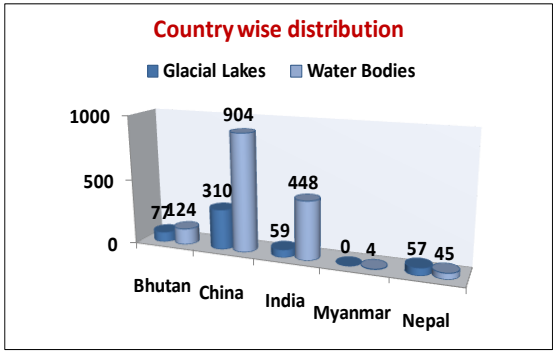
Inventory and monitoring of glacial lakes & water bodies in Himalayan region of Indian river basins

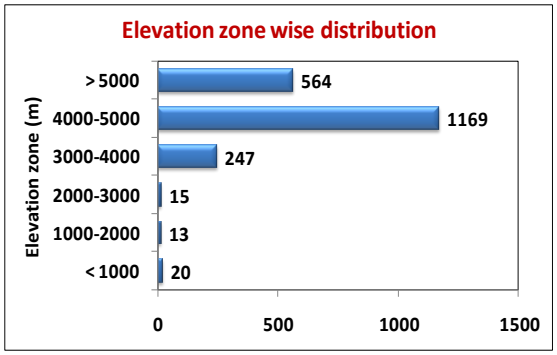
- Inventory of glacial lakes/water bodies in the Himalayan region of Indian River basins using satellite data (spatial extent > 10ha)
- Monitoring the spatial extent changes of the lakes/water bodies (> 50ha) on monthly basis during June to October months for 5 years, succeeding the inventorying year

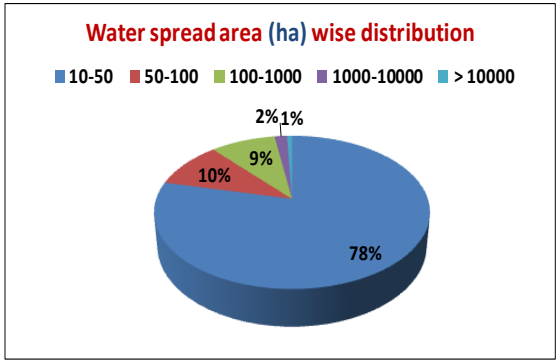


Inventory of glacial lakes/water bodies - 2009
Using Resourcesat -1 AWiFS Data









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

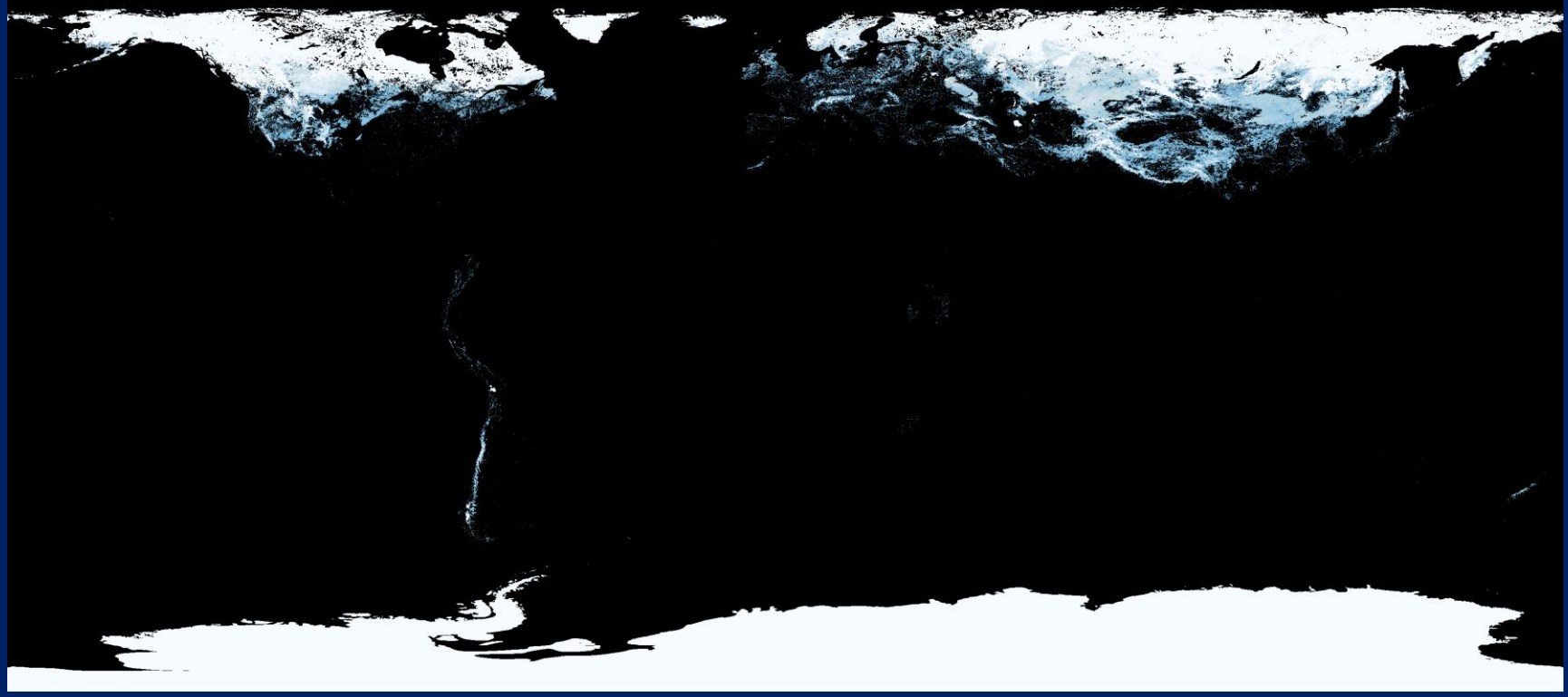
Status of glacial lakes/water bodies - 2012

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

Snow Cover

- Information on snow cover extent and its characteristics during accumulation and melt season are extremely important and useful for snow-melt runoff quantification, forecasting and climate change impact studies

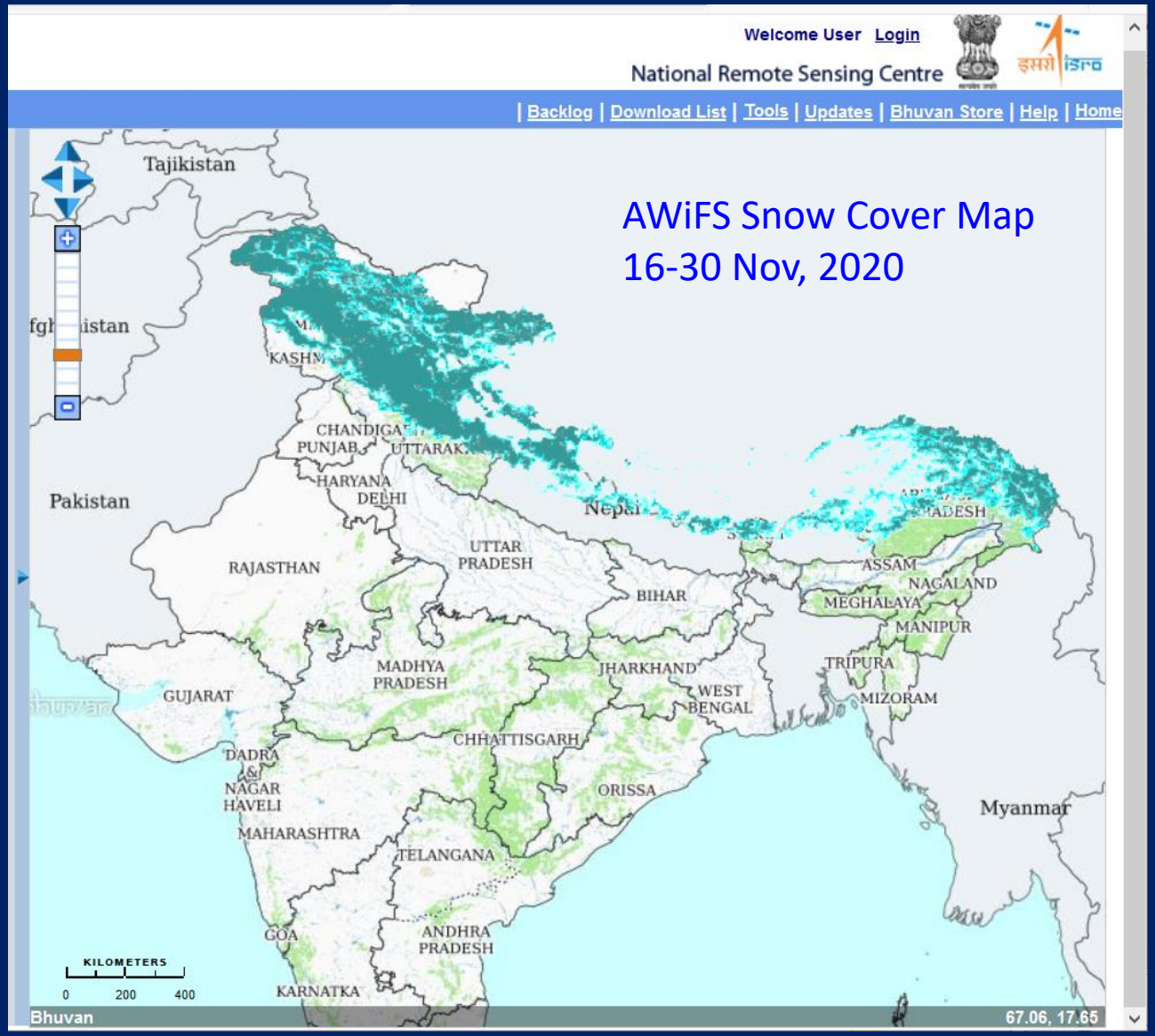
MODIS Global Snow Cover Map – Nov, 2020



Available since 2002

https://neo.sci.gsfc.nasa.gov

Snow Cover

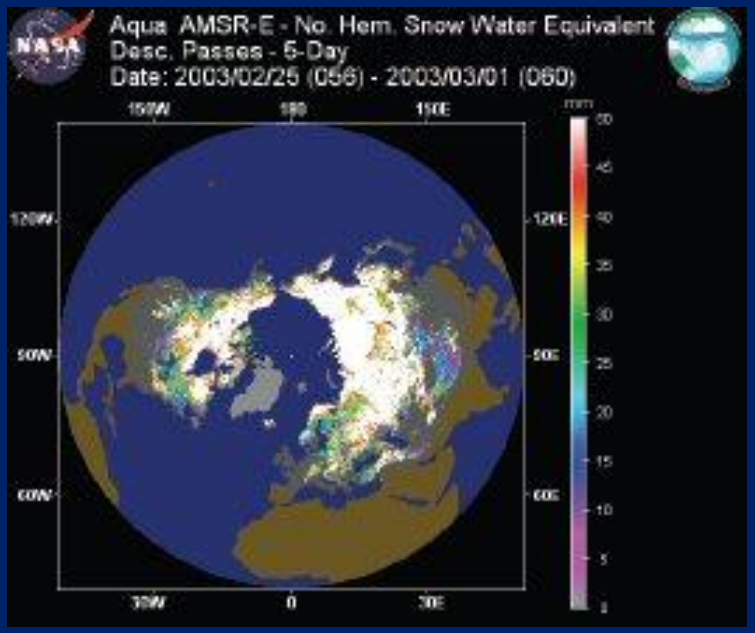


Available since 2012

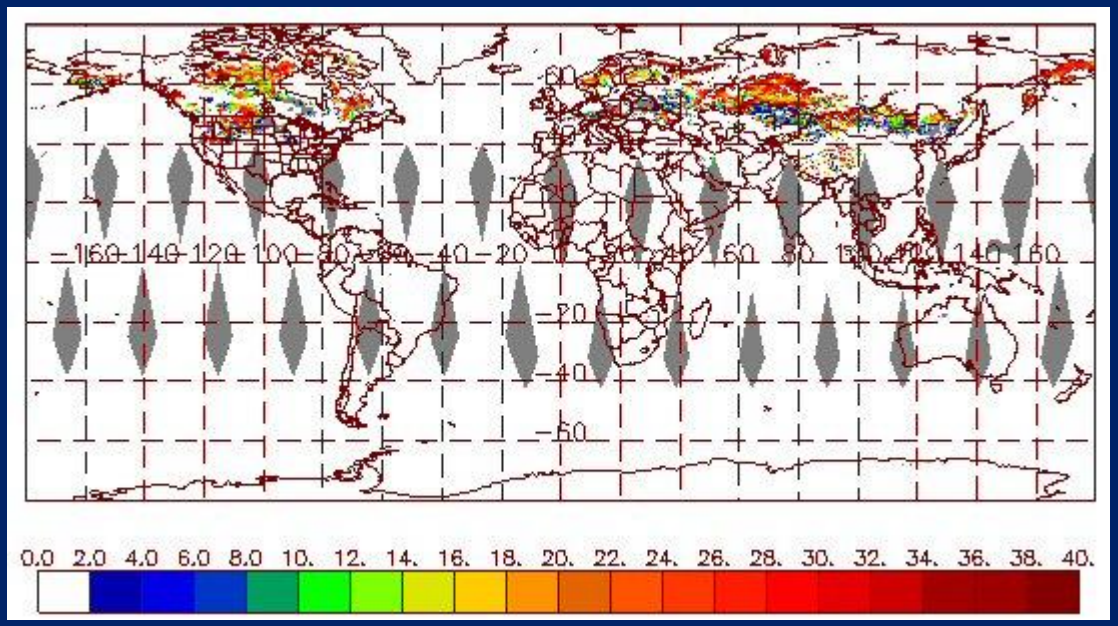
https://bhuvan-app3.nrsc.gov.in

Snow Parameter Retrieval

- Snow Depth
- Snow Water Equivalent



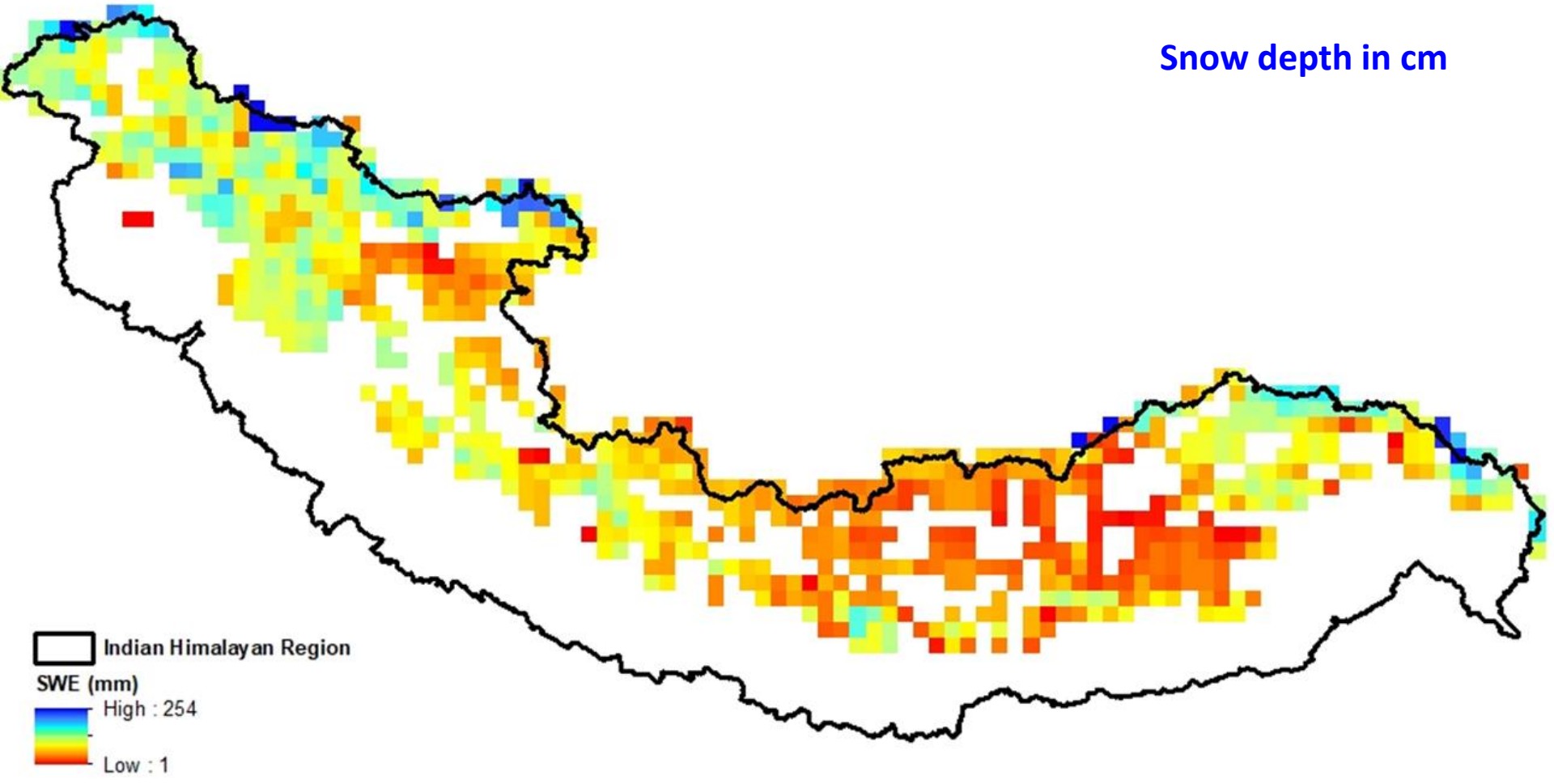
Global SWE map from AMSR-E



Global map of dry snow depth from SSM/I

Historical record back to 1978 (SMMR, SSM/I) available in consistent 25 km grid format

Snow Cover and Parameter Retrieval

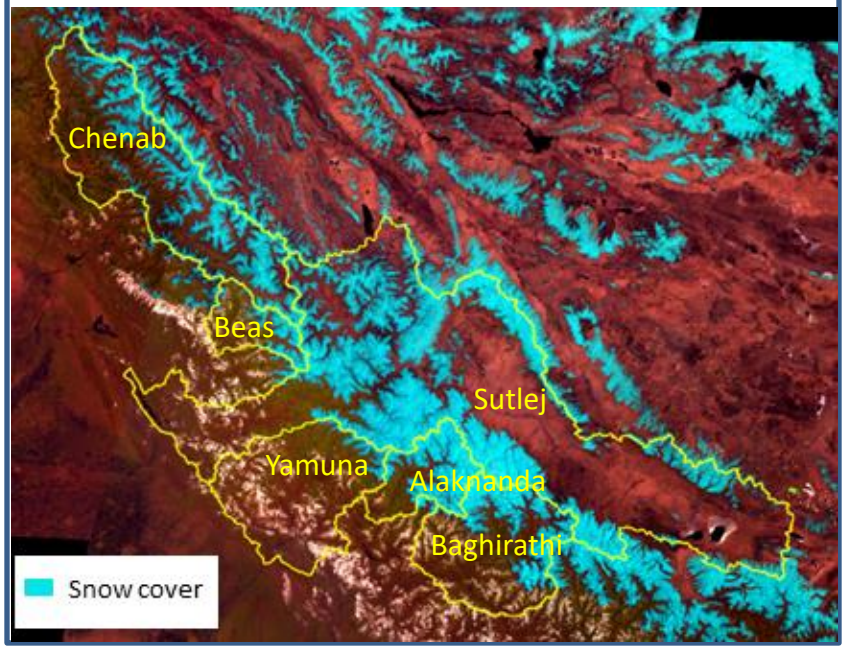


GCOM-W1/AMSR2 Snow Water Equivalent of Jan 2020

Snowmelt Runoff Forecasting in Himalayan basins

- Developed Snow melt Runoff Forecast models for Beas, Chenab, Ganga, Sutlej and Yamuna river basins using Remote Sensing inputs.
- Seasonal Forecast (Apr to June) and short-term forecast (16 day) provided during 2012 to 2016 and validated.

Resourcesat AWiFS data of May 2016



- *Snowmelt runoff forecasting based on Energy Balance approach with Space inputs*
- *Developed models were calibrated and validated with observed runoff*
- *Trained CWC Officials and internalized through transfer of Forecast Models and Geo-spatial data*
- *CWC is internally implementing the methodology with NRSC Technical support*
- *The Snow melt forecasting is being extended to entire Himalayan River basins under NHP project*

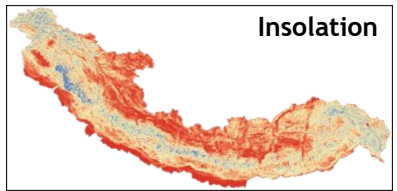
✓ **The seasonal forecasts are useful for advance planning of reservoir operations**

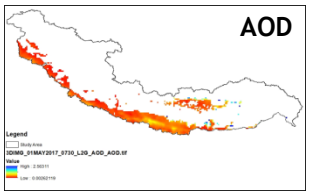
✓ **Short term forecasts can be useful for water releases for different purposes**

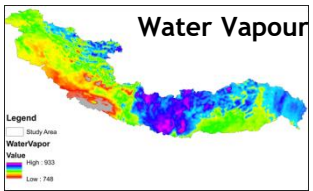
Spatial Snowmelt Runoff Product in Indian Himalayas (NHP)

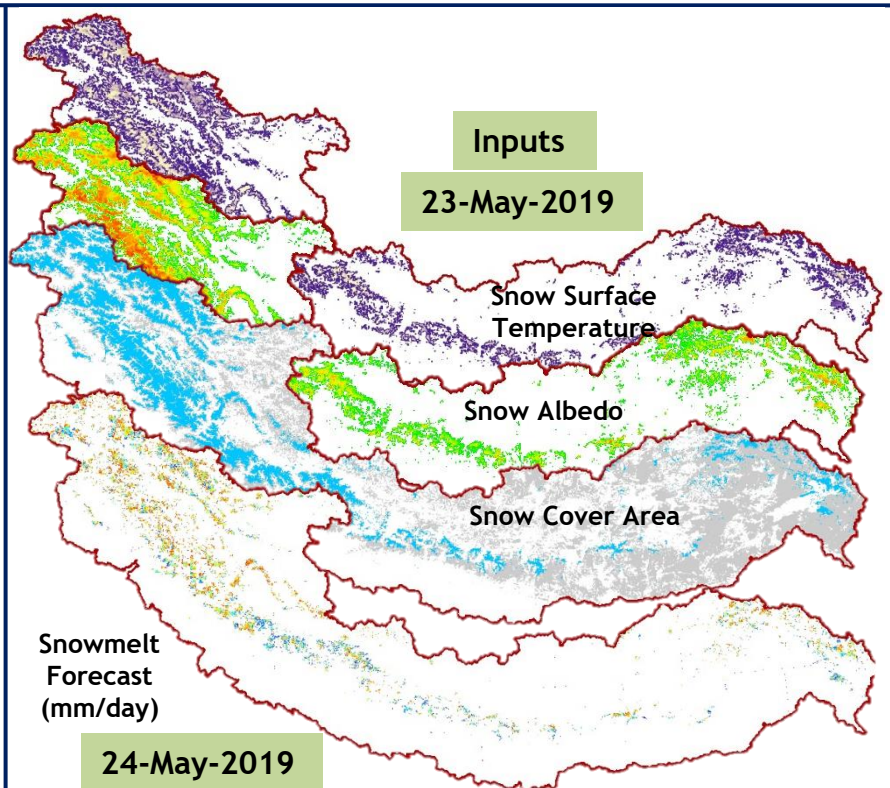
- Short-term (daily/3-day) snowmelt runoff forecast is critical for reservoir managers in allocating the water resources for drinking water supply, irrigation and industrial purposes
- Snowmelt runoff forecasting has been extend from 5 to 16 basins covering entire Indian Himalayas
- Forecasting is being done with improved methodology using Energy Balance approach in spatially distributed modelling environment
- Satellite derived inputs such as Snow Cover Area, Snow Albedo, Snow Surface Temperature, AOD, Water Vapour, Ozone, Cloud Cover, etc, are used for computing net short and long wave radiation
- Daily maximum possible Snow Cover Area being generated from Suomi-NPP
- Experimental daily/3-day spatial snowmelt runoff forecast products are being generated from 1st April 2019
- Spatial snowmelt runoff forecast products to be uploaded in NWIC portal shortly

Input Data Used	Source
Aerosol Optical Depth	INSAT-3D Imager Half-hourly data
Water Vapour, Ozone	INSAT-3D Sounder Hourly data
Cloud Cover	INSAT-3D Imager Half-hourly data
Incoming Solar Radiation	f(Julian day, lat, long, elevation, slope, aspect)
Snow Cover Area	Suomi-NPP derived data
Snow Surface Temperature	Suomi-NPP derived data
Snow Albedo	Suomi-NPP derived data
Land Cover	AWiFS satellite data
DEM	Cartosat / SRTM data
Discharge, Rainfall	CWC- Field data



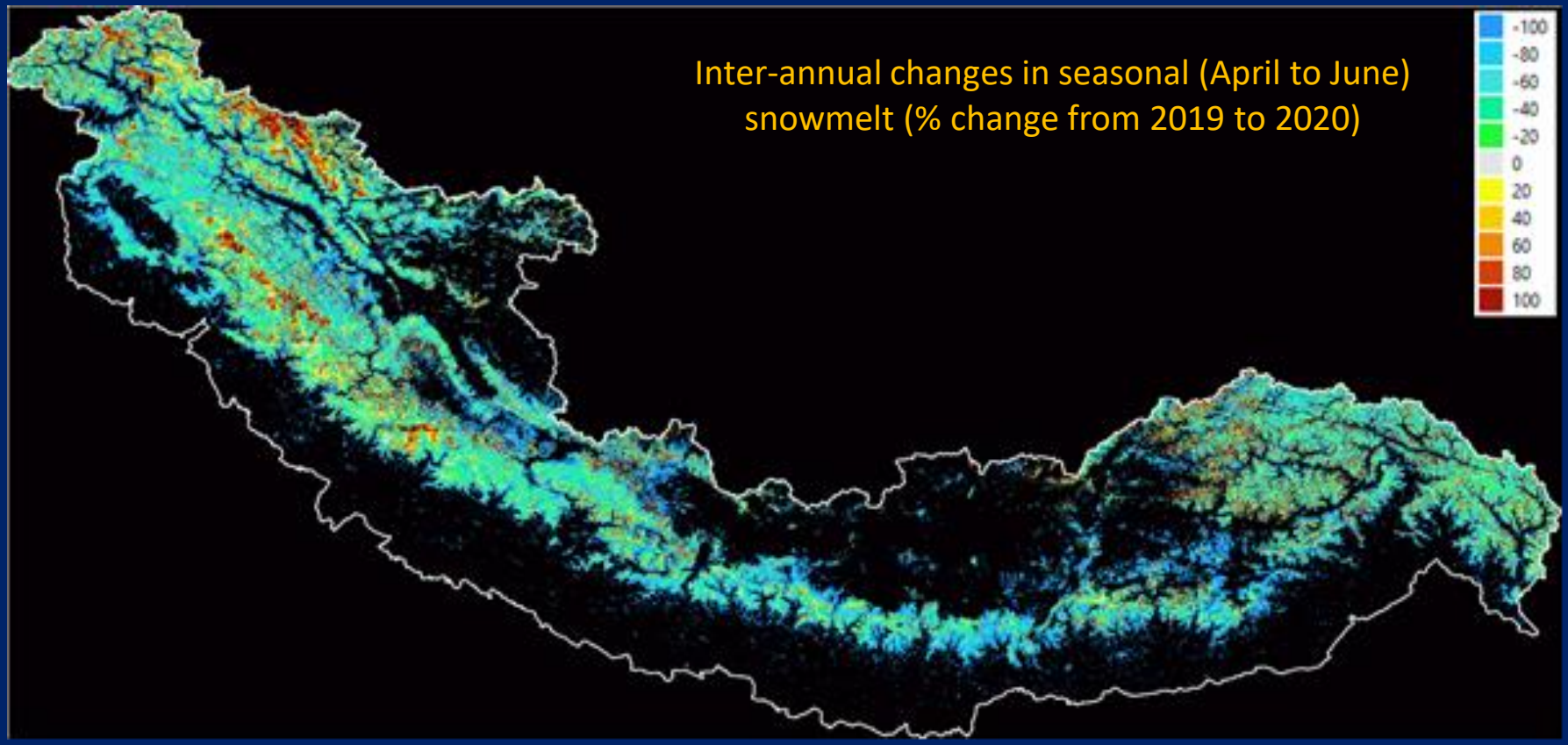






Snowmelt Runoff Quantification and Forecast

- Spatial Snowmelt estimation for India Himalayan rivers with short-term runoff forecast at selected locations
- Spatial snowmelt rate forecast (daily/T+3) products during 1st April to 30th June (2019 & 2020) on experimental basis
- Calibration and validation with observed field discharge in progress for short-term runoff forecast at selected locations



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Reassessment of Water Resources of India using Space Inputs

NRSC & CWC Joint Study

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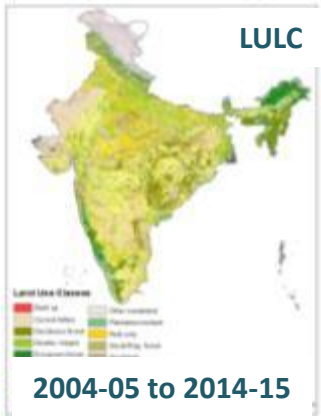
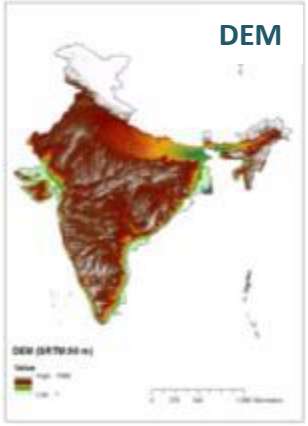
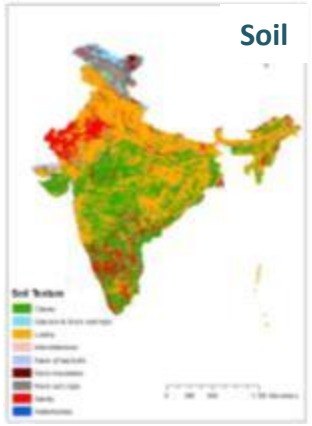
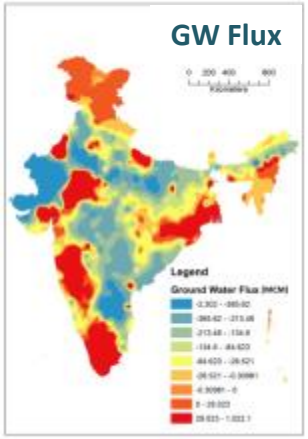
Reassessment of Water Availability in India using Space Inputs

- *MoWR, RD & GR taken up reassessment of the Country's water availability considering current climate, geographic and socioeconomic conditions*
- *Repeating previous approach (1993) is not feasible due to non-availability of water use data and progressive changes in Land use, Water Infrastructure, Climate, etc.*
- *NRSC and CWC jointly developed hydrological modelling framework for assessing basin scale water availability using geospatial (Space) inputs*



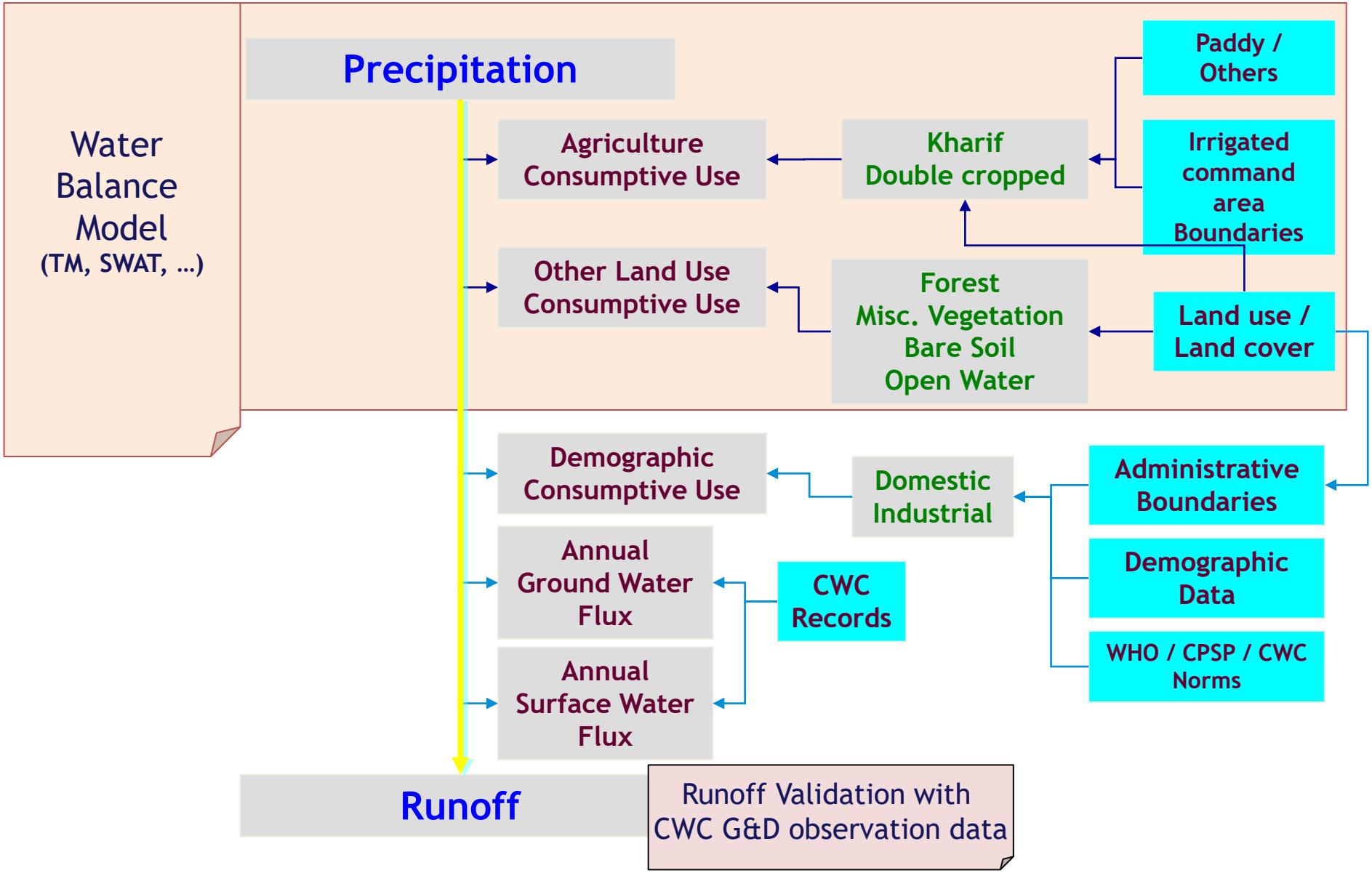






- *NRSC provided capacity building and handholding to CWC Regional offices to conduct the study for all 20 river basins (Jul, 2016 – Nov, 2017)*

Water balance computation at HRU Level …



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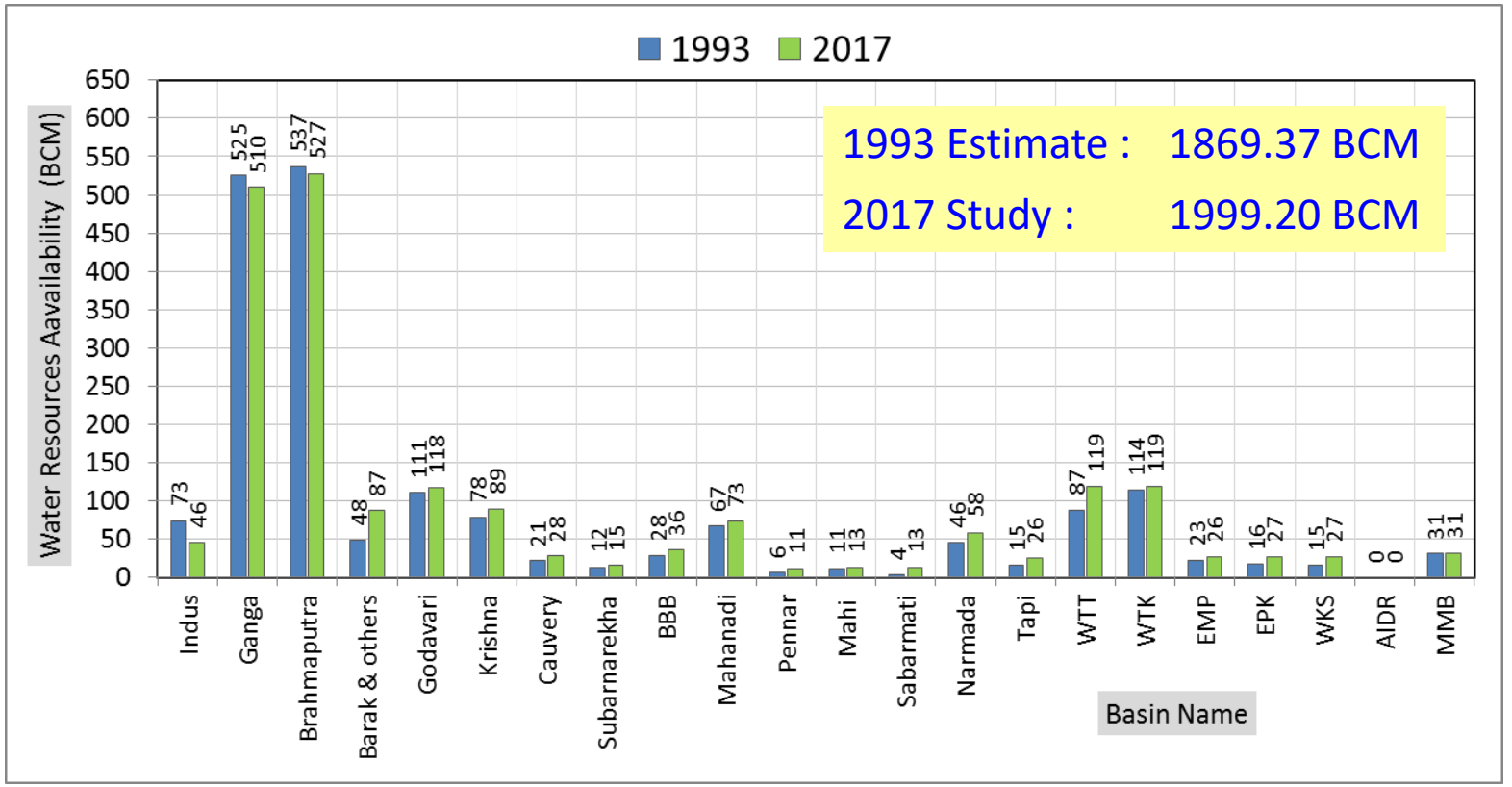
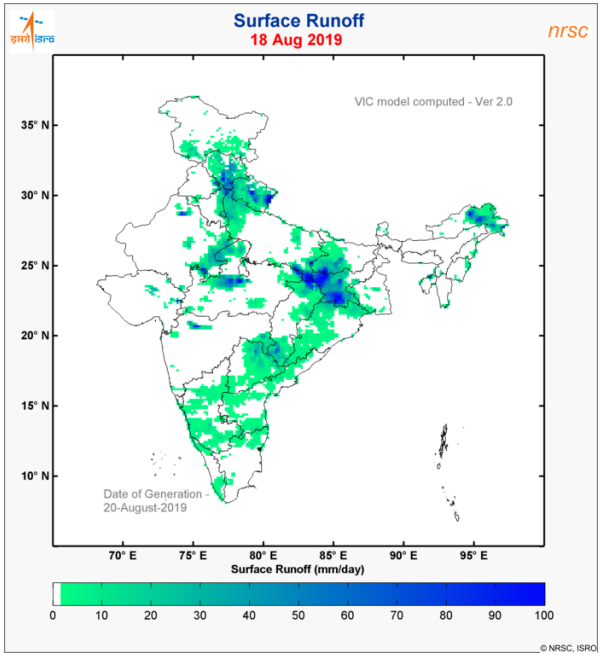
Reassessment of Water Availability in India using Space Inputs

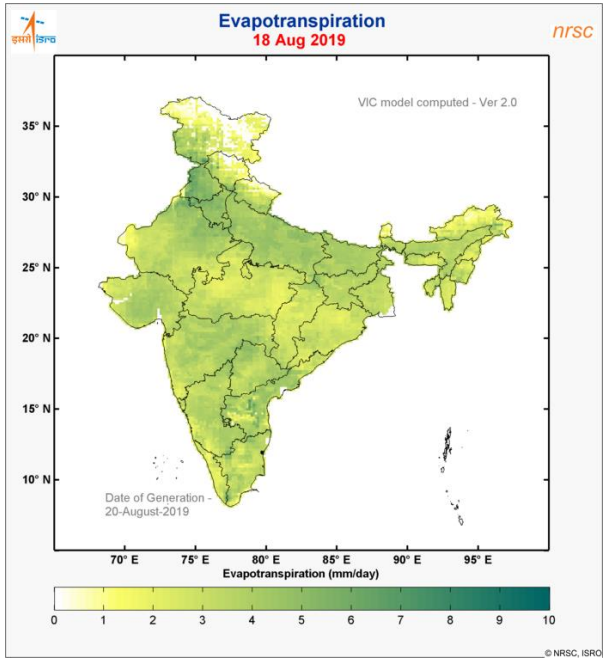


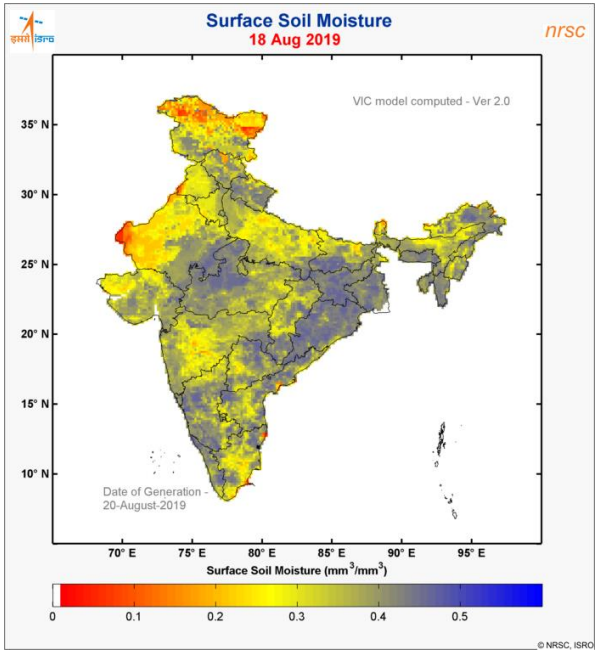
Benefits and End Use

- *Latest update on country's water resources potential*
- *Impact of land use/land cover & climate changes*
- *Quantification of import/export of water use (intra & inter basin) and natural evapotranspiration (Green Water)*
- *Standard Framework for periodic re-assessment and assessment under future climate scenarios*
- *Internalized at CWC, MoWR, RD & GR with Infrastructure & Trained Human Resource*

NEAR REAL TIME HYDROLOGICAL MODELLING - PRODUCTS & SERVICES







Grid Details and Features

- 9min (~16.5km), 3min (~5.5km) grid level modelling frame work
- Product downloadable at daily time step in NetCDF format
- Product provides spatial representation of water balance components over entire India on a given day

Water Resources Infrastructure Planning & Development

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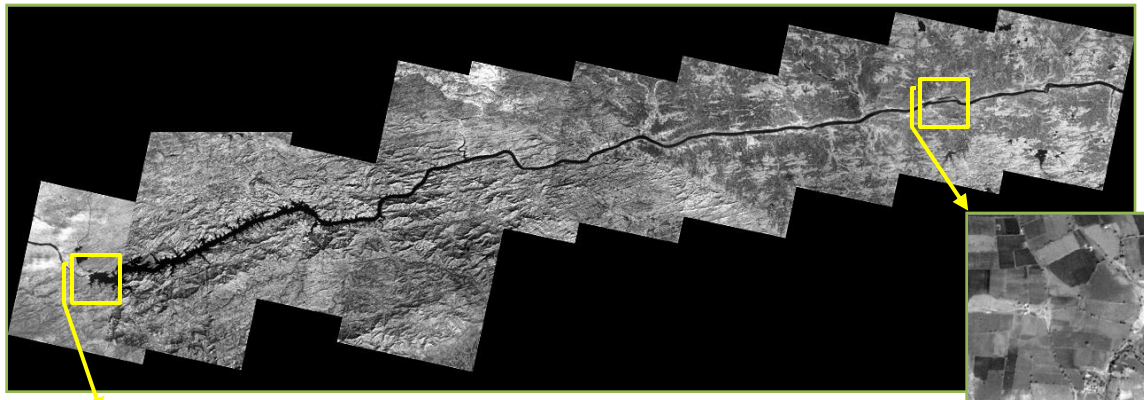
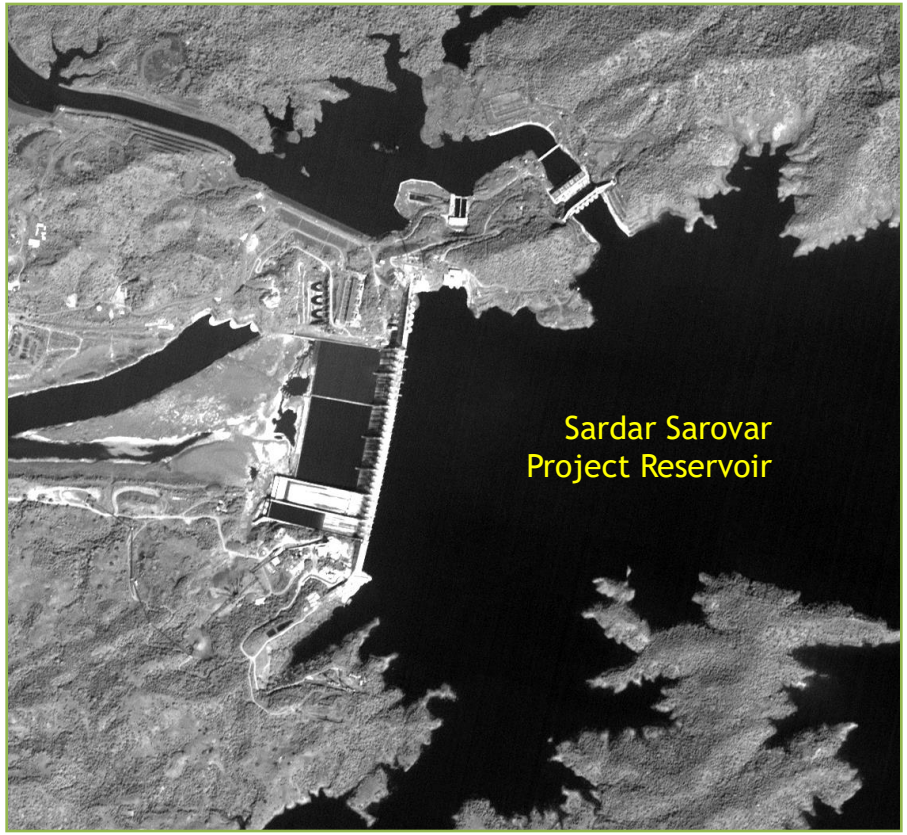
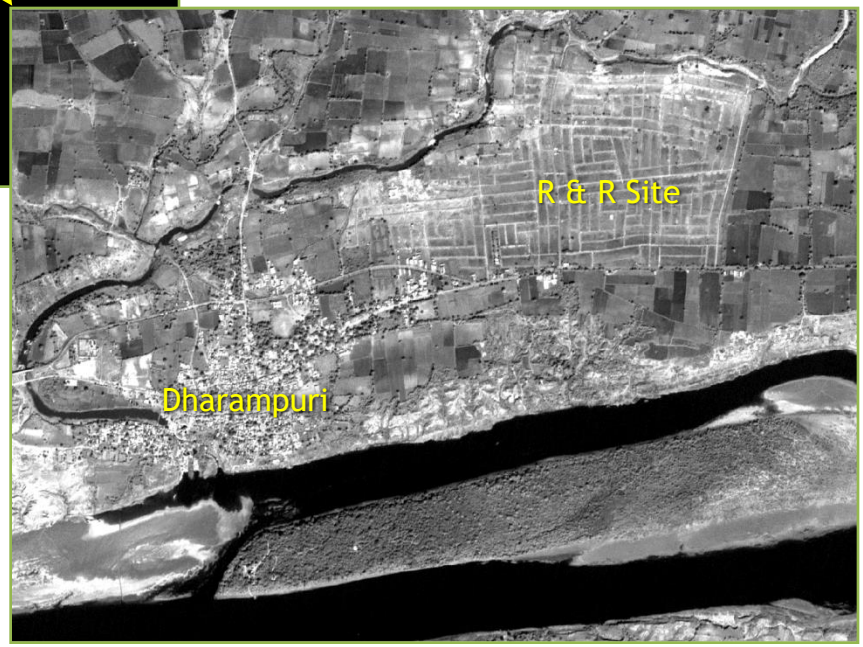
Corridor of Sardar Sarovar Project Submergence Area







Terrain and Topographic information derived from high resolution Cartosat-1 satellite data is supporting

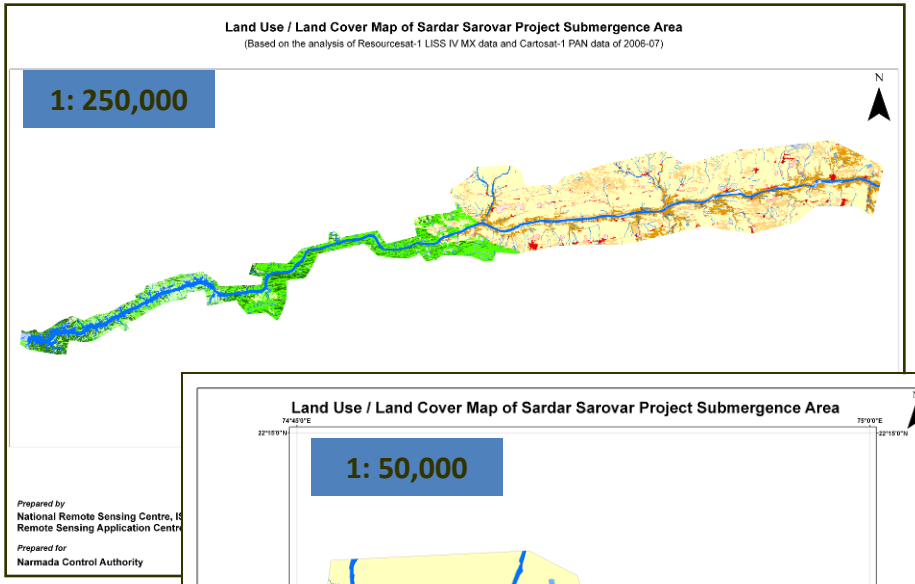
Effective implementation of R & R program,

Infrastructure Planning,

Rehabilitation Management and

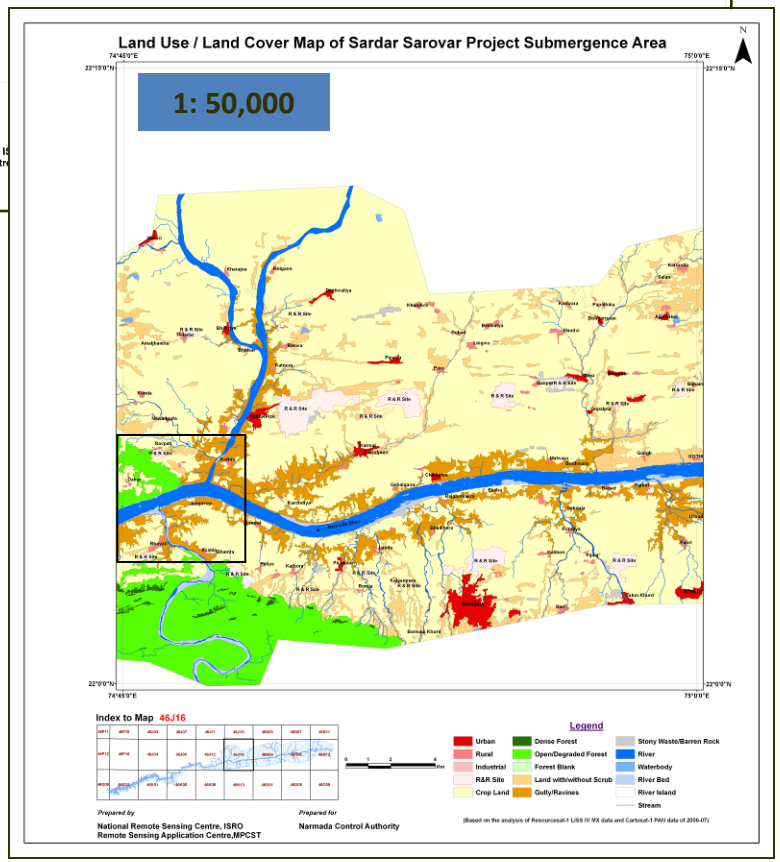
Foreshore Regulation

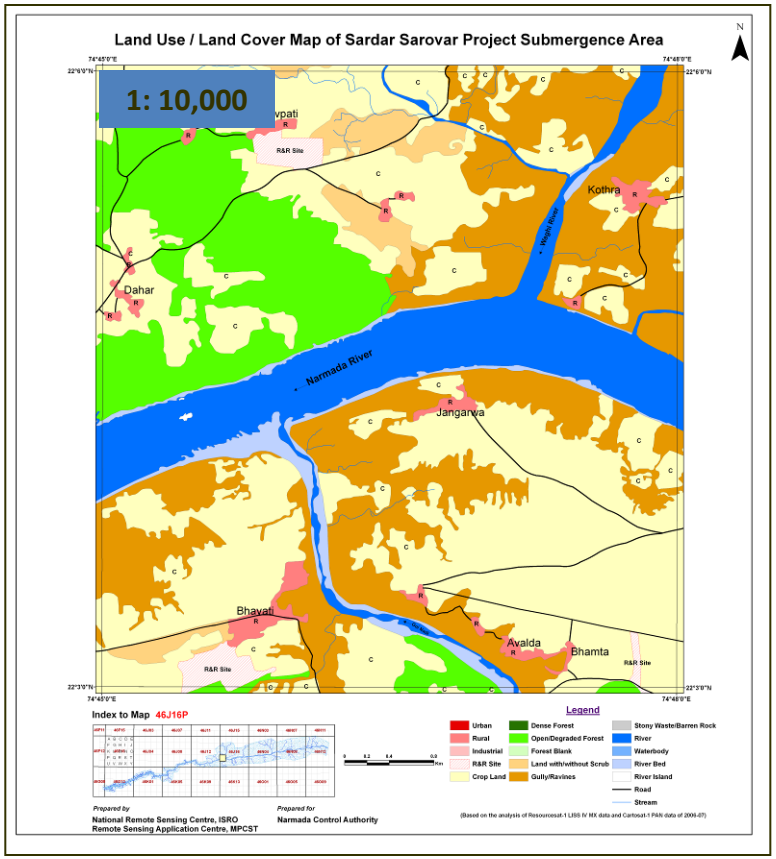
Development of Preliminary GIS Database along the corridor of Sardar Sarovar Project Submergence Area



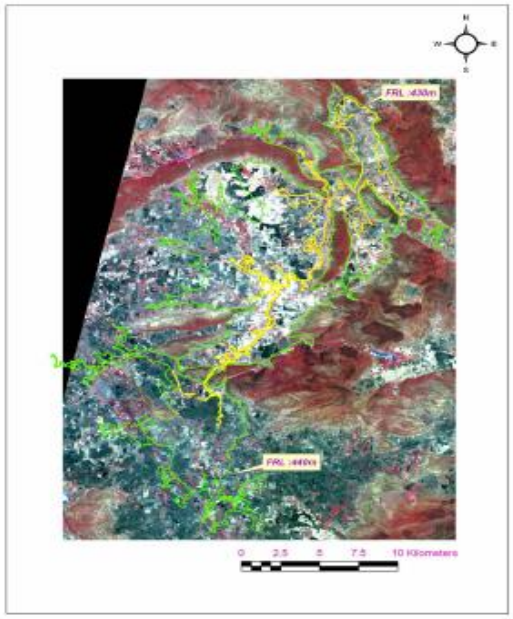
The GIS Database is useful for

- *Formulating Relief and Resettlement works*
- *Identification of Relief & Resettlement Sites*
- *Effective Implementation of Rehabilitation*
- *Reservoir Submergence Area Analysis*

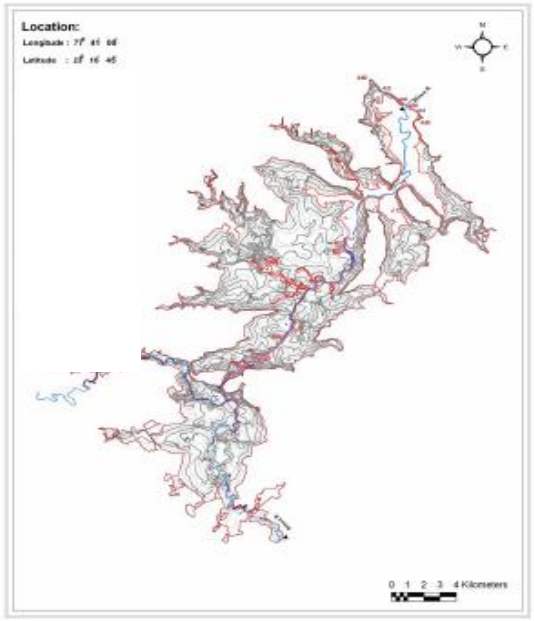




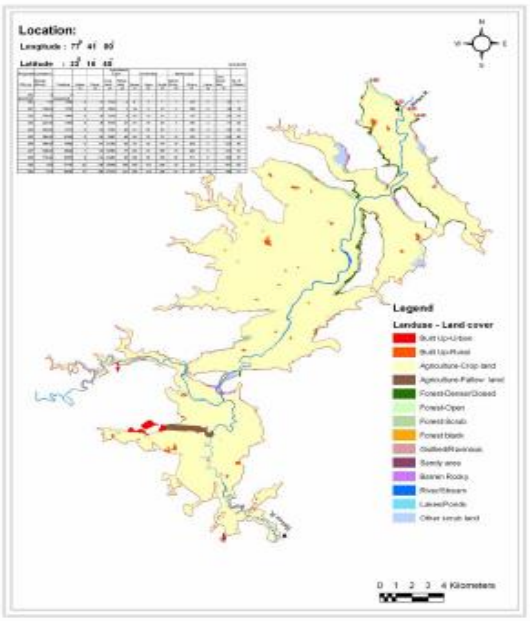
Neemkheda Dam – Submergence area analysis



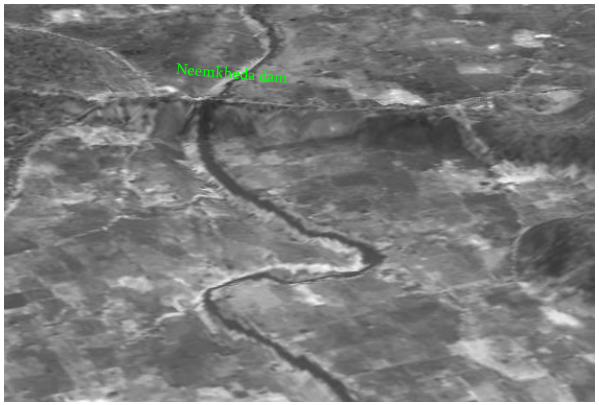
IRS LISS IV Image : Submergence area

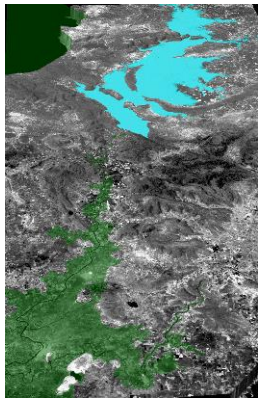


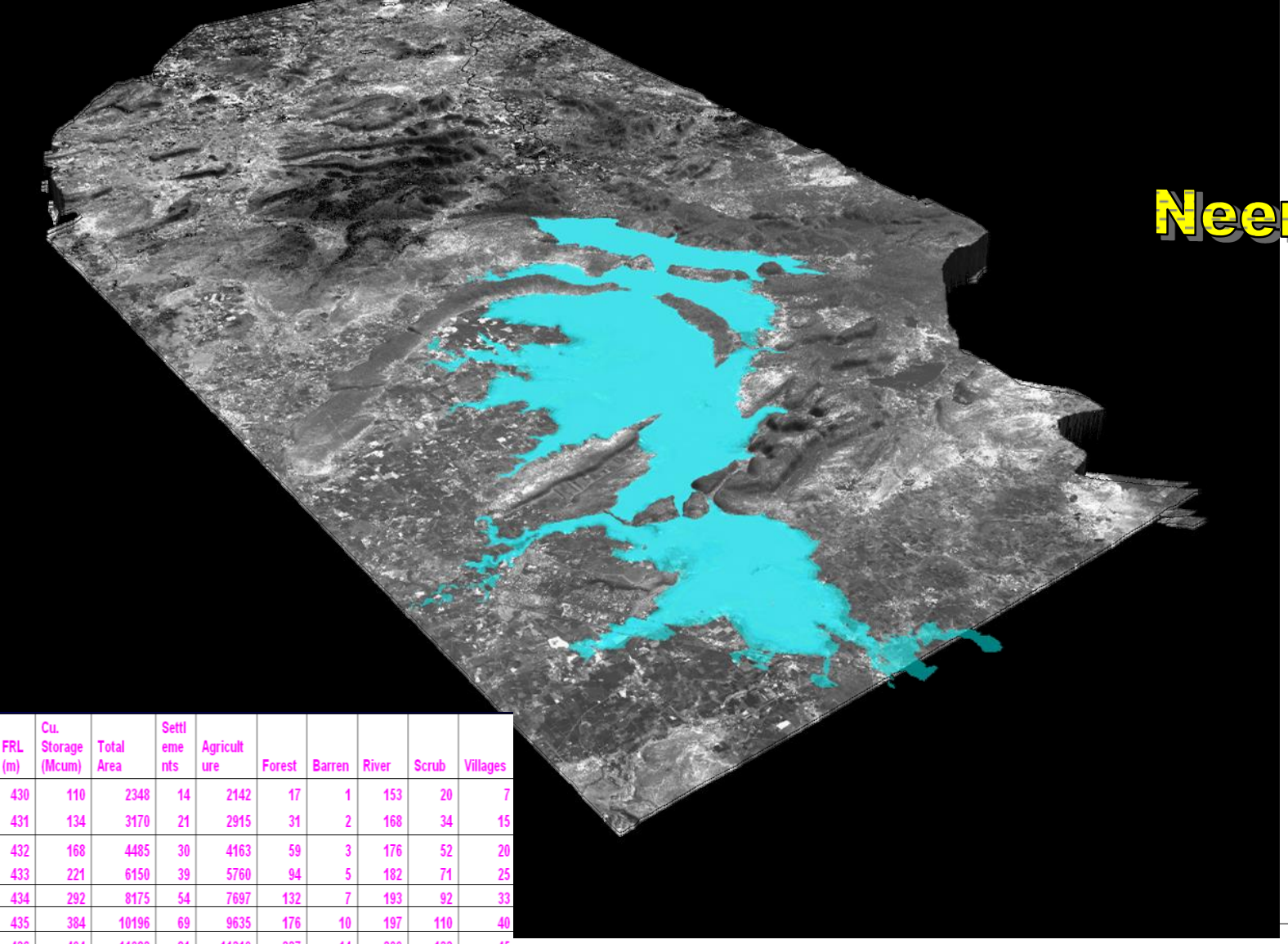
1m contours (430m - 440m) : Submergence area



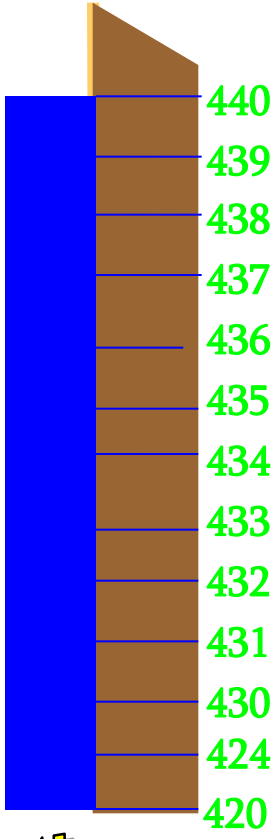
Land use Map (440m) : Submergence area







Neemkheda



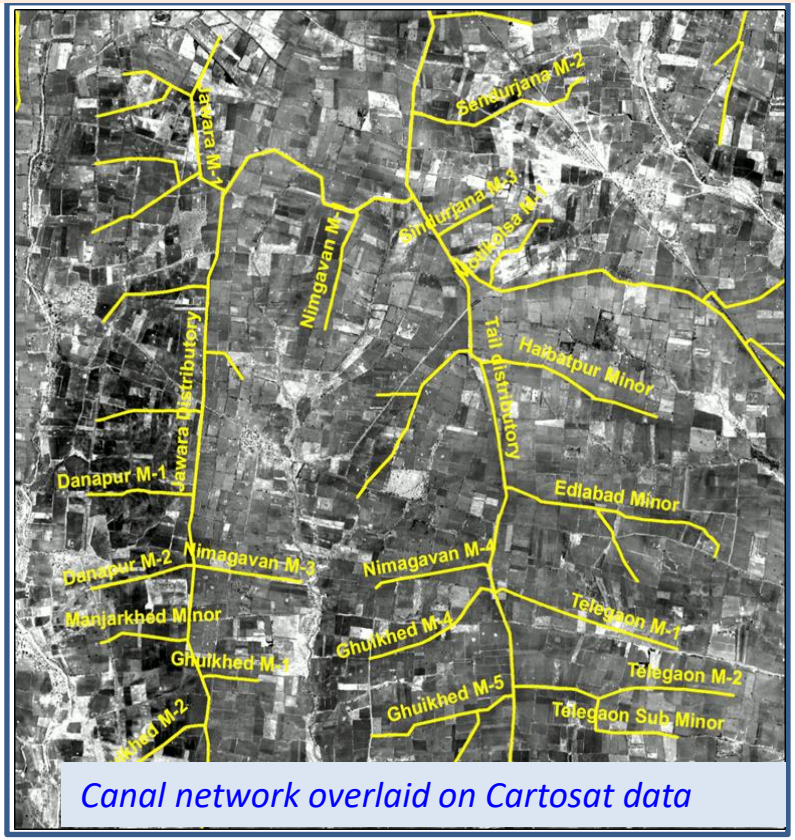
FRL (m)	Cu. Storage (Mcum)	Total Area	Settl eme nts	Agricult ure	Forest	Barren	River	Scrub	Villages
430	110	2348	14	2142	17	1	153	20	7
431	134	3170	21	2915	31	2	168	34	15
432	168	4485	30	4163	59	3	176	52	20
433	221	6150	39	5760	94	5	182	71	25
434	292	8175	54	7697	132	7	193	92	33
435	384	10196	69	9635	176	10	197	110	40
436	494	11982	81	11319	237	14	209	123	45
437	628	13842	94	13060	314	19	214	141	51
438	770	15479	122	14544	403	28	216	166	57
439	933	17115	158	16015	500	39	222	181	60
440	1114	19040	235	17731	601	50	225	198	71

Dam Submeregnce : Simulation

Water Resources Infrastructure Monitoring

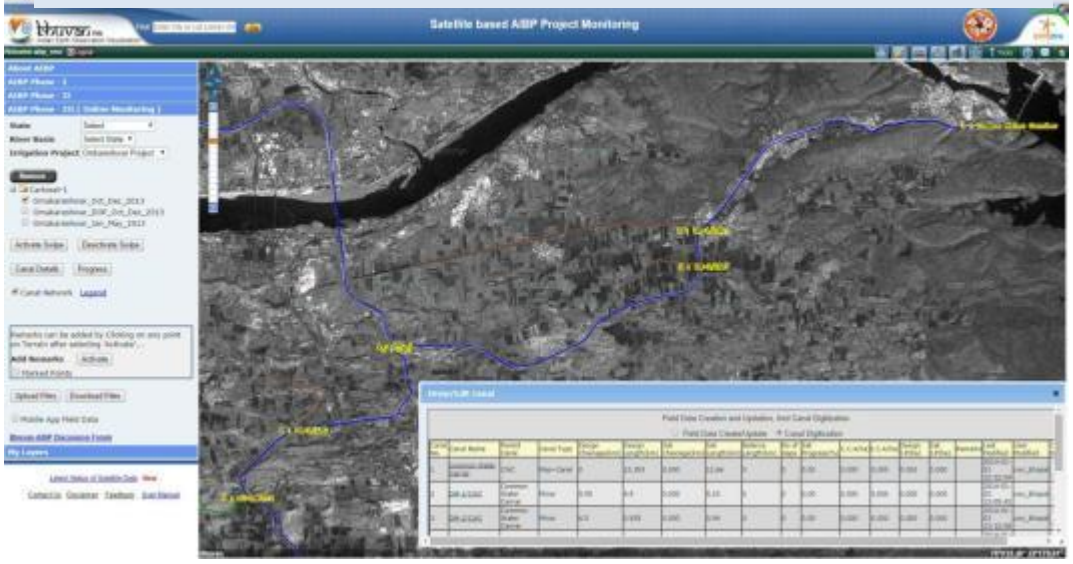
Monitoring & Evaluation of Irrigation Infrastructure using High Resolution Satellite Data

- Accelerated Irrigation Benefit Program (AIBP) is a flagship program of Govt. of India under PMKSY for expeditious completion of ongoing irrigation projects.



Canal network overlaid on Cartosat data

Bhuvan-AIBP portal for satellite based online monitoring of AIBP projects



- ***High resolution Cartosat satellite data captures ground reality of irrigation infrastructure status including critical gaps for prioritisation.***
- ***NRSC monitored 103 AIBP projects and utilised by Central Water Commission (CWC)***
- ***Internalized in CWC through Capacity building***
- ***CWC to monitor 99 priority projects under PMKSY-AIBP***

✓ **End Use/Major Benefits :**

✓ **Effective AIBP implementation through compliance monitoring**

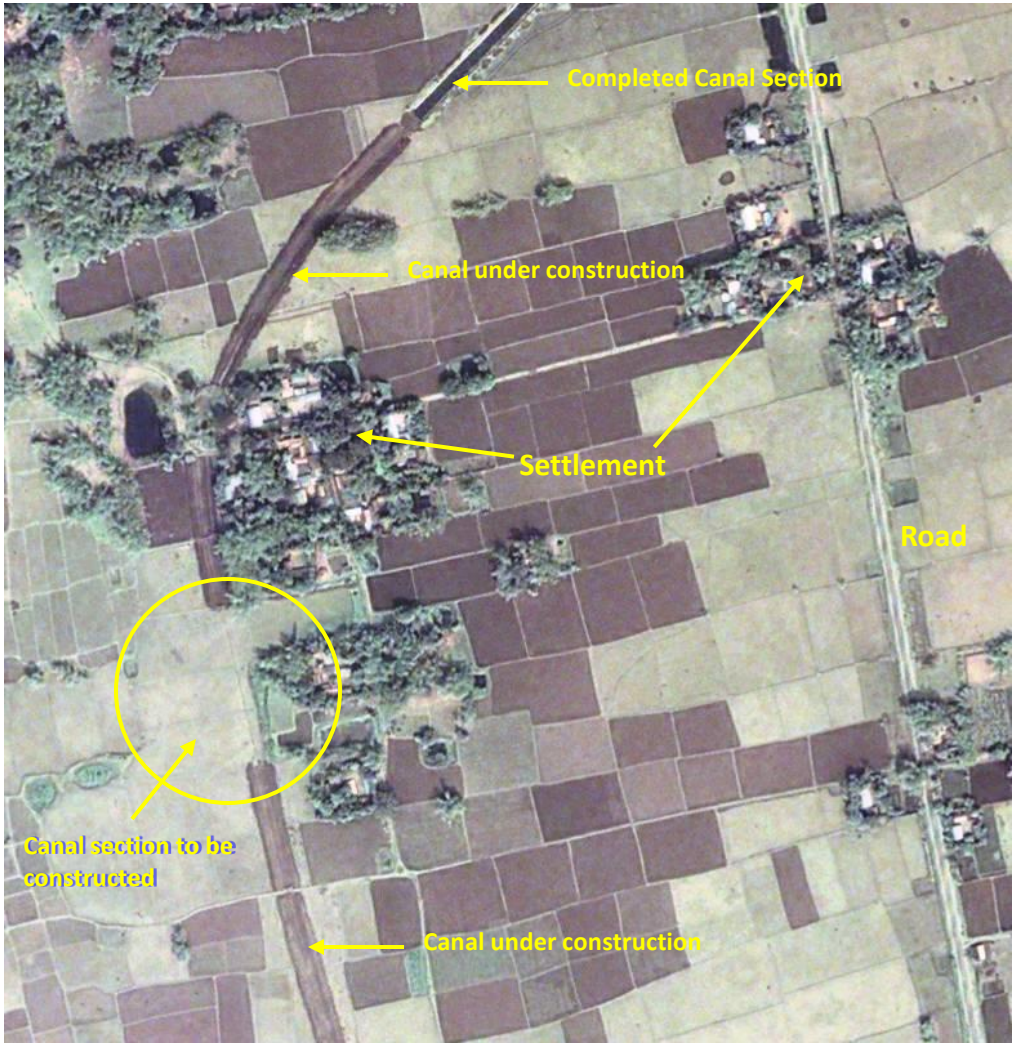
Irrigation Infrastructure Mapping using high resolution satellite data

Head Regulator

Road Bridge

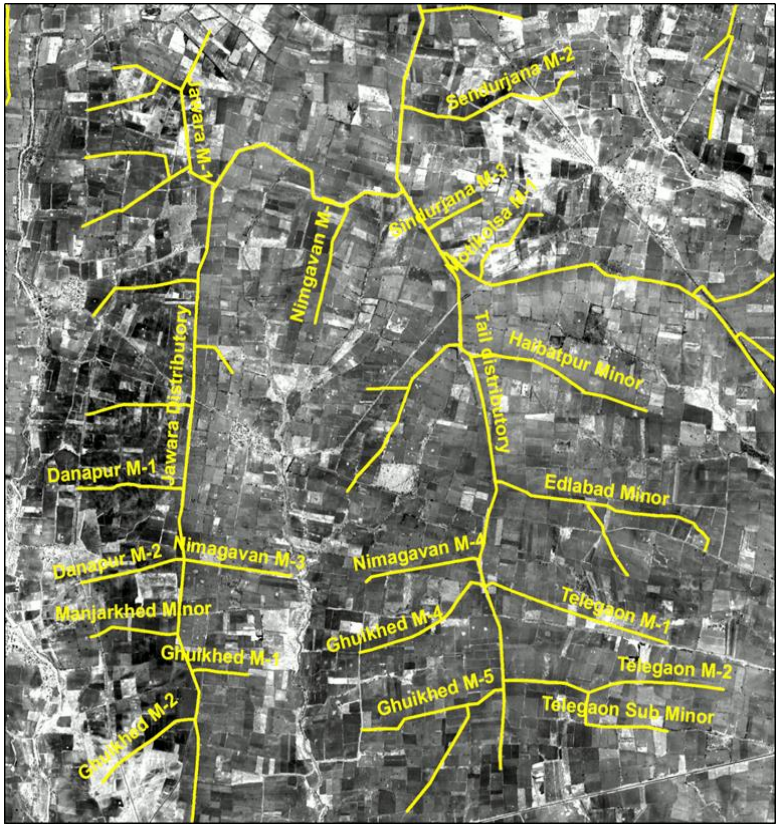
Aqueduct

Sub-minor 5R of minor 3L of 2nd distributary of TMLC

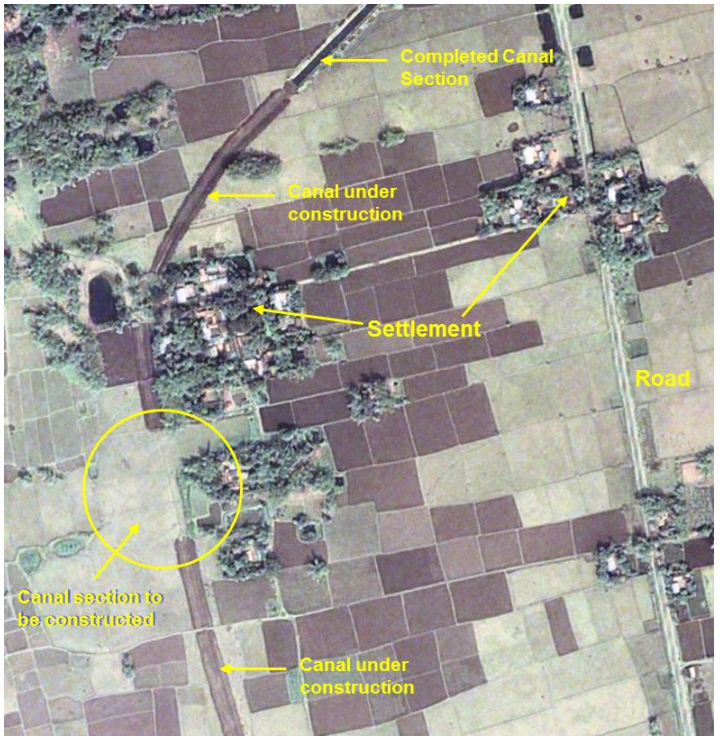


Water Infrastructure Progress Monitoring and Potential Created Assessment

Irrigation Network from Cartosat satellite data



Construction Status of Irrigation Network



- ✓ Time-stamping of irrigation network
- ✓ Critical gaps
- ✓ Effective compliance monitoring
- ✓ Online Monitoring using Bhuvan web services

nrsc

Monitoring Periodic Progress of Irrigation Infrastructure Creation

Lower Penganga Irrigation Project, Telangana State

nrsc

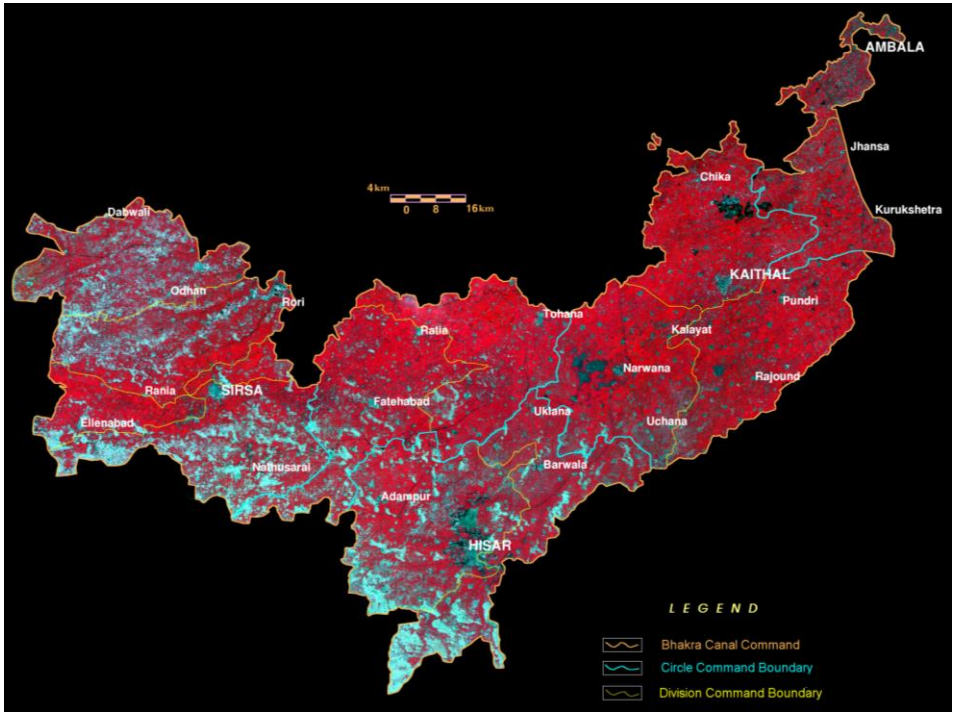
Irrigation Command Area Management

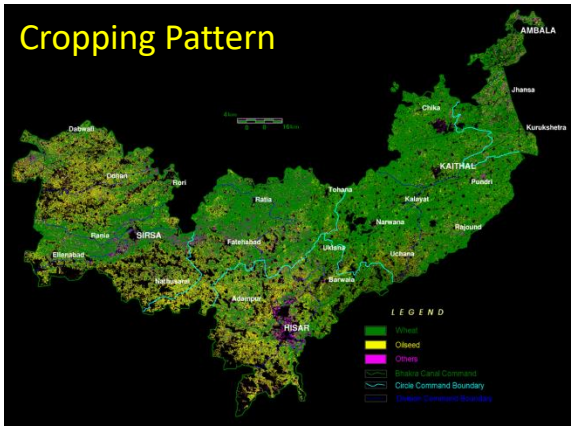
Enhancing Water Use Efficiency

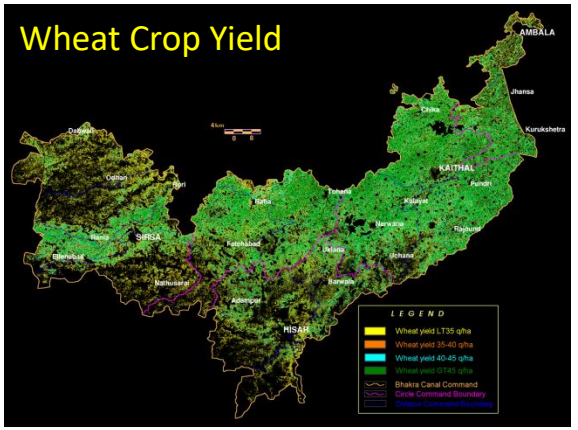
Irrigated Agriculture: Geo-Spatial Applications

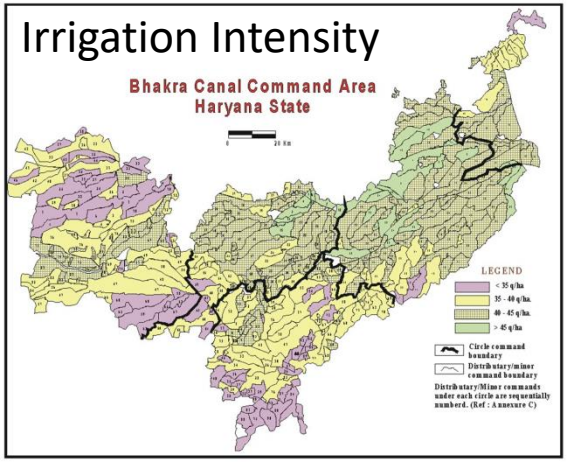
- Infrastructure creation progress monitoring
- Baseline inventory / monitoring
- Irrigation system performance
- Effectiveness/sustenance of interventions scheme
- Near-real time inputs for effective water management
- Minor irrigation management

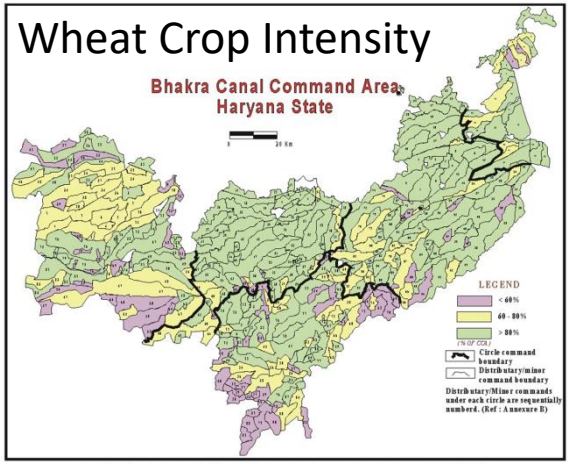
Inventory of Bhakra Canal Command Area Haryana State

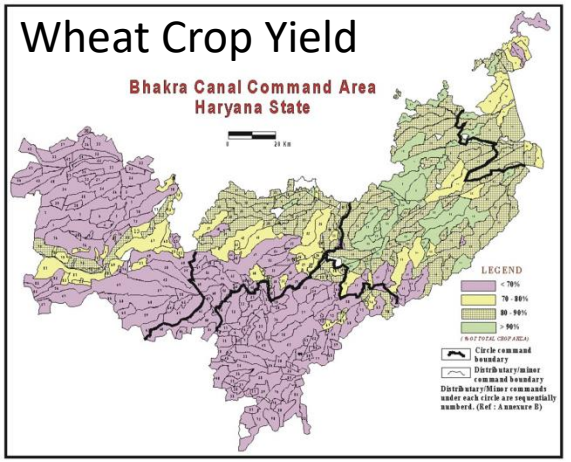








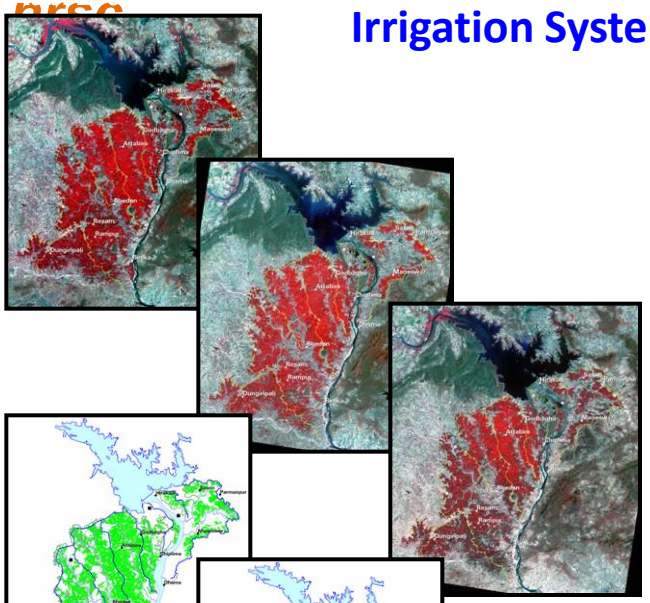




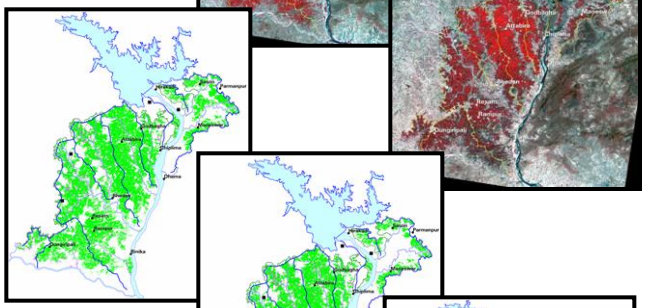
Irrigation System Performance Monitoring through the years

Hirakud Command Area

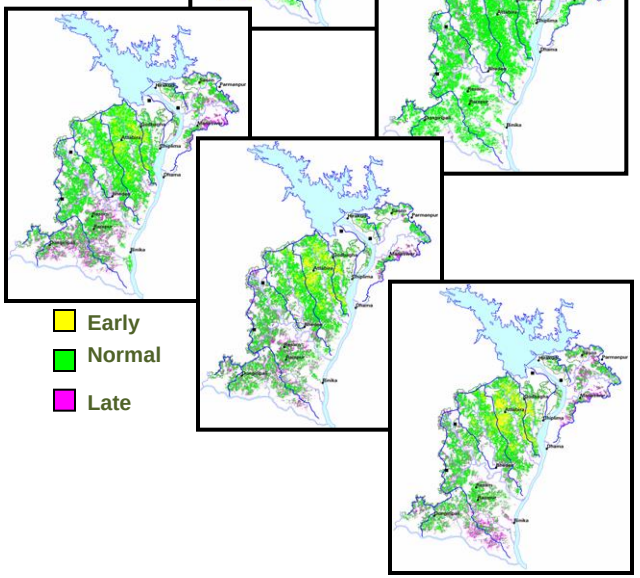
Standard FCC



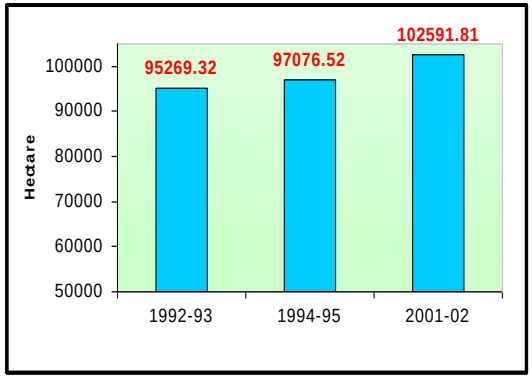
Crop Map



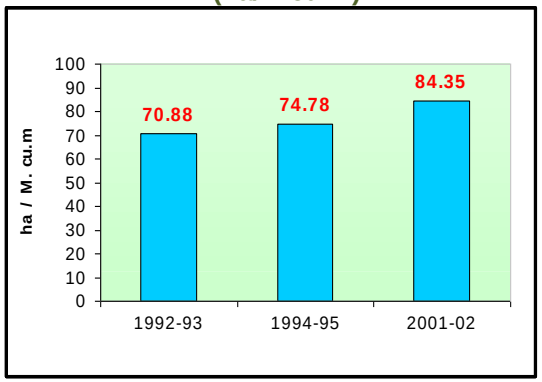
Paddy Transplantation Variability



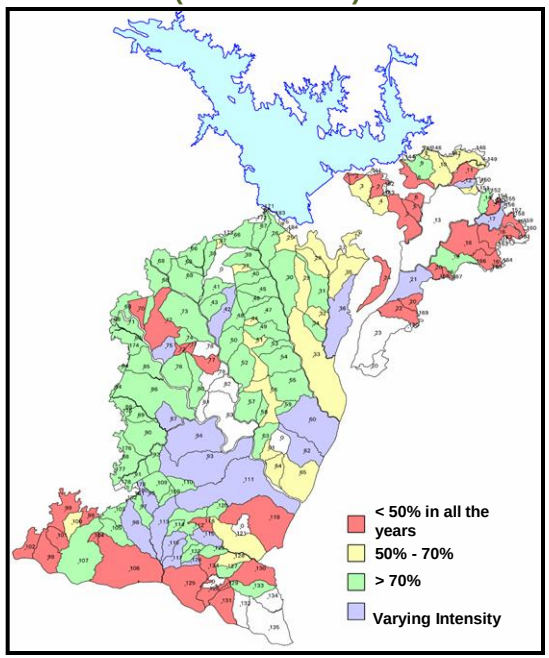
Rabi Crop Area (ha)



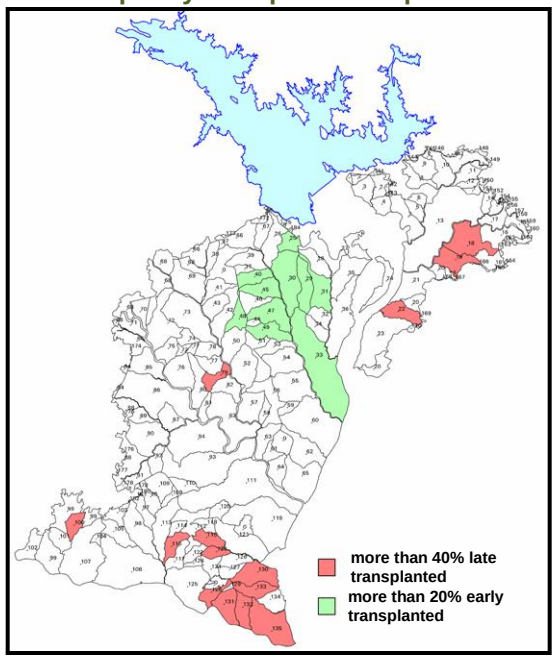
Area Irrigated per unit of Water (ha/M.cu.m)



Rabi Crop Intensity (% out of CCA)

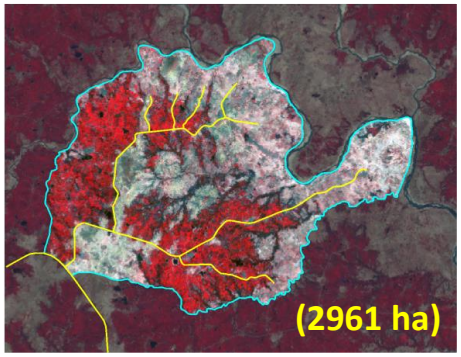


Geographical preference in paddy transplantation period

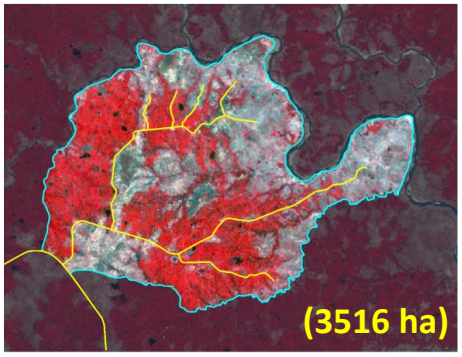


Impact of Intervention Schemes

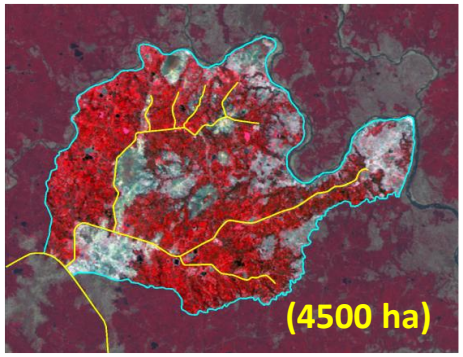
Increase and sustenance of irrigation utilization



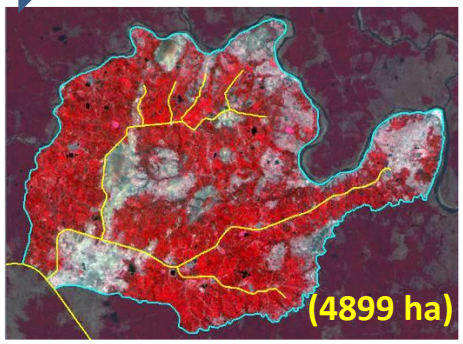
1993



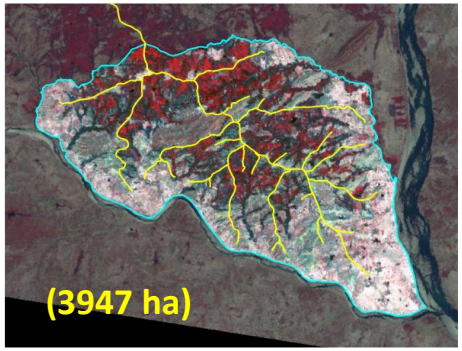
1995

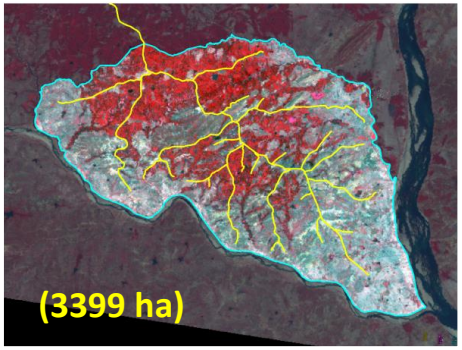


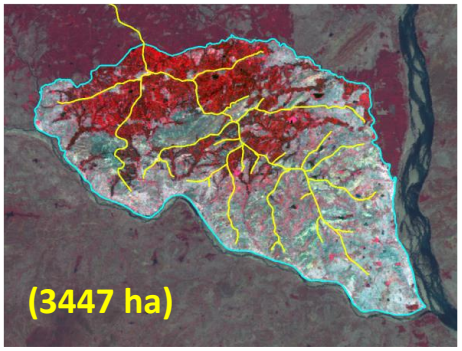
2002

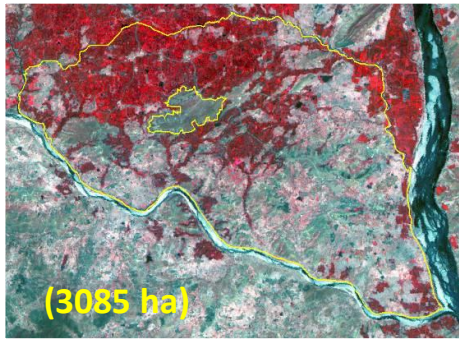


2007





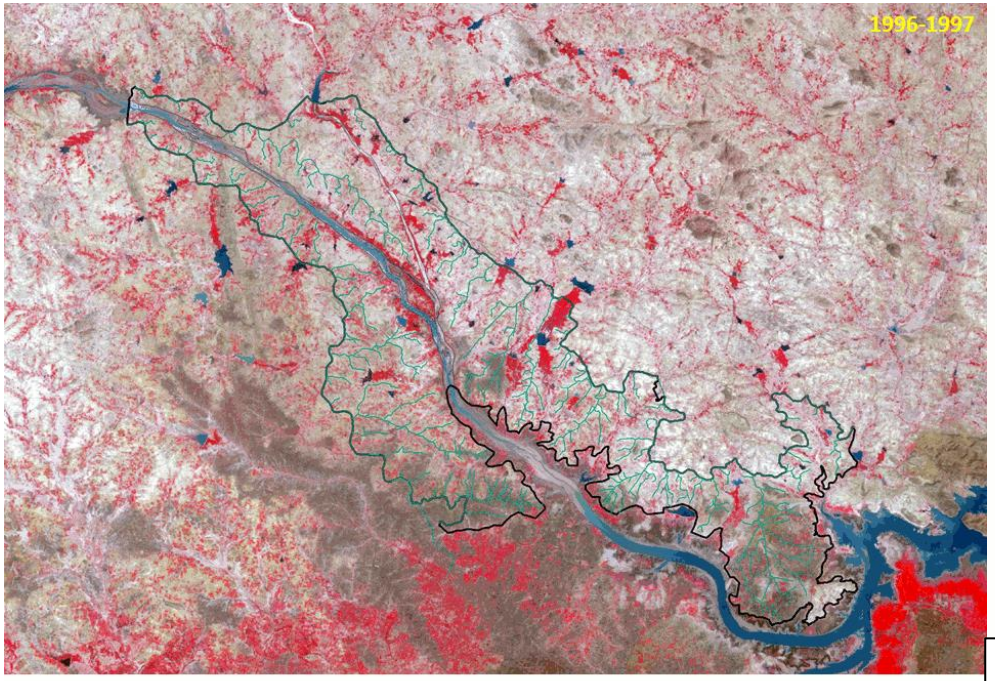




Deterioration of irrigation utilization

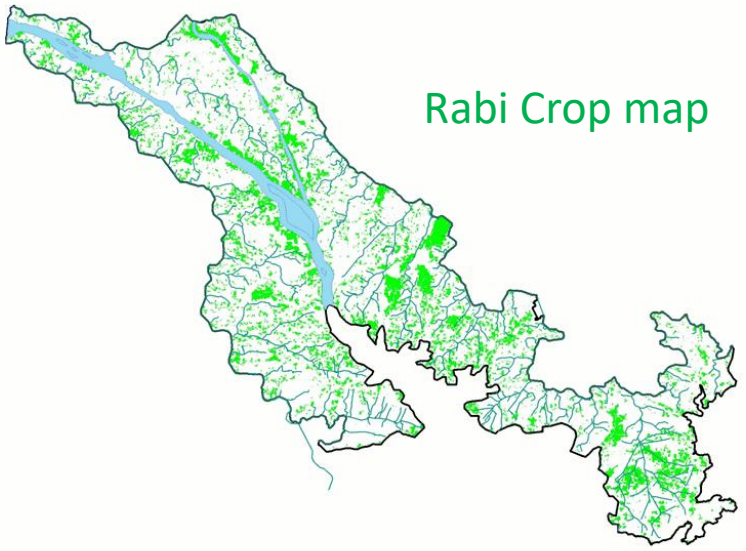
Monitoring of Irrigation Potential Utilisation

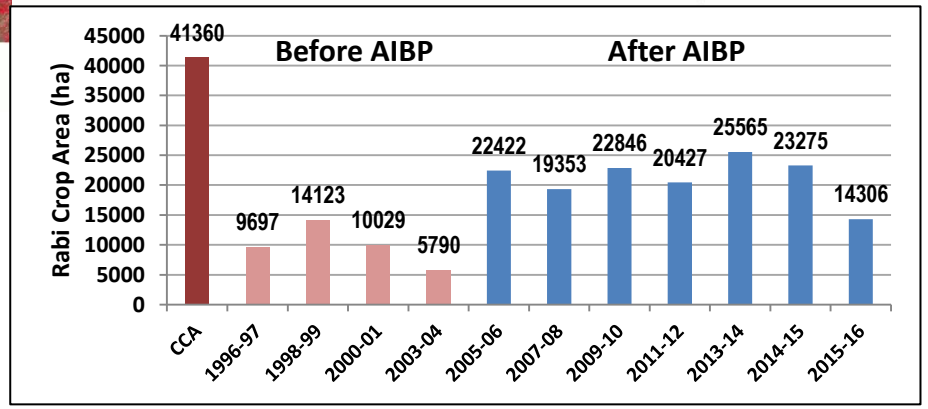
- AIBP is expected to increase in Irrigation Potential Utilisation in the country. Temporal satellite data was used to evaluate the Irrigation Potential (I.P) Utilisation



Jurala Project, Telangana State

1996-1997





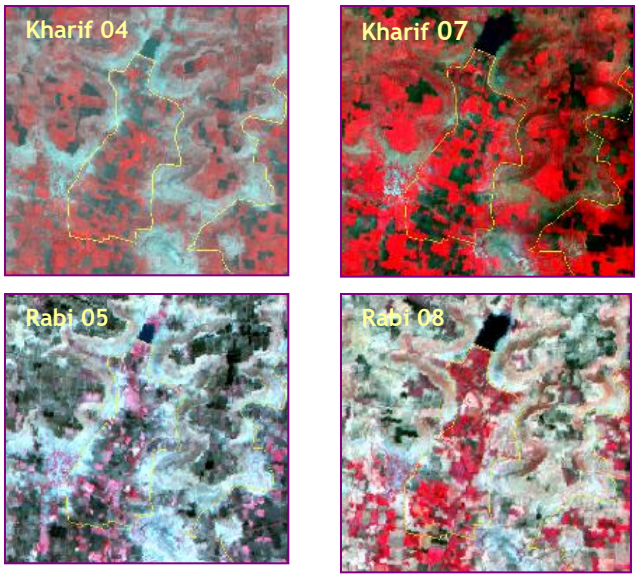
- *Satellite data analysis clearly indicated increase in Irrigation Potential Utilisation (IPU)*

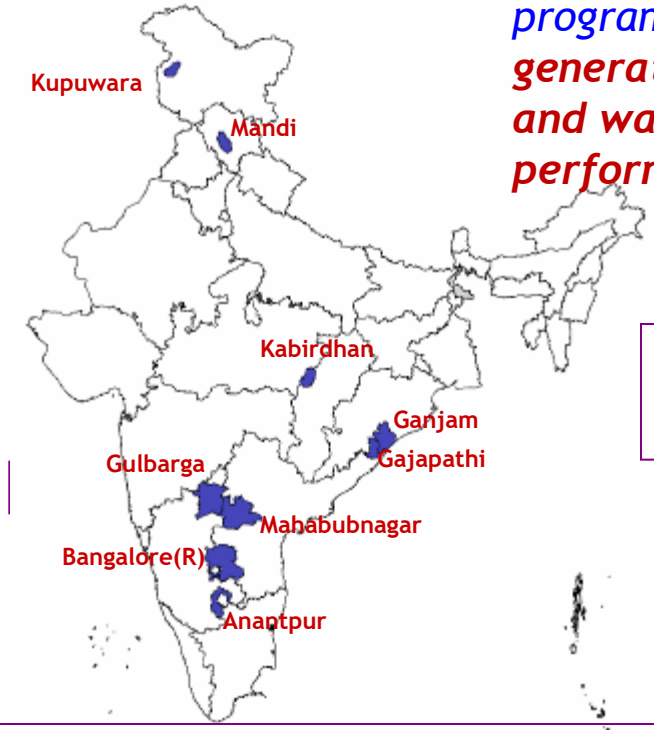
- ✓ **Satellite data enables evaluation of impact of AIBP implementation**
- ✓ **Quantification of potential created and utilized**

Tank / Minor Irrigation Water Management

4.78 M.ha in 1962-63
3.07 M.ha 1985-86
1.97 M.ha 2008-09

*Multi-year satellite data helps in evaluating impact of developmental programs – **through generation of agriculture and water related performance indicators***

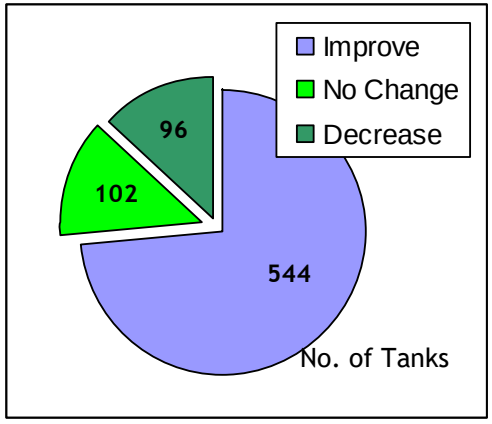


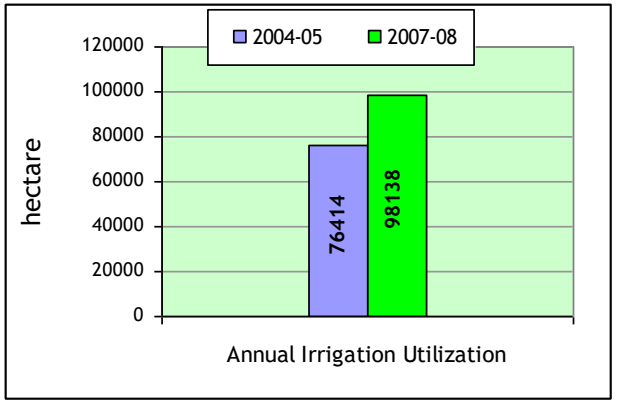


The satellite data based evaluation covered
742 Minor Irrigation schemes in 9 Districts spread over 6 States

- Total CCA covered - 1,01,788 hectare
- Two years of study
  2004-05 (Pre) and 2007-08 (Post)

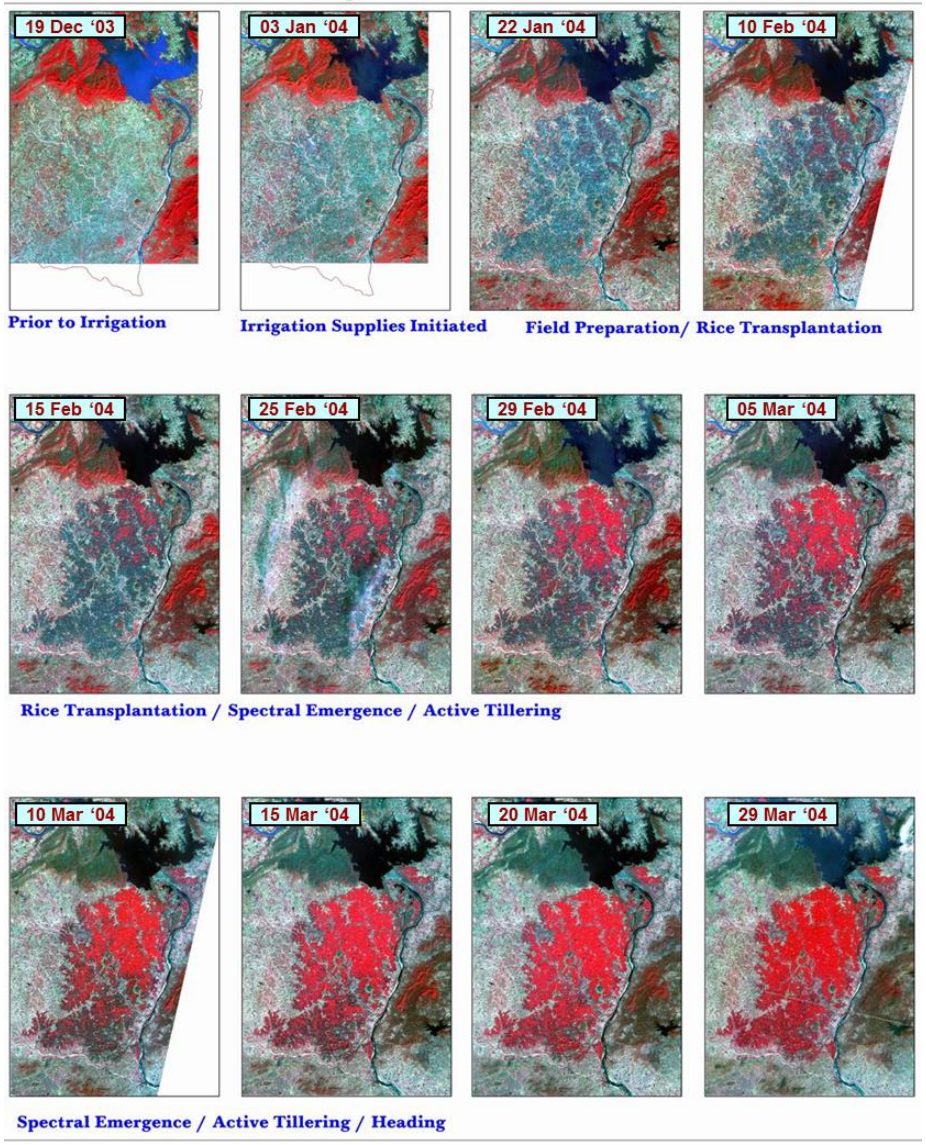
The satellite data based evaluation considers the temporal change (from 2004-05 to 2007-08) in Water spread area, Season-wise cropped area, Principal crop condition & Annual irrigation utilization



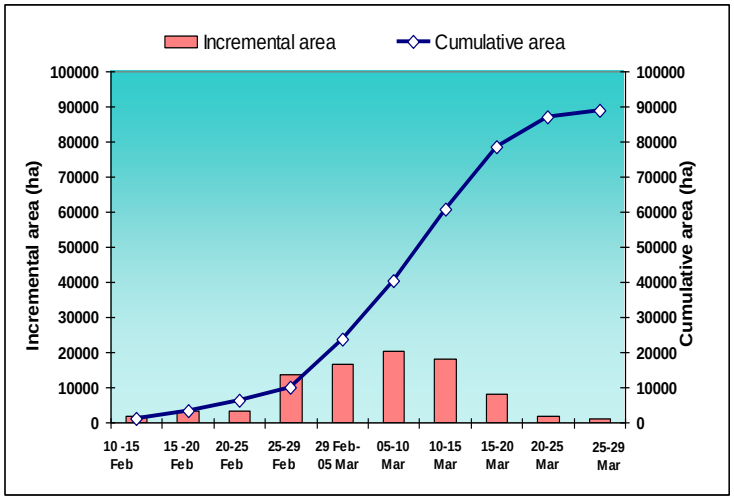


Overall Performance of 742 Tanks

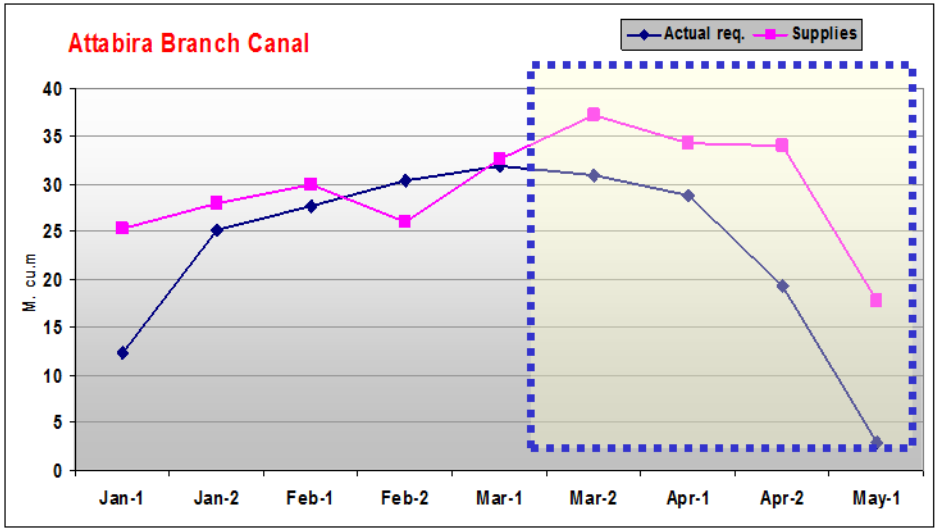
Satellite data based Irrigation Scheduling



Progression of 2003-04 Rabi Crop

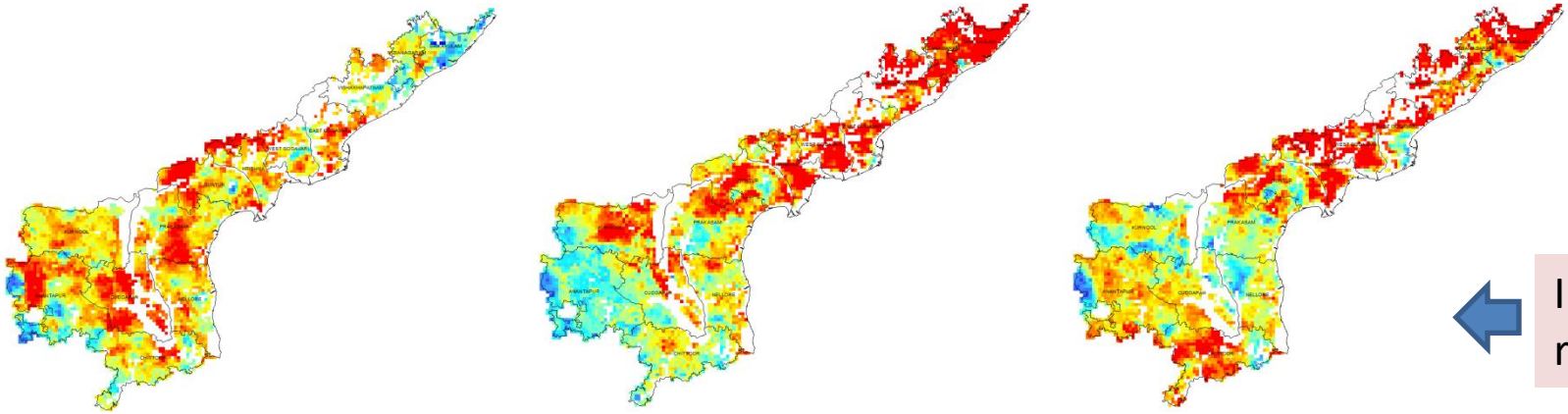


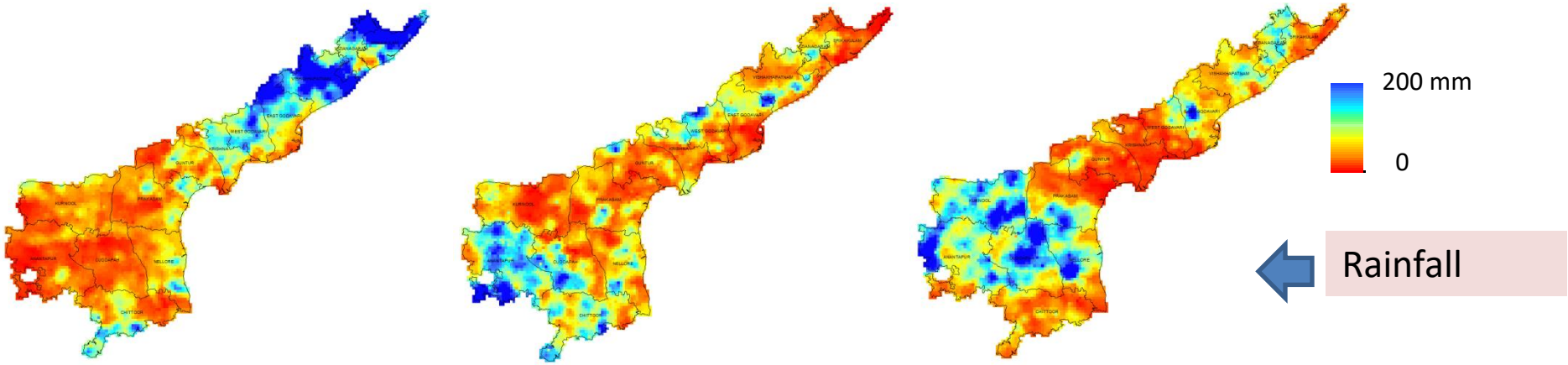
Irrigation Water Requirements



Irrigation Demand Estimation

Andhra Pradesh, Kharif 2017 (Experimental)





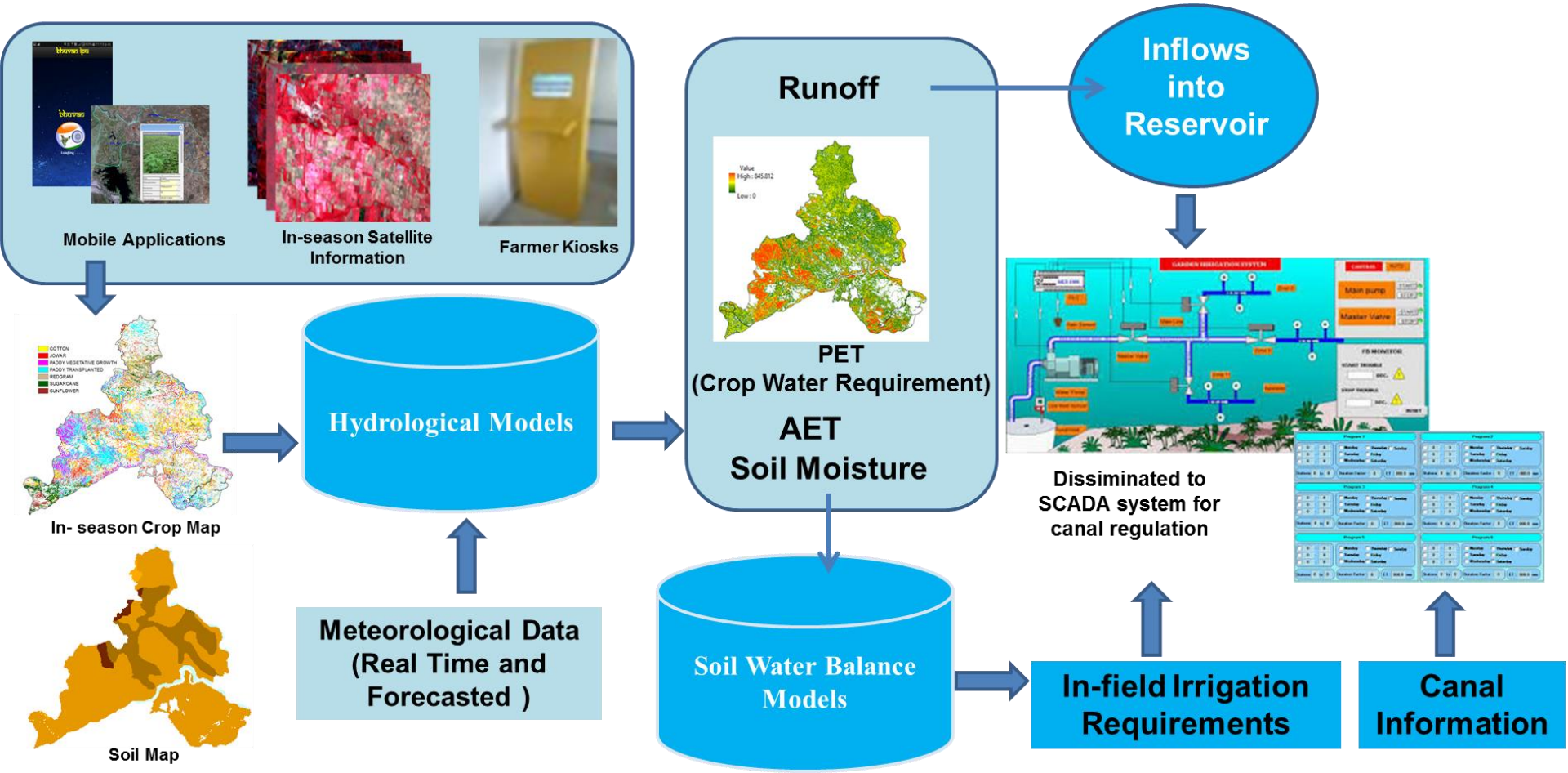
Week-13 (27 Aug-2 Sep)

Week-14 (3 Sep – 9 Sep)

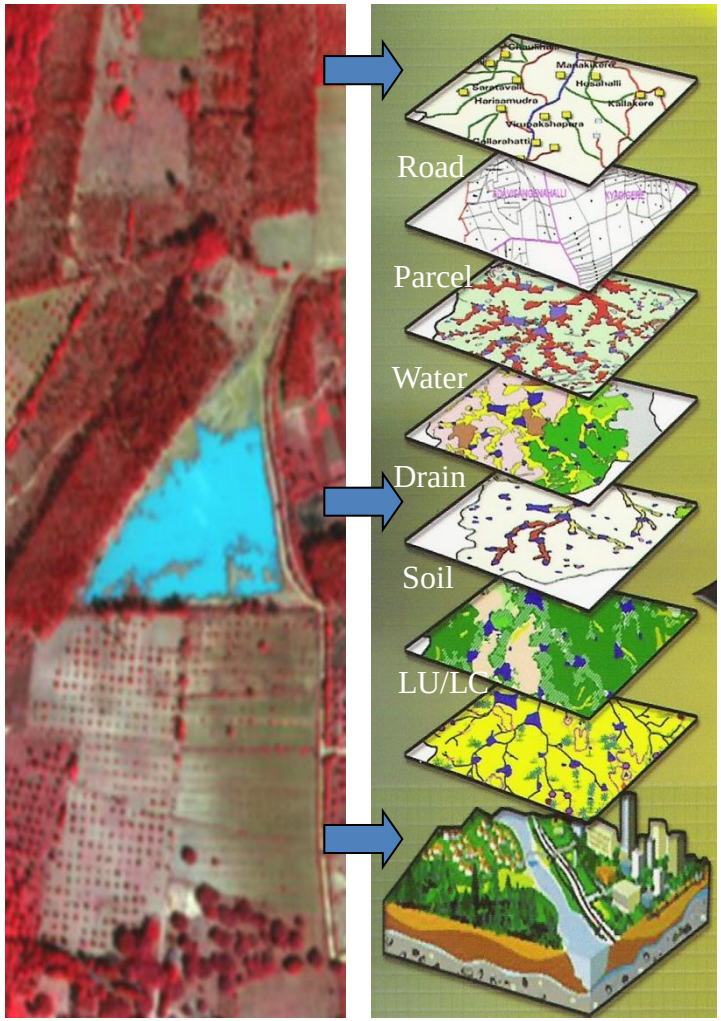
Week-15 (10 Sep – 16 Sep)

Satellite data based inputs for Irrigation Scheduling

- *Geo-spatial database*
- *In-season cropping pattern*
- *Decision Support System*
- *In-season irrigation water demand at weekly/fortnightly time-step*
- *Performance of irrigation system.*

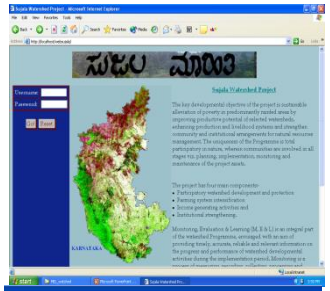


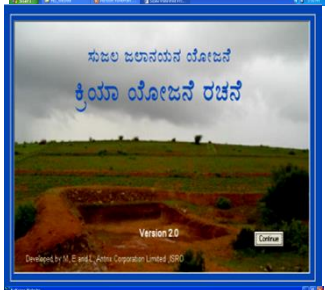
Watershed Management: EO Inputs



Satellite Inputs (Resource Maps)

Community Participation





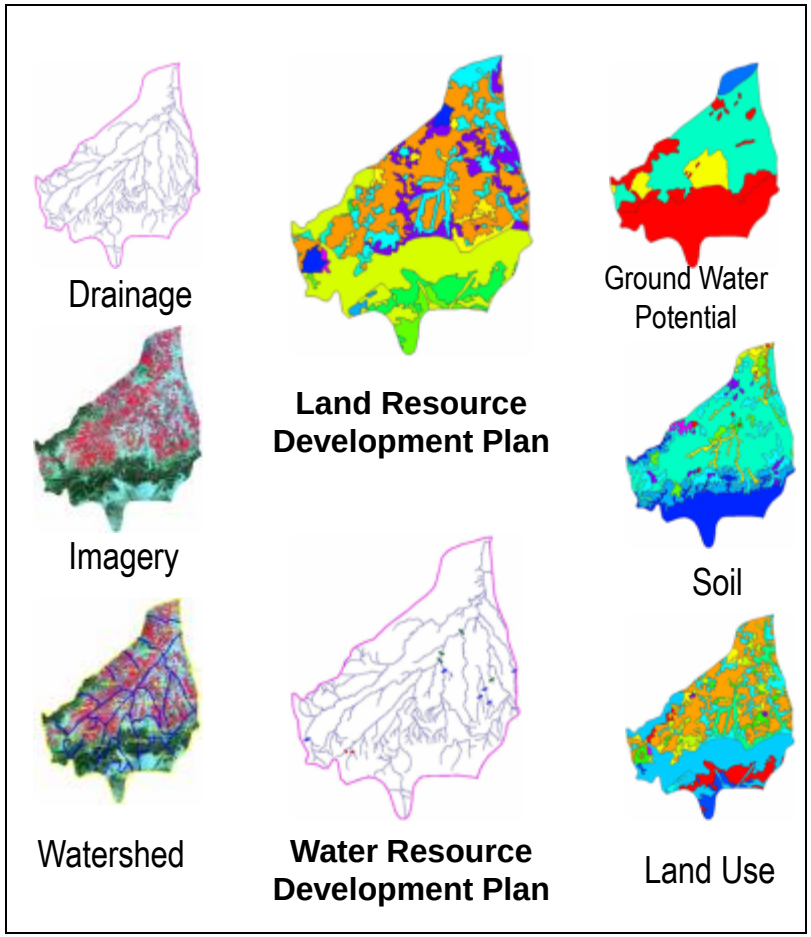
GIS / MIS

- Watershed Prioritization & Action Plan
- Concurrent Monitoring of Implementation
- Impact Assessment

Improving Productivity in Drylands

Integrated Mission for Sustainable Development (IMSD)

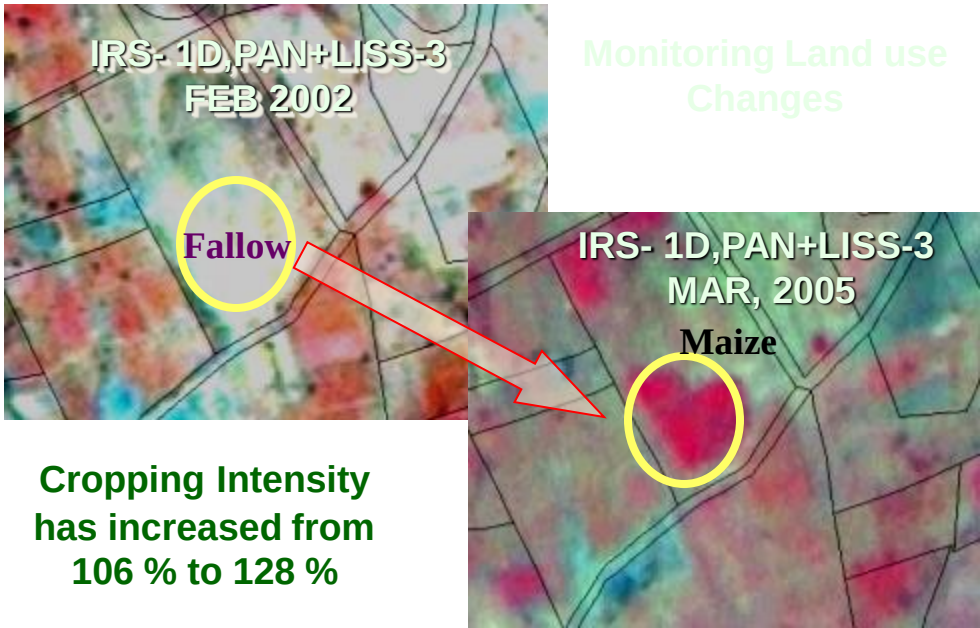
Land & Water resources development plans for 84 Mha in 175 dists. in country



Participatory Land and Water Resources Management : Sujala

Monitoring & Evaluation of Dev. Activity in 77 Sub-watersheds in 5 Dists. of Karnataka

- Watershed prioritisation & Development using EO inputs
- Concurrent Monitoring & Mid-course correction of Implementation
- Social & Environmental Impact Assessment
- Improving the quality of life



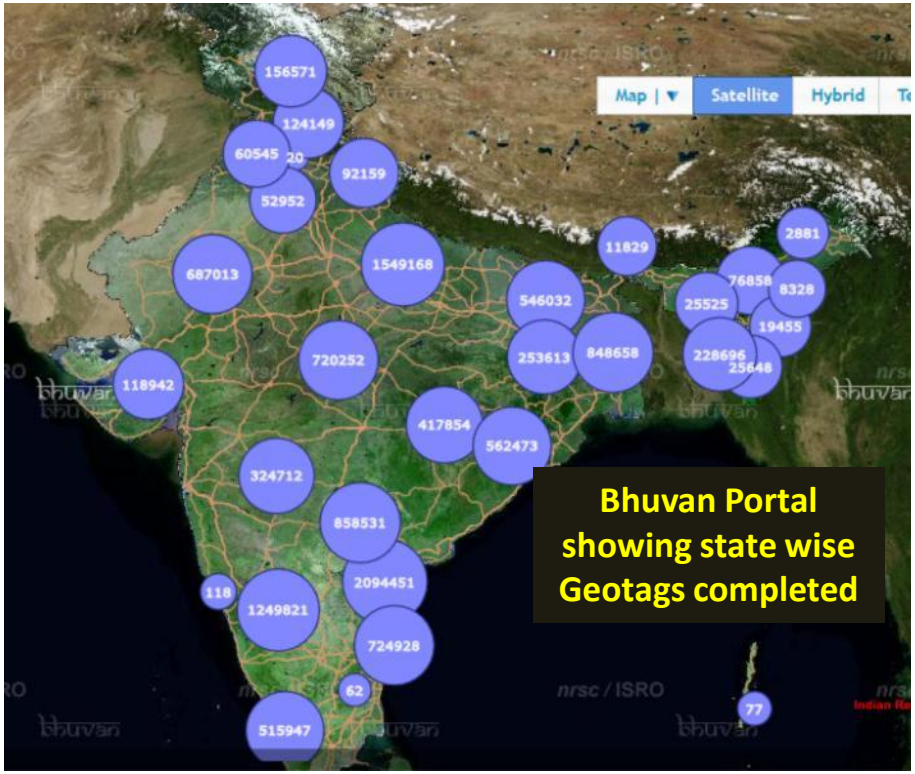
Monitoring Land use Changes

Cropping Intensity has increased from 106 % to 128 %

Rural Development (MGNREGA and IWMP)

GeoMGNREGA

- Under rural employment guarantee scheme of Govt. of India
- 3.5 Cr assets geotagged
- 1,20,000 officers till Panchayat level Trained through ToT Approach



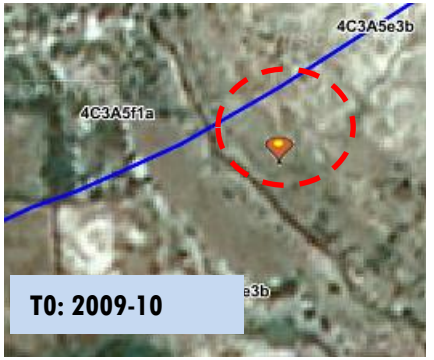
Bhuvan Portal showing state wise Geotags completed

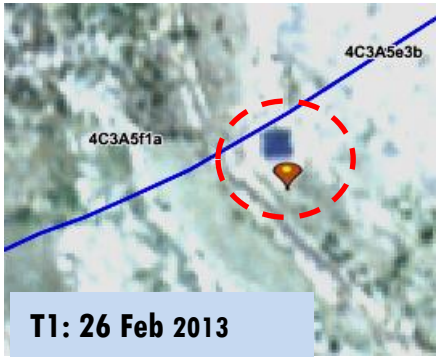
IWMP

8200 watershed projects

Across States 1200 Officers trained to use Srishti and Drishti (Smart Phone App)

8.4 lakh Geotags till date





Dugout pond observed through Bhuvan Visualisation

MONITORING OF WATERSHEDS & RURAL ASSETS

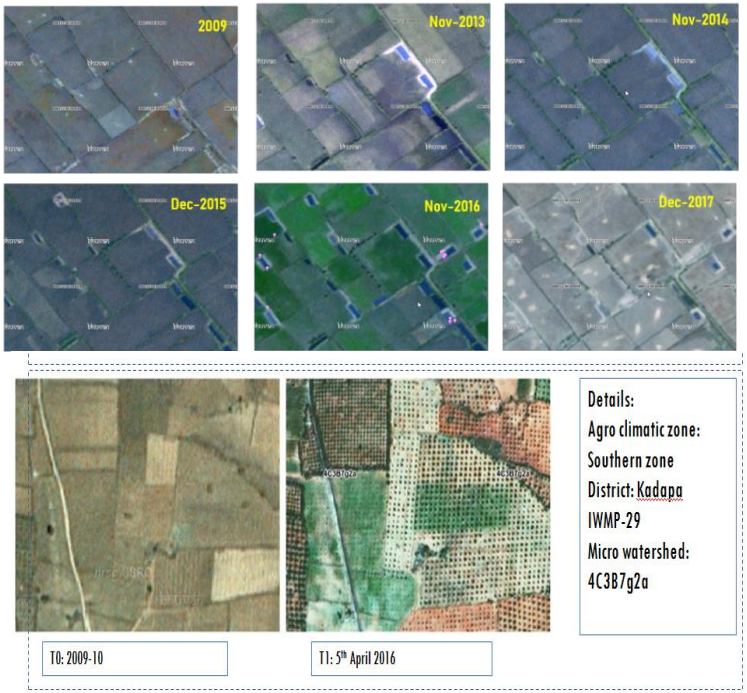
IWMP Monitoring:

- 7629 projects
- 13525 satellite images
- 4 App Versions
- Geotags 12.25 lakhs
- Reports 4234
- Capacity : 1400 Officers
- Funds : Rs 3503 Lakhs

NABARD Funded Watershed Monitoring

- Focused Area Approach
- 1504 Projects
- Capacity : 400 Officers
- Customisation for MIS integration
- Institutionalisation for GIS Cell efforts
- Funds : Rs 300 Lakhs

Increase in the number of farm ponds were observed in the watershed Project - Karauli - IWMP - 02/2009-10 (T1,T2,T3,T4)



Monitoring of establishment of plantations

GeoMGNREGA

- Inventory of Asstes of MGNREGA.
- Geotag linked financing (B-D-A)
- Asset planning with Bhuvan
- Total Assets geotagged : 3.64 Crore (Phase I&II)
- Analytics Web Service for 172 subcategories
- Linkages to Jal Shakti Abhiyan

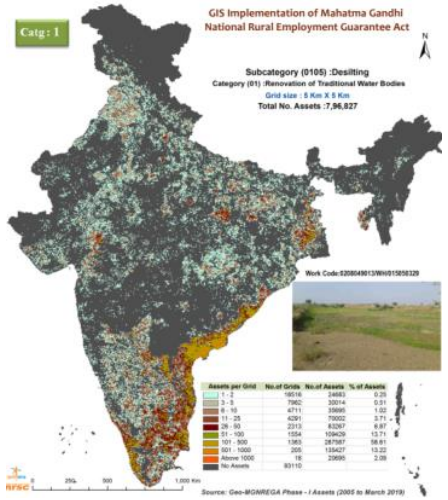
Yuktdhara
Geospatial Planning Portal for Geo-MGNREGA

RKVY : Rashtriya Krishi Vikas Yojana

- Asset geotags collected : 3,95, 202
- Trained 2600 officials & 11000 user accounts are active.

PDMC – Per Drop More Crop

162120 Geotags has demonstrated Micro irrigation assets spread



Impact of Farm Ponds in Watersheds

Welcome to Bhuvan | ISRO... | ISRO's Geoportal | Gateway...

bhuvan.nrsc.gov.in/projects/iwmp/index.php?type=dataprovider

Data-Provider

Department of Land Resources, Ministry of Rural Development

Bhuvan IWMP-SRISHTI | Enter City or Lat,Lon(ex:chennai or :

Project IWMP Microwatersheds

Upload (Base/DPR/Action Plan...) Data

- Satellite Data (2014)
- Satellite Data (2015)
- Field Photographs (Mobile)
- LULC 50K: 2005-06
- LULC 50K: 2011-12
- Wasteland 50K: 2008-09
- Geomorphology 50K: 2005-06
- Lineament 50K
- Erosion 50K: 2005-06
- Salt Affected 50K: 2005-06
- Soil Depth
- Soil Erosion
- Soil Productivity
- Soil Slope
- Soil Texture
- Cadastral Bounda

Activate Swipe | Deactivate Swipe

Field Data

Action Plan Preparation

User Added Layers

Discussion Forum | Legend

4C3E5n2b 4C3E5n2c 4C3E5n2d

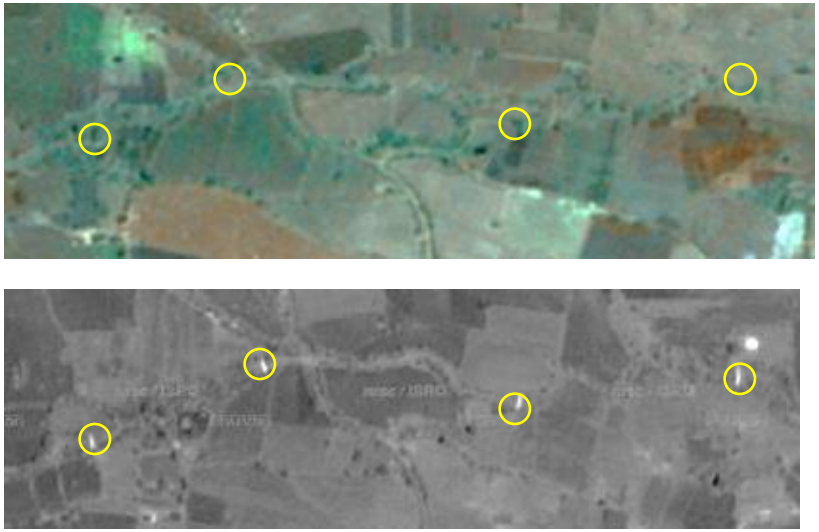
Construction of dug out ponds in Owk micro watershed (4c3e5n2d), Kurnool Dt. (IWMP-8, 2009-10) AP

OUTCOMES OF WEB BASED MONITORING OF WATERSHEDS

- Tracks the IWMP activities in terms of location and category
- Changes brought about in terms of water, vegetation, structures are used as parameters of impact
- Scope exists to understand patterns of agricultural production
- Srishti also enables functionaries to prepare plans for the proposed watershed
- Overall impact on Natural Resource Management – increased biomass, improved crop productivity, increase in crop intensity, generation of employment opportunities etc.

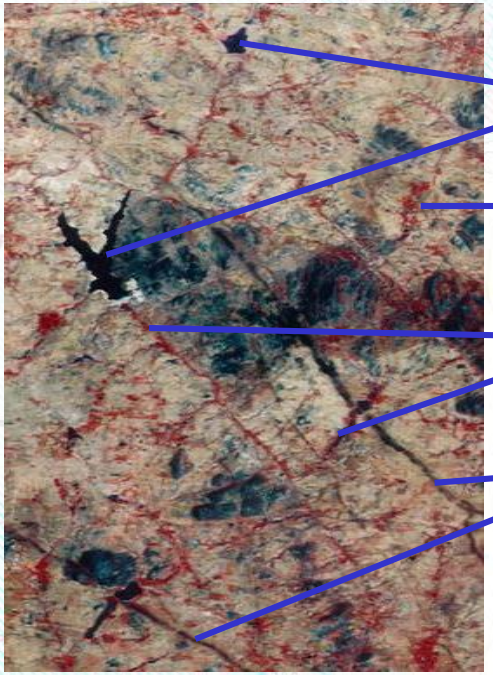
Pre -Implementation Post -Implementation

Farm ponds constructed in IWMP watershed



Series of Check Dams Constructed in IWMP Watershed

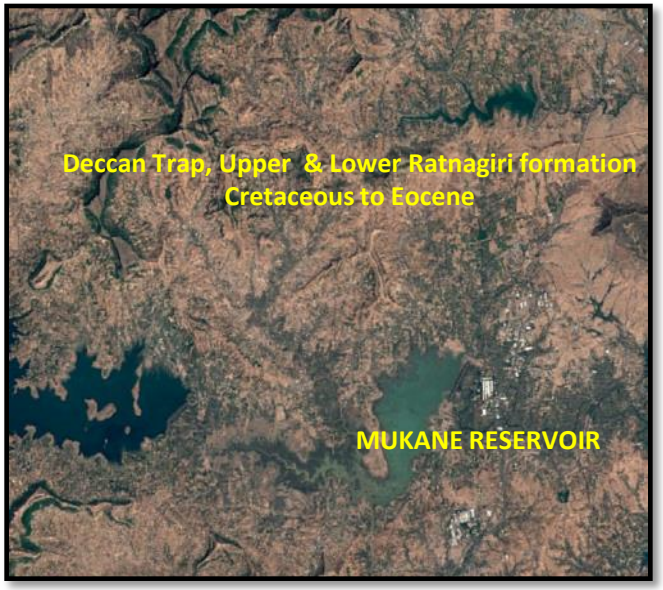
Ground Water Prospect Mapping and Quality

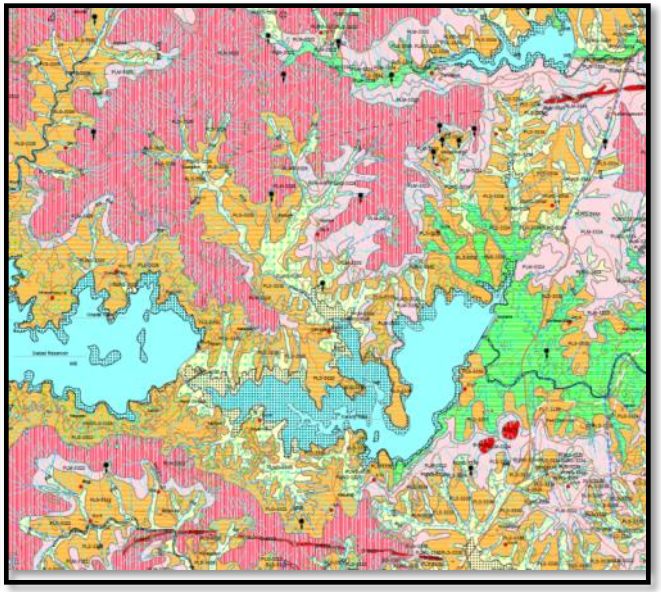


- Under National Rural Drinking Water Program (NRDWP) of Ministry of Drinking Water & Sanitation (MoDWS), NRSC has prepared Groundwater Prospect (HGM) maps of entire India using integrated geo-spatial techniques.
- A total of 4598 maps are prepared with probable depth and yield information of ground water resource
- Groundwater quality mapping is under progress.

Part of Nasik & Thane District, Maharashtra

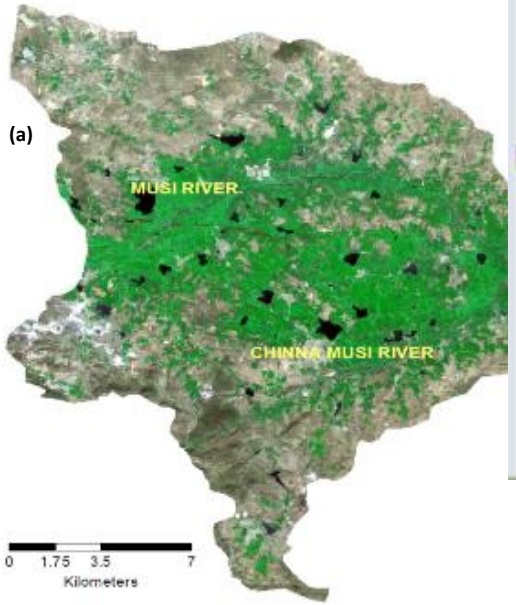
Green: Good prospect
Orange: Moderate prospect
Pink: Low prospect
Red: Poor prospect



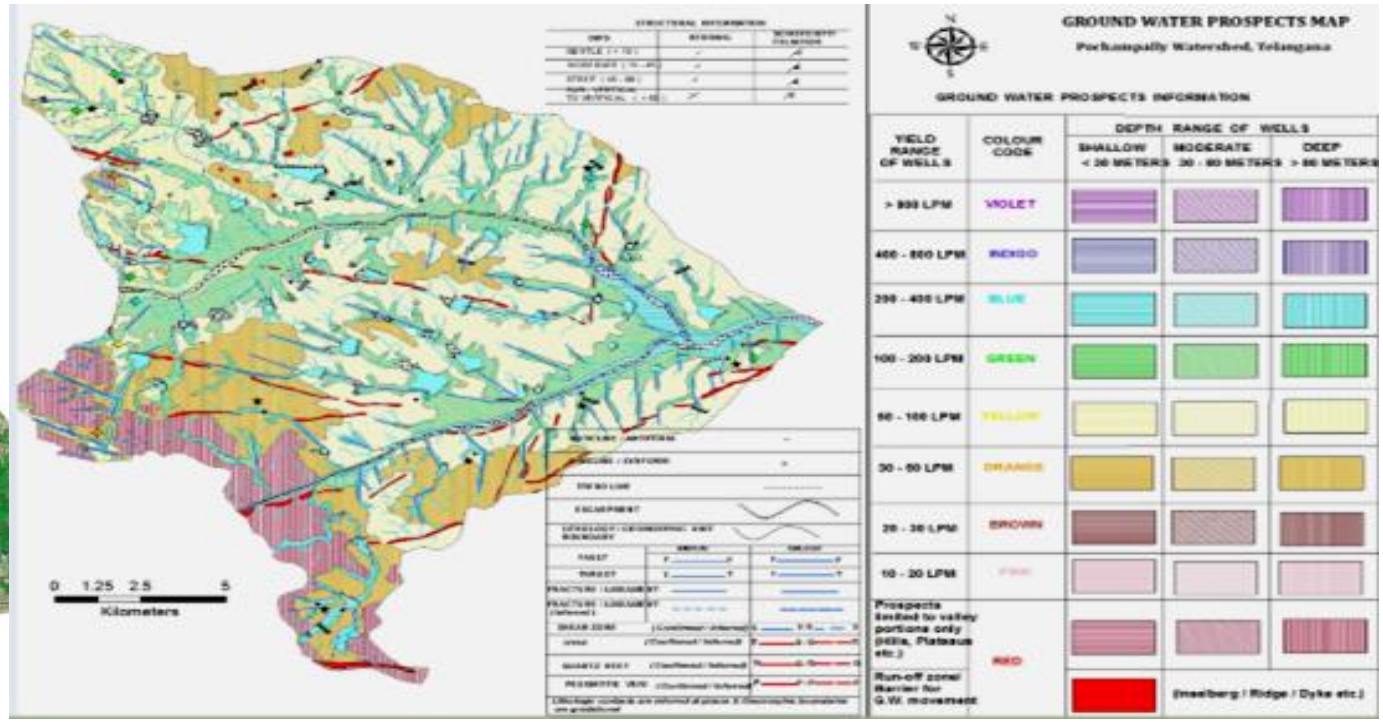


Large Scale Mapping for Priority Areas

(a)



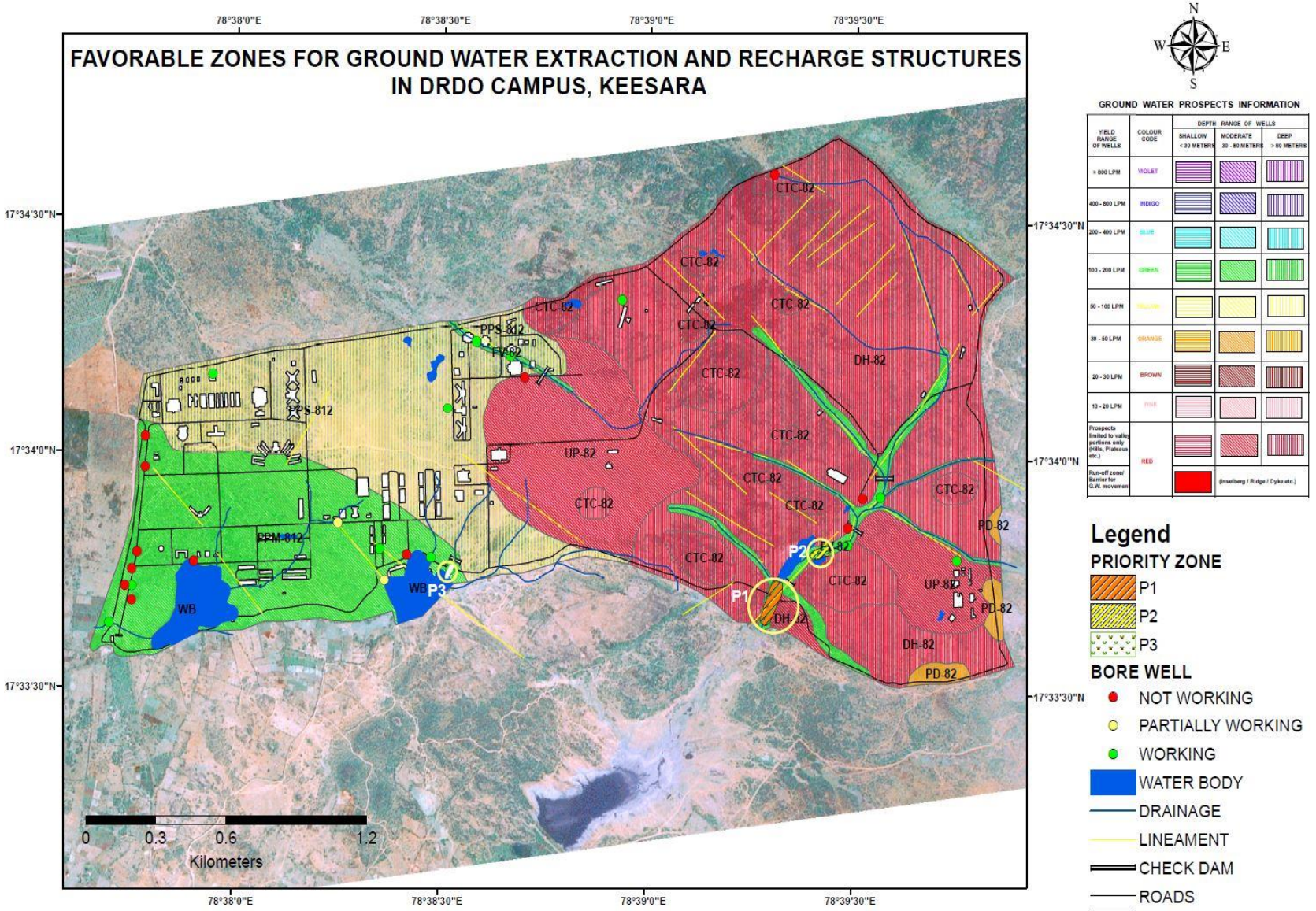
(b)



(a) Pochampally Watershed, Telangana
(b) Ground water Prospect Map

- *BHUVAN BHUJAL ISRO* GEO-Portal for public usage
- Groundwater Quality maps are under progress (14 states completed)

Large Scale Mapping for Priority Areas



Priority zones marked on Hydro-Geomorphology Map (1:10000) of DRDO campus

Evapotranspiration – Water Use

- Evapotranspiration (ET) summarizes all processes that return liquid water back to the atmosphere into water vapor
  - evporation: direct transfer of water from open water bodies
  - transpiration: indirect transfer of water from root-stomatal system
- ET is a core driver of the Earth's water cycle, returning water to the atmosphere to fall again as precipitation
- ET is driven by energy exchange at the land surface
- Satellite observations can be used to compute residual energy through energy balance computations

Latent Heat Flux = Net Radiation (Rn) – Soil Heat Flux (G) – Sensible Heat Flux (H)

- Satellite remote sensing is a promising tool to estimate the spatial distribution of ET with minimal use of in situ observational data

Algorithms for Evapotranspiration Estimation

Algorithm	Parameters	Merits	Demerits
Surface Energy Balance System (SEBS)	Surface and Air Temperature, Wind Speed, Net Radiation, Soil Heat Flux, Height	Uncertainties in SEBS from meteorological parameters can be partially solved.	Requires too many input parameters.
Surface Energy Balance Algorithm for Land (SEBAL)	Surface Temperature, Wind Speed, Net Radiation, Soil Heat Flux, Height, VI	Requires minimum ground measurements.	Applied over plain surfaces and possess uncertainties in determination of anchor pixels.
Surface Energy Balance Index (SEBI)	Net Radiation, Shortwave Albedo, Soil Heat Flux, Surface Temperature	Ground based measurements are not required.	Extreme temperatures are location specific.
Mapping ET at High Resolution with Internalized Calibration (METRIC)	Surface Temperature, Wind Speed, Net Radiation, Soil Heat Flux, Height, Vegetation Canopy Temperature, Air Temperature, Vegetation Fraction	Similar to SEBAL but surface slope aspects can be considered.	Possess uncertainties in determination of anchor pixels.

Modified Priestley Taylor - Methodology

Energy Balance Principle

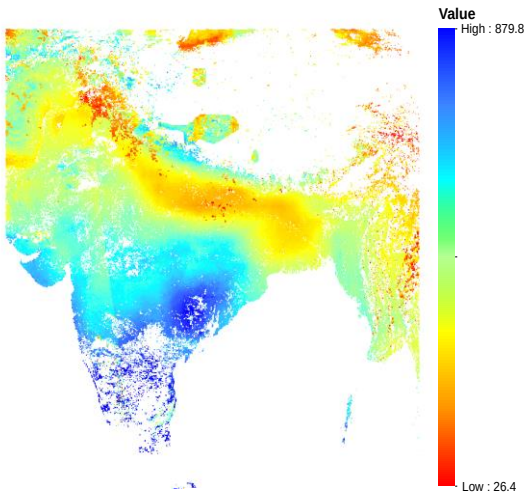
$$R_n = \lambda E + H + G + P_s$$

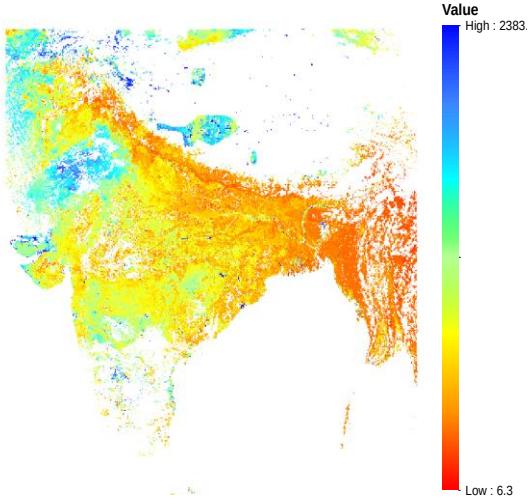
R_n	-	Net radiation on surface
	-	Latent heat flux
H	-	energy flux that heats the air/sensible heat
G	-	heat of conduction to ground rate of energy storage in
	-	terrestrial system
Ps	-	energy of photosynthesis~ very less
		(for a snow free condition)

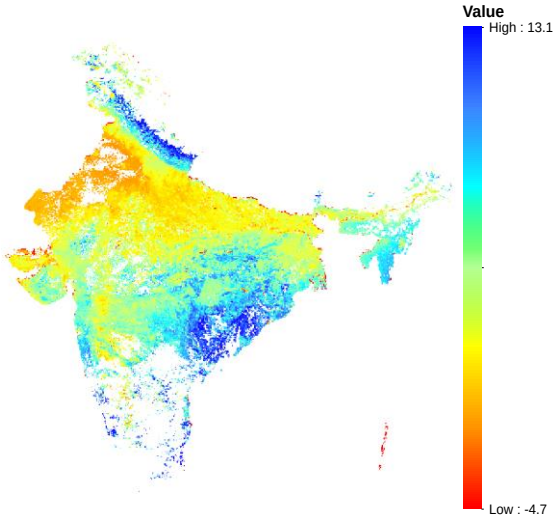
$$\lambda E = \alpha_e \cdot (R_n - G) \cdot \frac{\Delta}{(\Delta + \gamma)}$$

α_e-	1.08 ~ 1.26 related to surface soil moisture
Rn-	net radiation
G -	soil heat flux
Δ -	gradient of saturated vapour pressure at a certain air temperature
γ -	psychrometric constant

Satellite derived output based on Modified Priestly Taylor algorithm







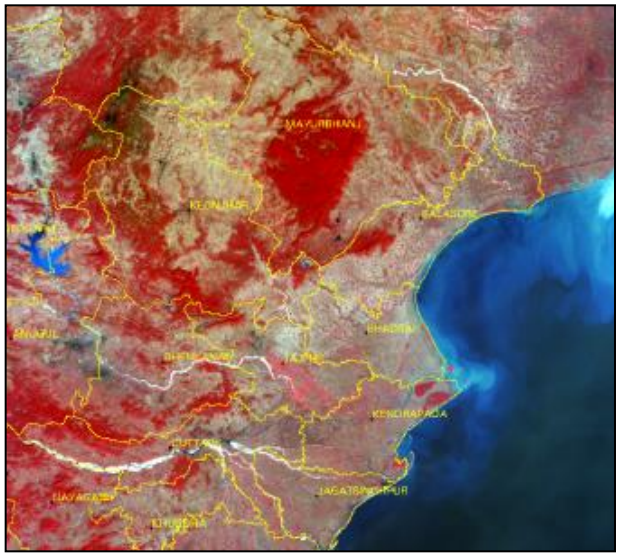
Net Radiation flux (W/m^2) *Soil Heat Flux (W/m^2)* *Actual Evapotranspiration (mm/day)*

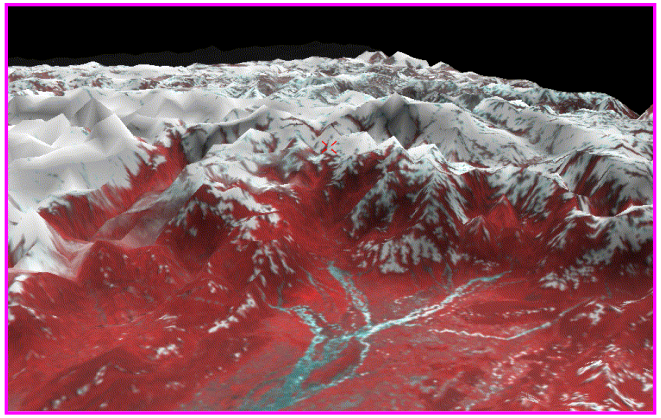
Estimated from NPP –S , INSAT3D, CDAS based Product at 1:30 PM (Date: 15.11.16)

- **Validation with field instrumentation (ET/Flux Towers)**

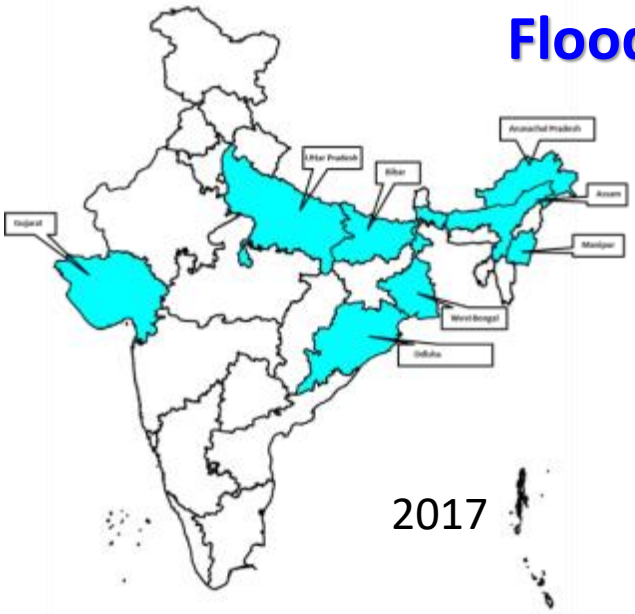
Disaster Management Support

- Near real time flood inundation mapping
- Flood hazard zonation: Assam, Bihar, Orissa & U.P
- Flood Forecast & Spatial Inundation Modelling
- Scientific assessment of Flood Prone Area
- River Morphological Studies & River Bank Erosion
- Inventory & Monitoring of Glacial Lakes for possible Glacial Lake Outburst Flood

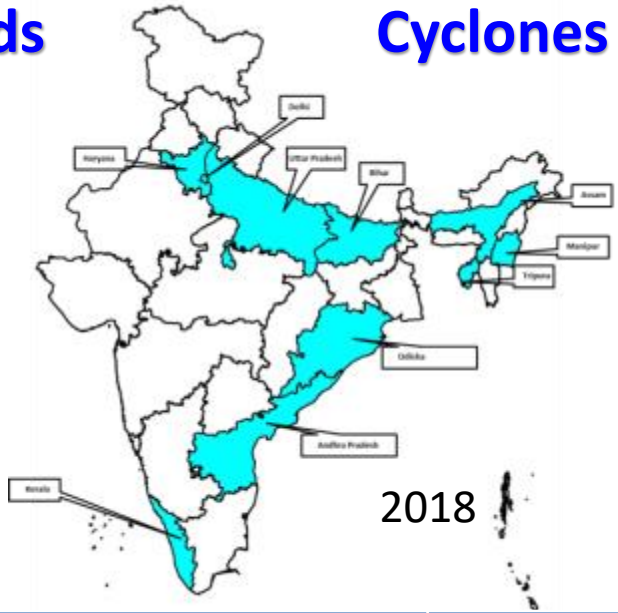


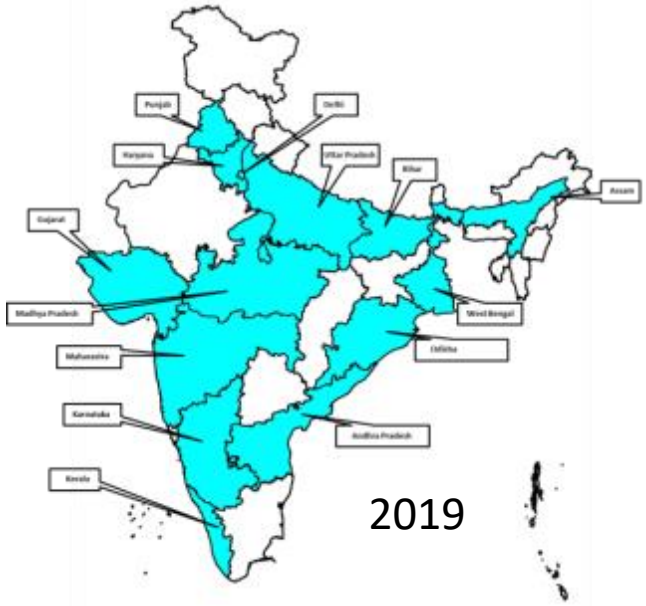


Floods



Cyclones



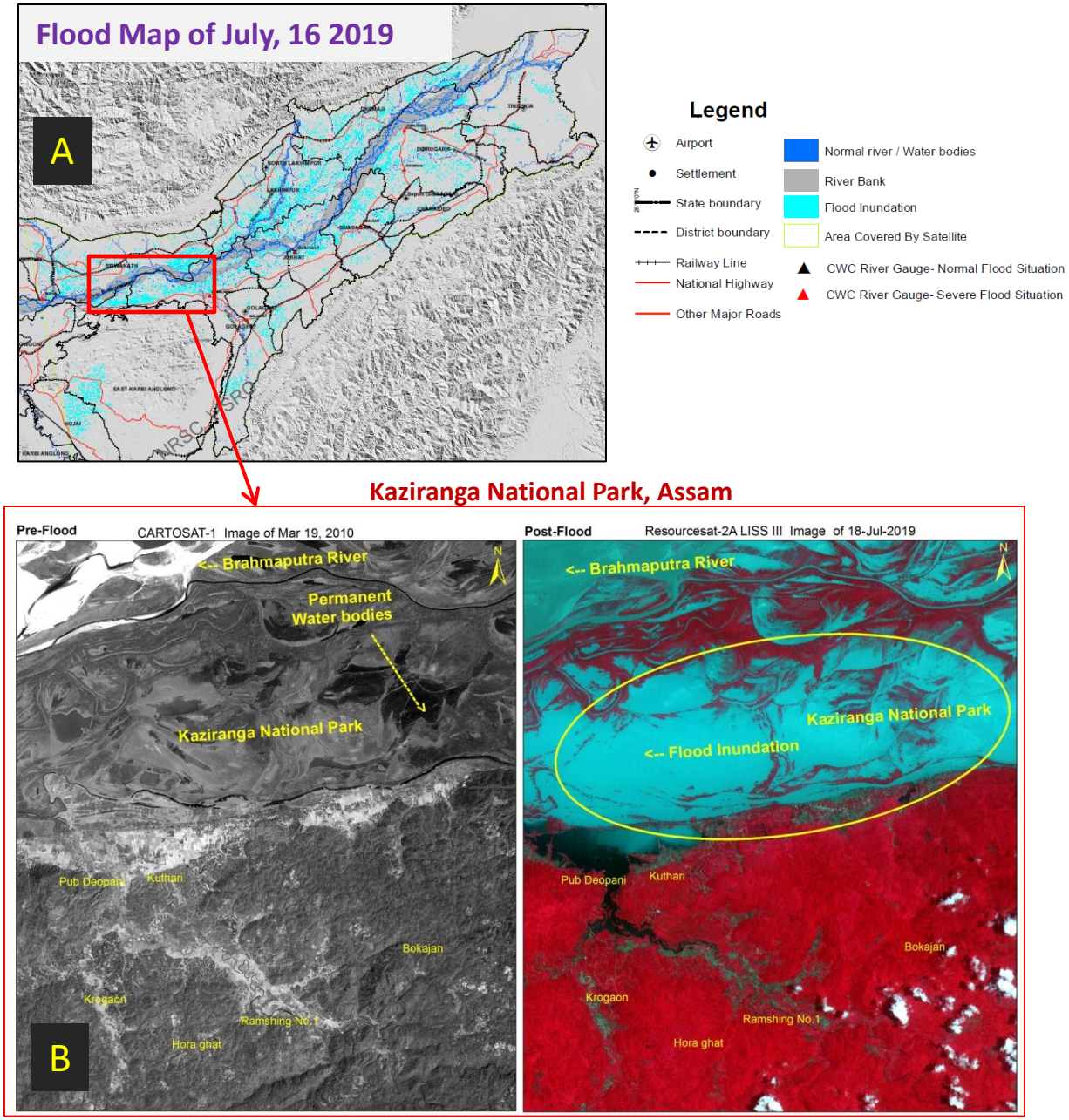


Coverage	Floods -2017	Floods -2018	Floods -2019
No. of States Flooded	8	10	14
No. of Districts affected	108	112	186
No. of flood maps/value added products	101	92	256
International Charter activation	-	1 (Kerala Floods)	3 (Cyclone “ FANI”, Assam & Bihar Floods
Sentinel Asia activation	1 (Cyclone Ockhi)	1 (Kerala Floods)	3 (Cyclone “ FANI”, Assam & Bihar Floods
Total flooded area (Hectares)	25,53,611	15,34,059	40,23,368

Flood / Cyclone affected States in the country during 2017 - 2019

Assam State Floods -2019

- Monitored the cloud cover from INSAT - 3DR and water levels from Central Water Commission (CWC) on daily basis.
- Planned and programmed the satellites of IRS (Optical) and SAR (RADARSAT-2 & Sentinel-1) based on the ground situation.
- The turn around time (TAT) for the dissemination of the flood inundation product was 6 hours.
- A) Flood Inundation map
- B) Value Added Product



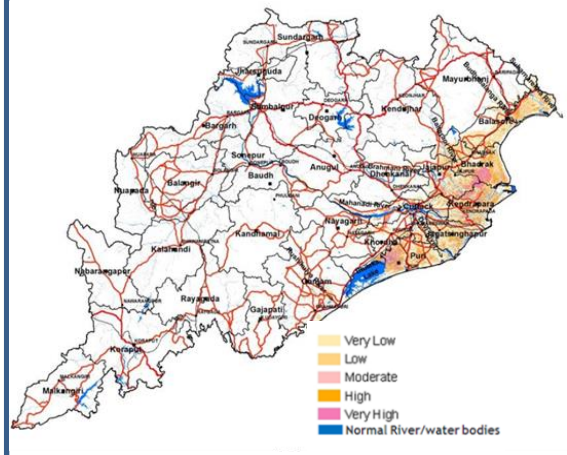
Flood Hazard Zonation

- Food hazard zonation atlas for Assam, Bihar & Odisha States using flood event historic satellite datasets.
- Useful for constructing flood retention structures, restricting developmental activities, proposing flood tolerant crops, and in planning relief & rescue centres in flood hazard areas.

Odisha Flood hazard Atlas - 2019

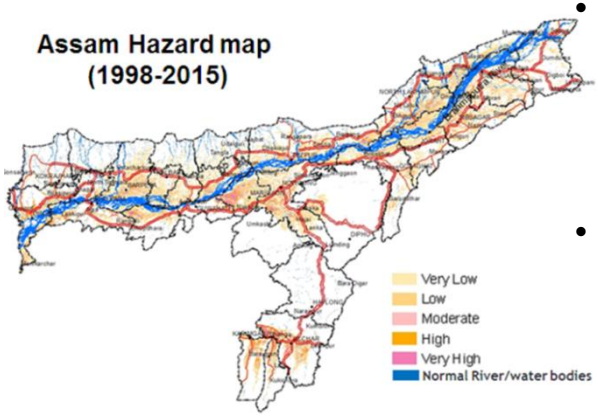
- Flood hazard atlas of Odisha was released during June 2019 by Hon'ble Chief Minister of State Shri Naveen Patnaik.
- About 13.96 Lakh hectares which is about 9% of the sate is flood affected

Odisha Hazard Map 2001-18



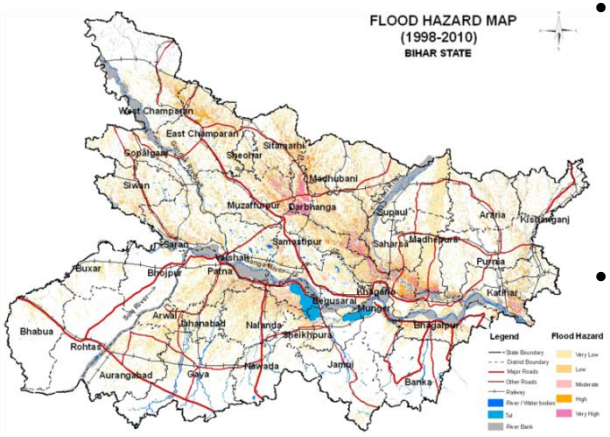
A total of 100 satellite datasets during 2001-18 were utilised to generate the flood hazard atlas.

Flood hazard Zonation- Assam State



- A total of 215 multi-temporal satellite datasets during 1998-2015 were utilised.
- About 22.54 Lakh Hectares which was 29% of the state is flood affected.

Flood hazard Zonation- Bihar State

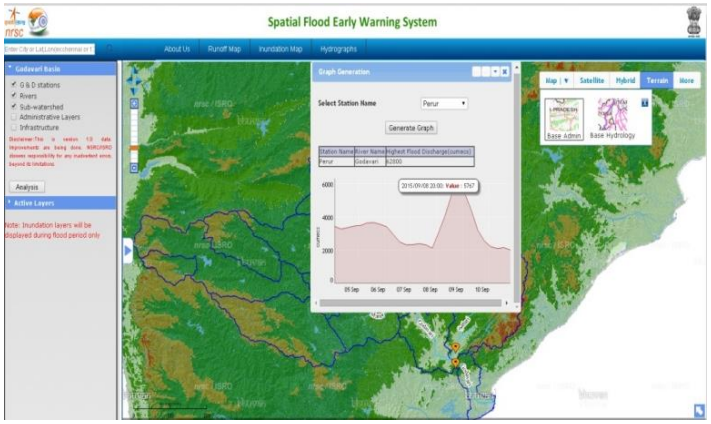


- A total of 128 multi-temporal satellite datasets during 1998-2010 were utilised.
- About 24.56 Lakh Hectares which was 26% of the state is flood affected.

Operational Spatial Flood Early Warning System

Godavari Flood Forecast System

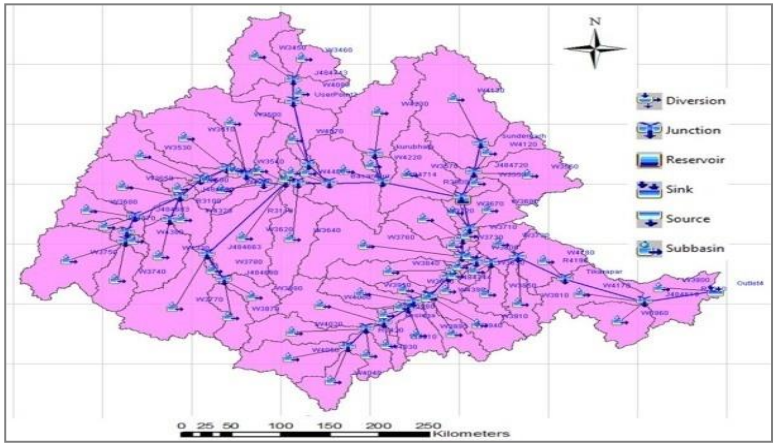
- Spatial flood early warning models were run in real-time for the Godavari and Mahanadi Rivers during 2015 to 2019 using very high density real-time hydro-meteorological data obtained from CWC and IMD.
- Flood alerts were given to AP State Disaster Management Authority during floods in the Godavari River



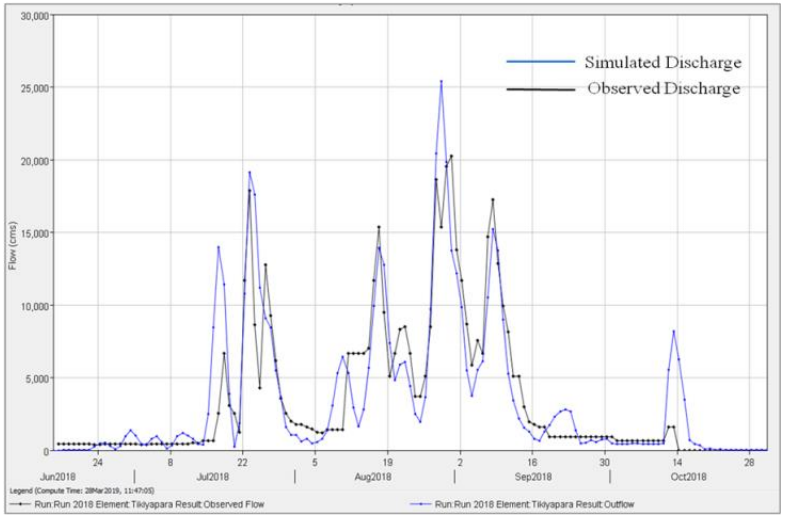
Real-time Spatial flood Early Warning system of the Godavari

Mahanadi Flood Forecast System

Computed flood hydrographs/flood forecast (previous 5 days + current day + 1 days forecast) at selected prominent CWC stations are posted in the Bhuvan



Topographic model of Mahanadi basin

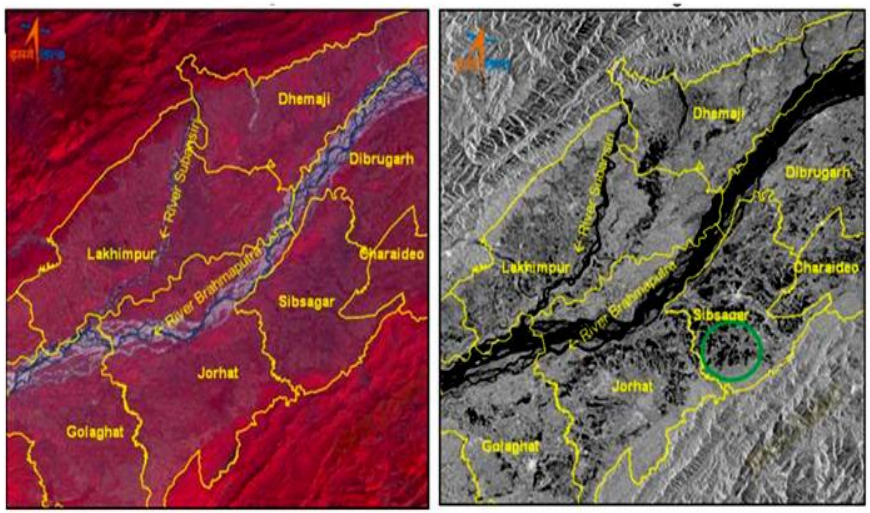


Flood hydrograph at Tikarpara station for the year 2018

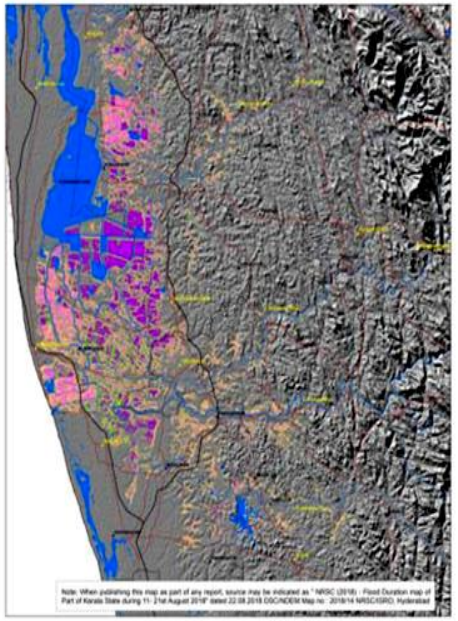
Near real time flood monitoring & inundation mapping

No of flood effected districts during 2018

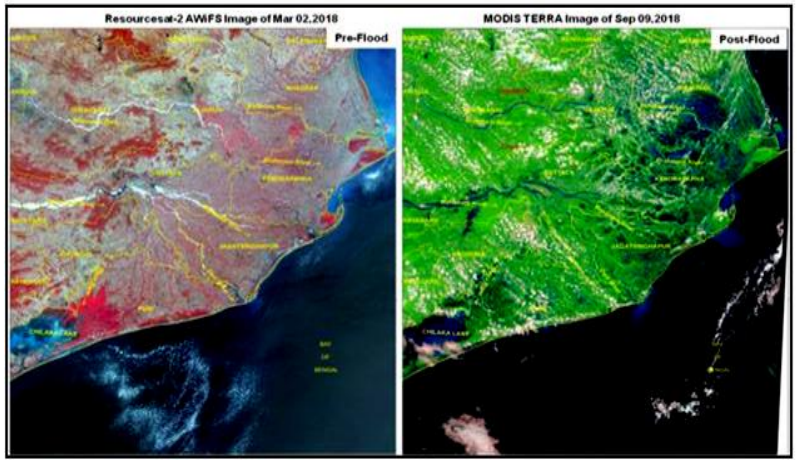
Assam Floods - 2018



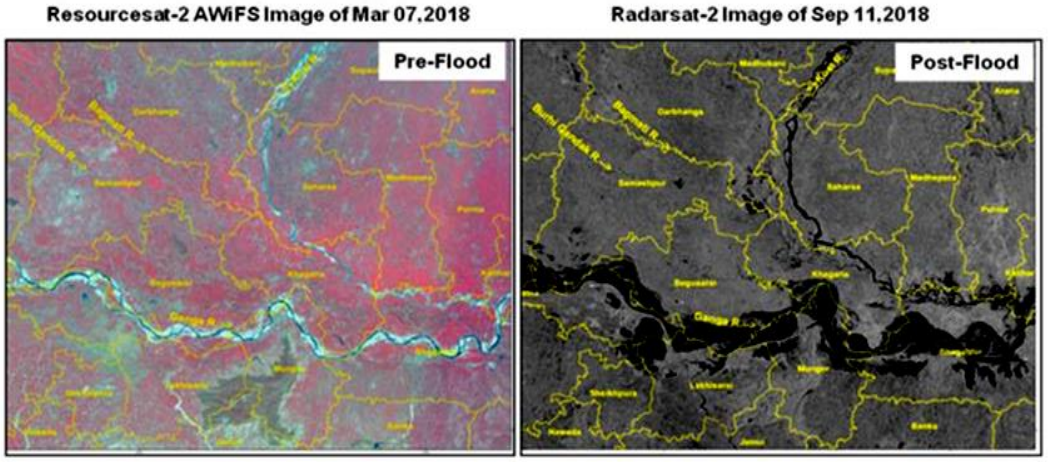
Kerala Floods – 2018
Flood duration map



Odisha Floods - 2018



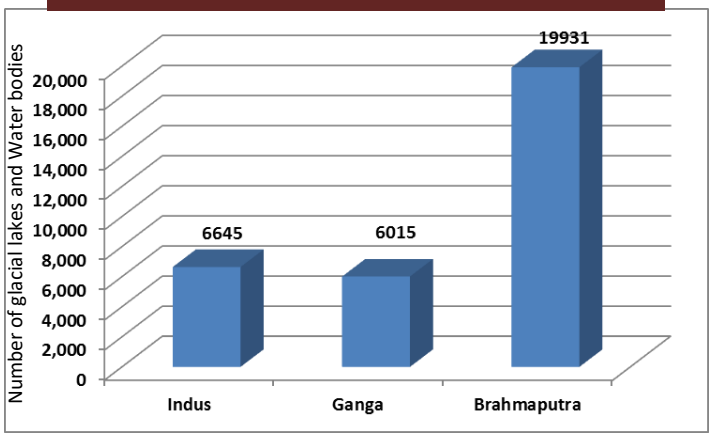
Bihar Floods - 2018



nrsc GLOF Risk Assessment of Glacial Lakes in Indian Himalayas (NHP)

- Information on glacial lakes in Indian Himalayas covering Indus, Ganga and Brahmaputra river basins is important for identifying the critical lakes which are prone to glof risk for disaster risk reduction
- Inventory of glacial lakes and water bodies greater than 0.25 ha covering entire Indian Himalayas is prepared
- About 27 attributes including glacial lake, glacier and dam characteristics are being generated
- Methodology developed for ranking of glacial lakes and risk assessment
- Ranking of glacial lakes is in progress for selecting critical lakes

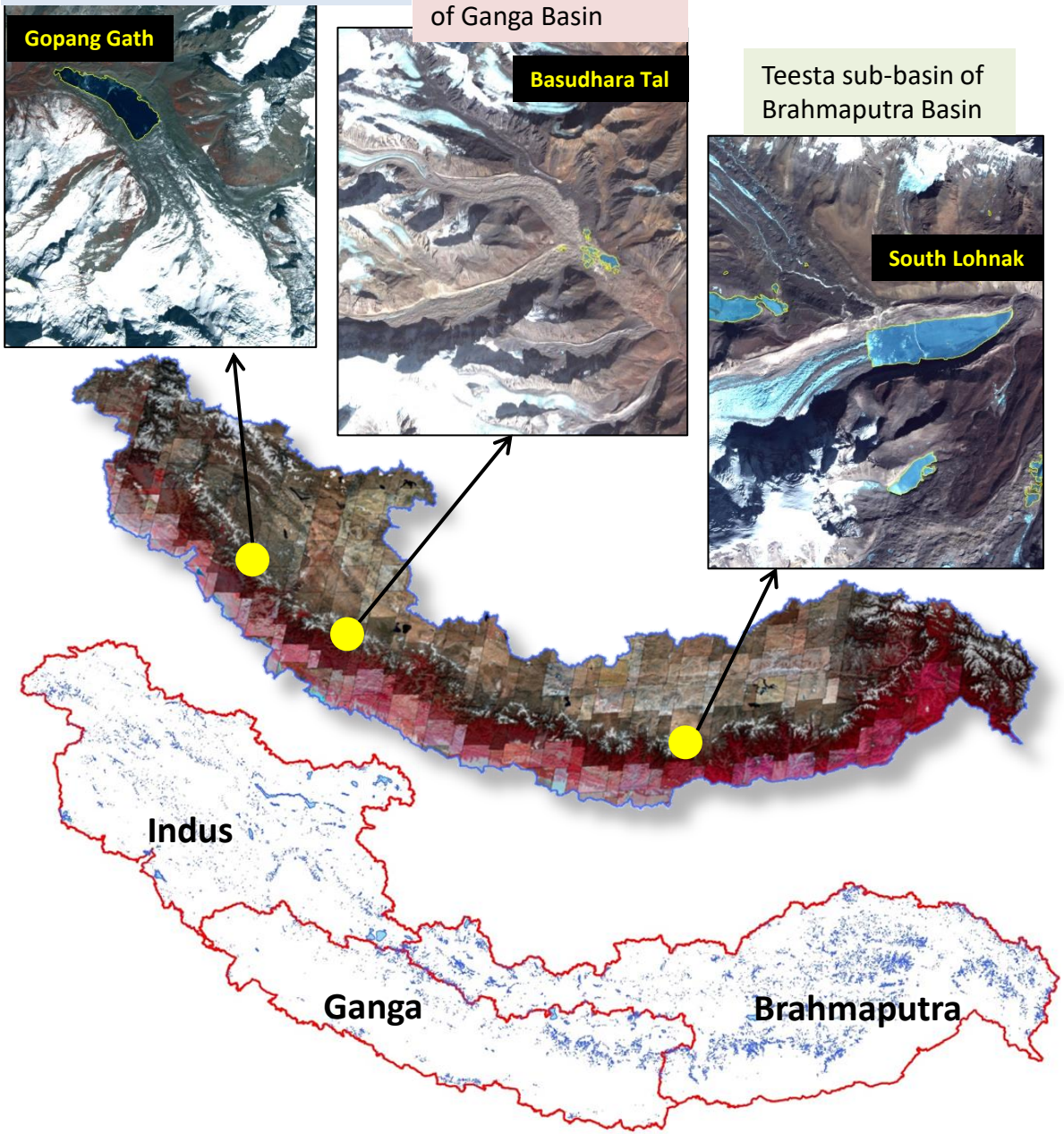
Lakes in Indus, Ganga & Brahmaputra Basins



Chenab sub-basin of Indus Basin

Alaknanda sub-basin of Ganga Basin

Teesta sub-basin of Brahmaputra Basin



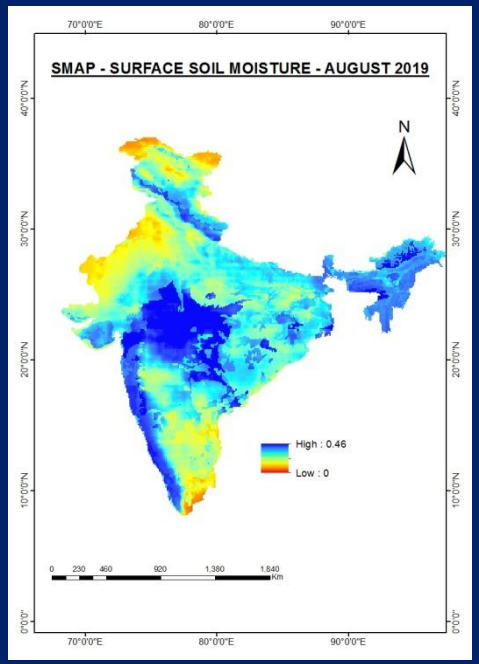
Soil Moisture

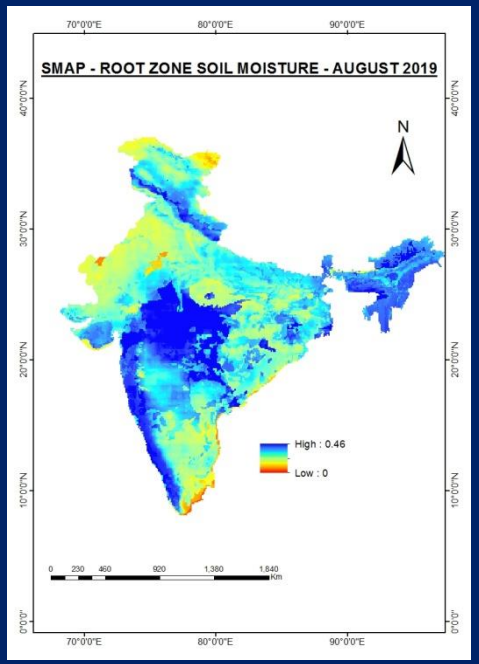
- Soil moisture is an important variable in land surface hydrology
- Monitoring of soil moisture dynamics from local to global scales is essential for various water related applications (Irrigation, Drought, Flood, Water Budget, Climate modelling, …)
- Soil moisture estimation through field instrumentation is location specfic and do not represent spatial variation
- Soil moisture at spatial scales can be simulated by hydrological modelling through water & energy computations - Constrained by data and representative parameterization
- Satellite observations in Microwave region (Passive & Active) provide opportunities for spatial soil moisture estimation
- Dedicated soil moisture satellite missions (SMOS, AMSR, AMSR2, SMAP) provided global near-surface soil moisture estimates since last two decades at coarse resolutions

Soil Moisture Active Passive (SMAP)

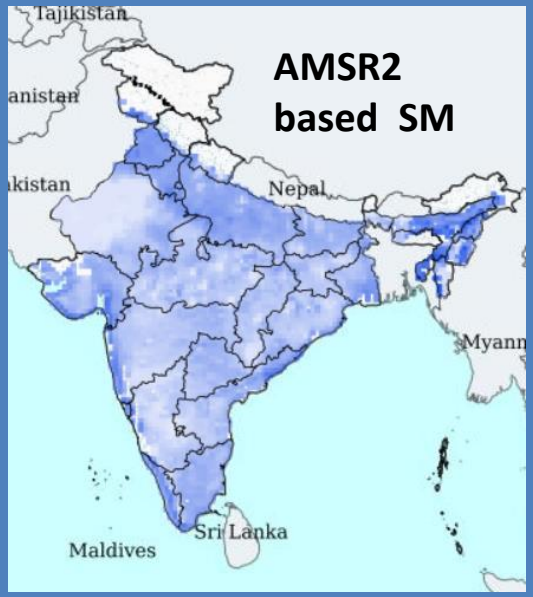
- Onboard with both Passive and Active MW Sensor in L-band
- The L-band frequency enables observations of soil moisture through moderate vegetation cover, independent of cloud cover and night or day
- Designed to measure soil moisture, every 2-3 days

1C	SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures, Version 4	36 km x 36 km	2015-03-31 to present
2	SMAP L2 Radiometer Half-Orbit 36 km EASE-Grid Soil Moisture, Version 6	36 km x 36 km	2015-03-31 to present
3	SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture, Version 6	36 km x 36 km	2015-03-31 to present
4	SMAP L4 Global 3-hourly 9 km EASE-Grid Surface and Root Zone Soil Moisture Analysis Update, Version 4	9 km x 9 km	2015-03-31 to present

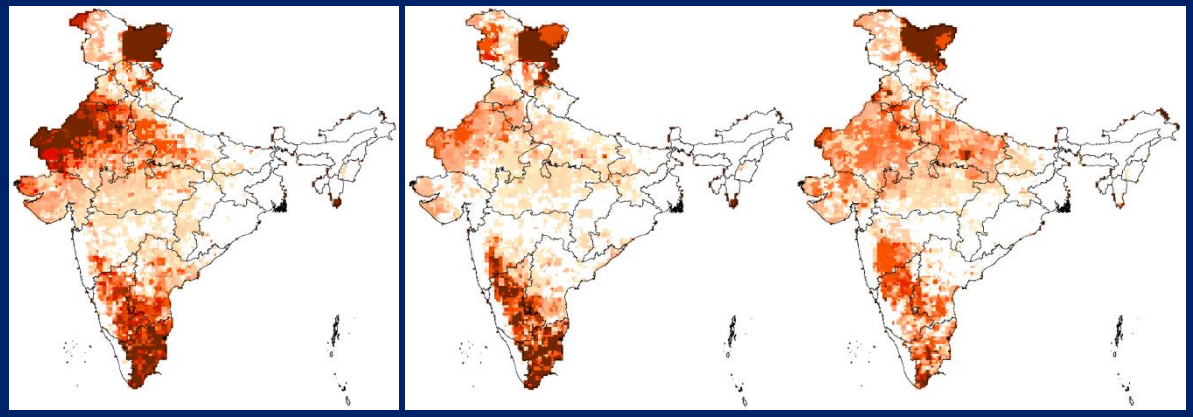




Soil Moisture Availability Index

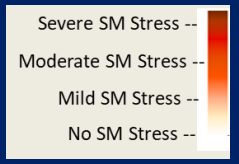


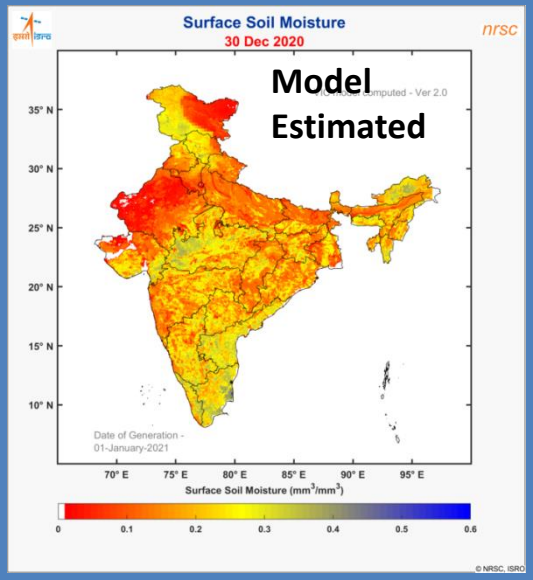
AMSR2 based SM



2002 **2003** **2015**

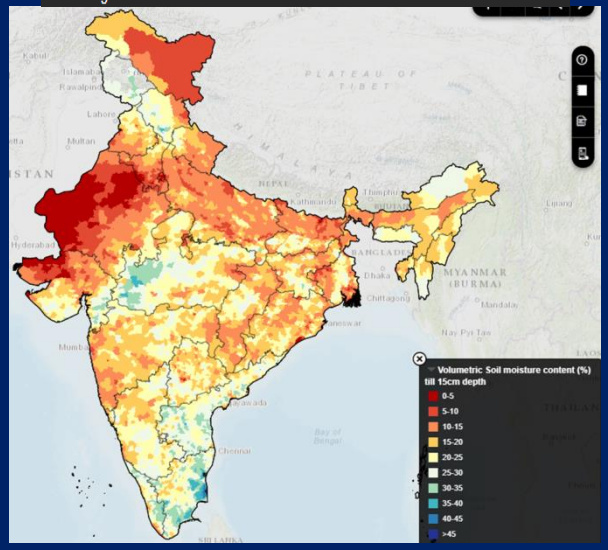
Drought Years in India (1986, 1987, 2002, 2009, 2015) –IMD Drought Manual 2016



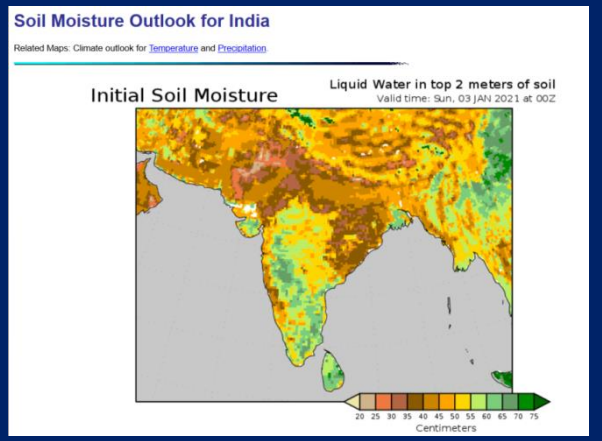


https://bhuvan-app3.nrsc.gov.in/data

Monthly Volumetric Soil Moisture content (%) till 15cm depth from 01-Jun-2020 to 30-Dec-2020 using NRSC VIC MODEL data

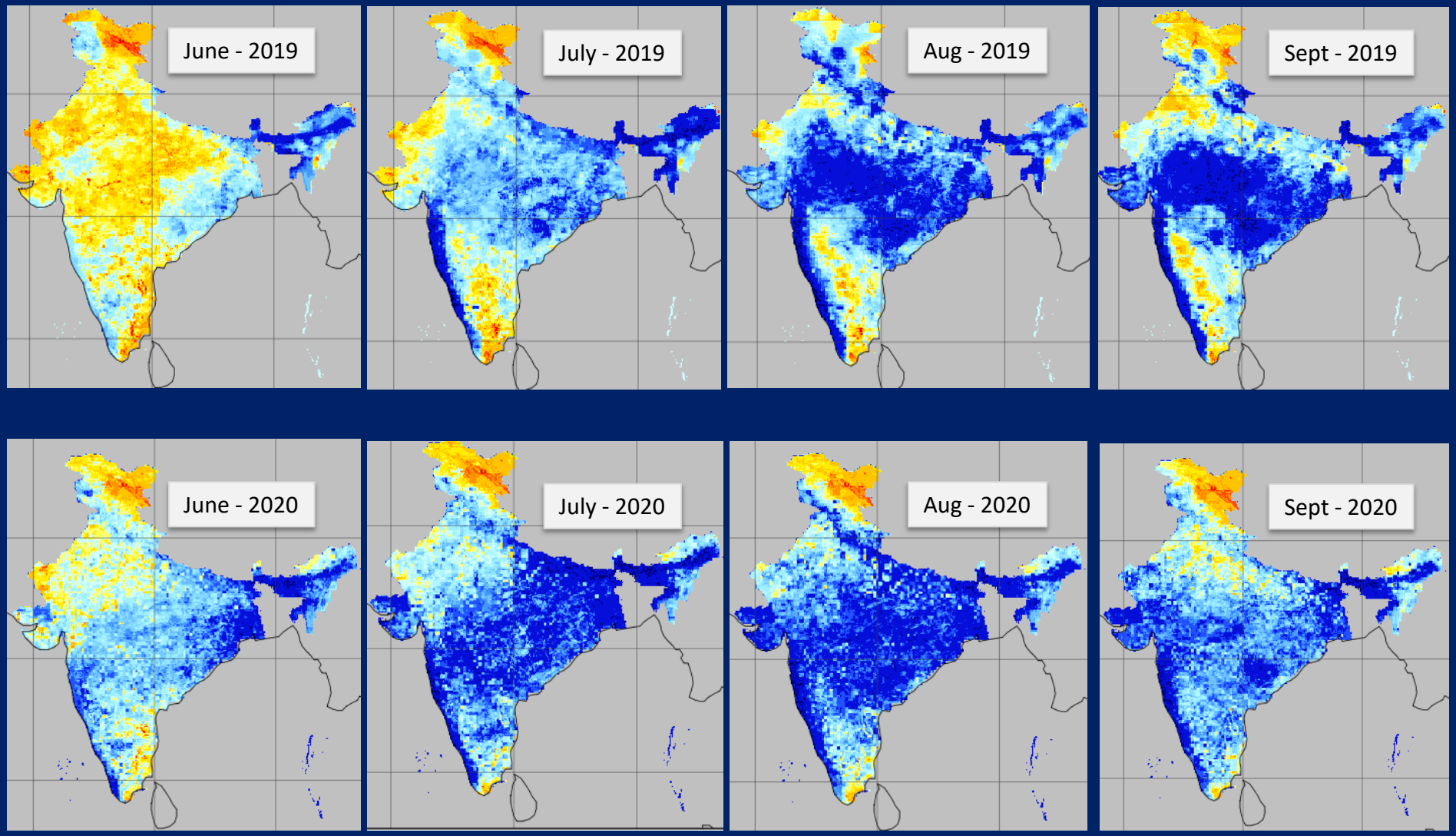


https://indiawris.gov.in/wris/#/soilMoisture



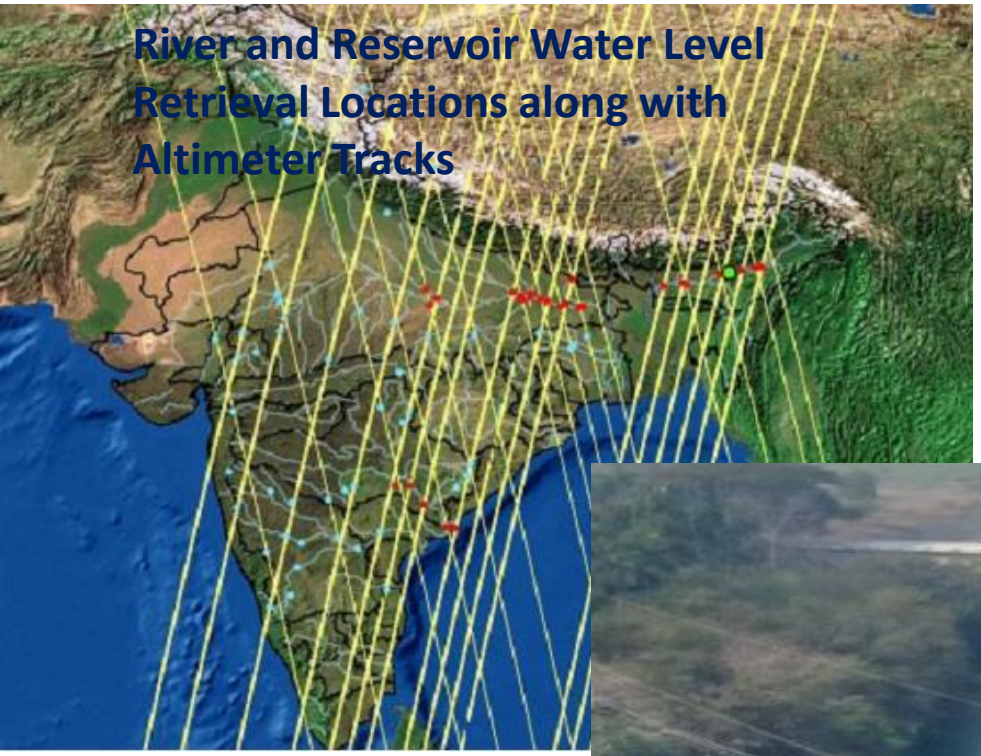
http://www.monsoondata.org/wx/soil.html

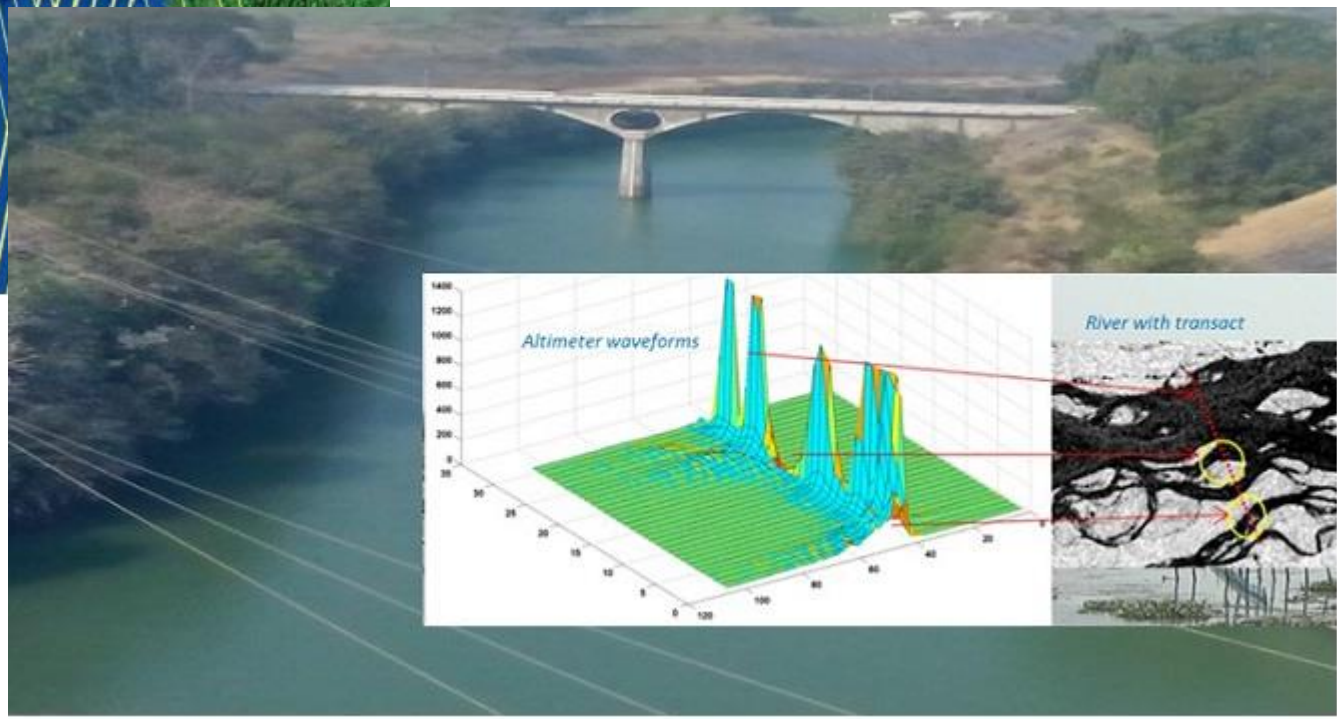
Soil Moisture Availability Index



Satellite Altimetry

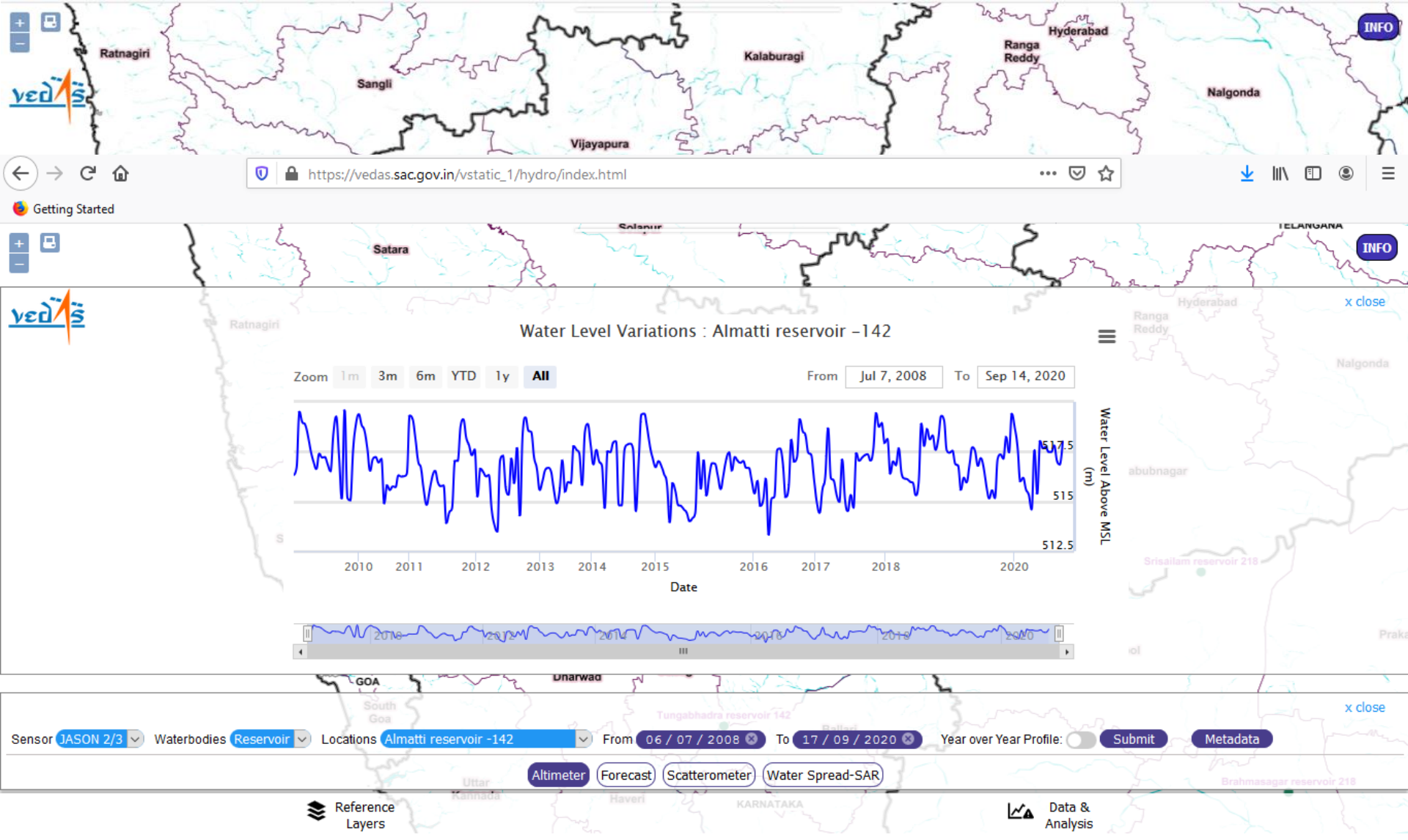
- Radar altimeters using time-range measurements provide accurate elevation of water surface
- Useful for relatively large water bodies and river widths
- Presently constrained by the revisit periods. However, with constellation capable of providing regular high accurate water elevation



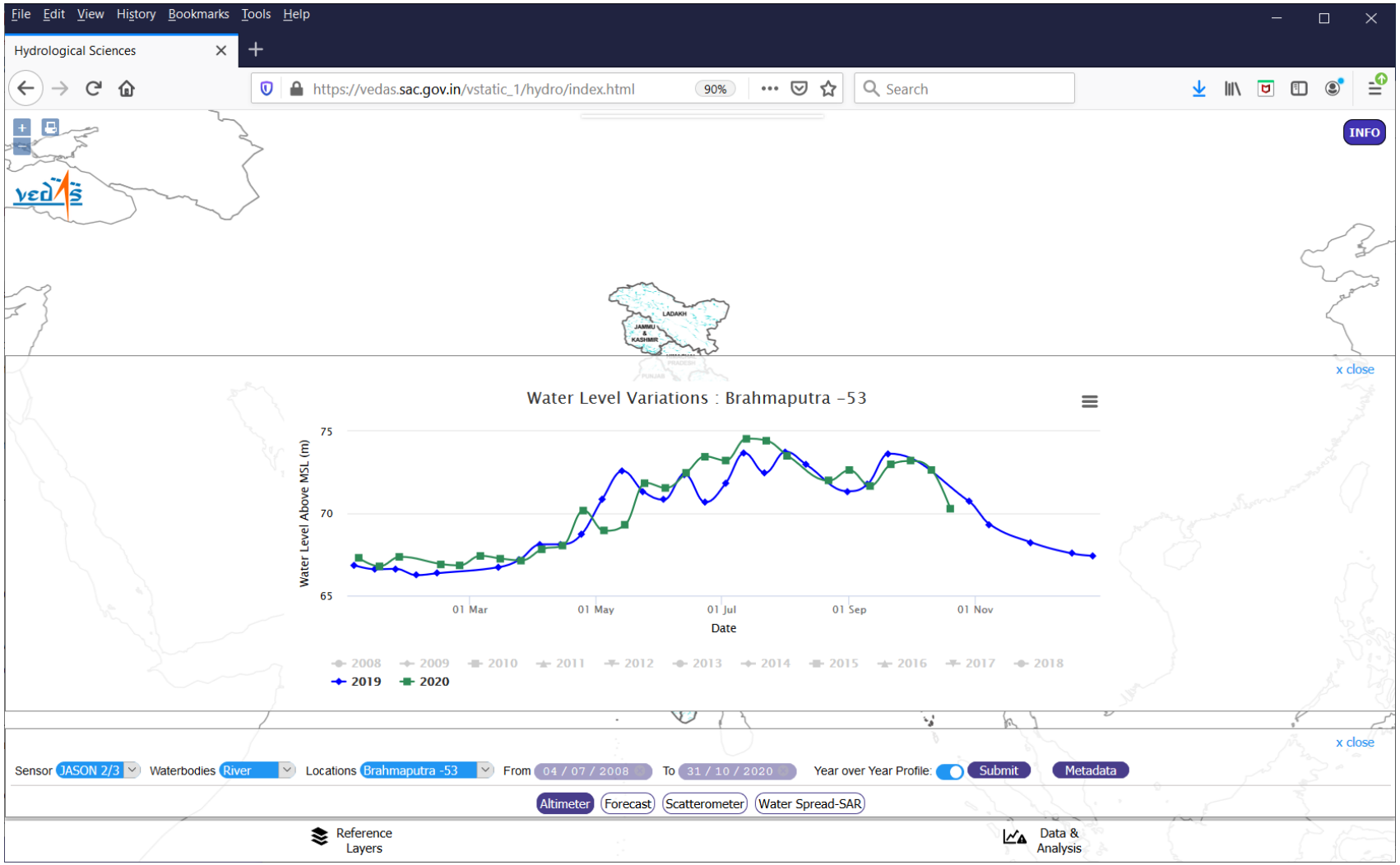


Altimeter Waveforms in a River Transact

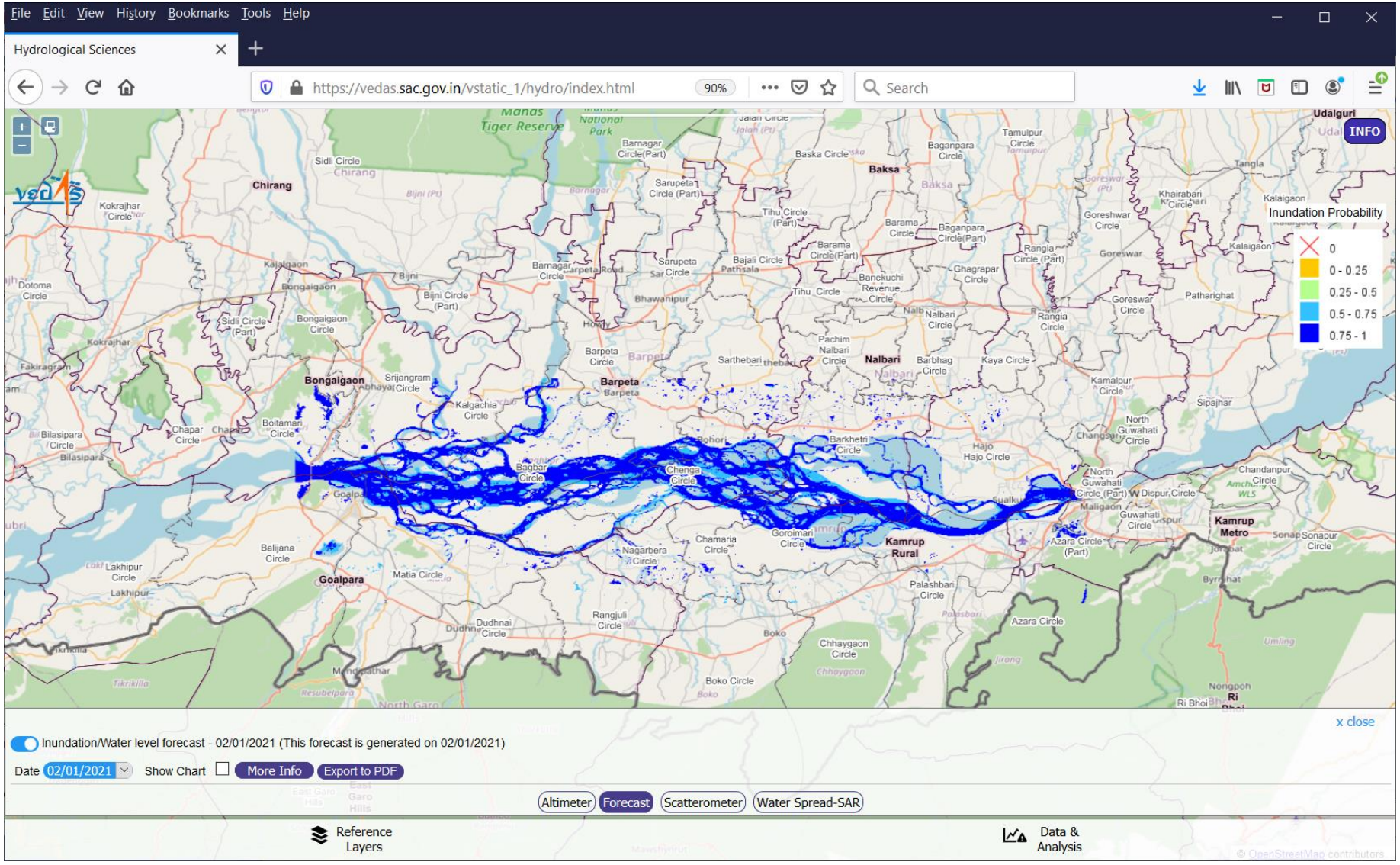
Satellite Altimetry – Reservoir Water Elevation



Satellite Altimetry – River Water Elevation

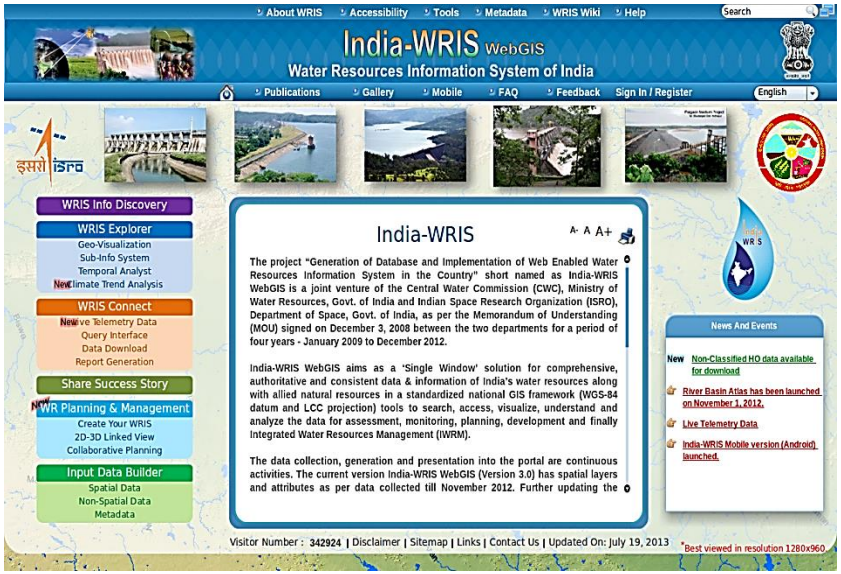


River Water Surface/Inundation Forecast



India Water Resources Information System - India-WRIS

- A 'Single Window' solution for comprehensive, authoritative and consistent data & information of India's water resources along with allied natural resources in a standardized national GIS framework for Integrated Water Resources Management (IWRM).

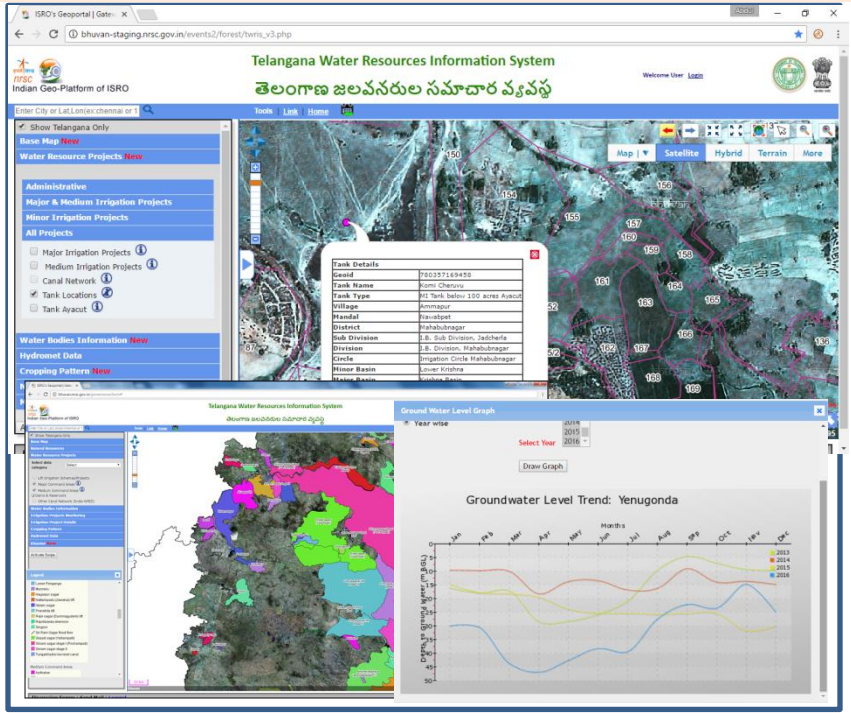


- *India-WRIS WebGIS Version 1.0 was launched on December 10, 2009 with Version 4.0 at present.*
- *Major Modules: 25 +*
- *Sub-Infosys: 36 (under 12 Major Infosys)*
- *Quantity of Data: 100 + GIS Datasets, Large attribute (> 4500) data of water resources assets & Temporal data of 5-100 years*
- *Update Frequency: Daily/ Weekly/ Monthly/ Yearly*
- *Live Telemetry Data: Hourly water level data of the last 72 hour*

- ✓ **Empowering citizens with accurate, adequate and contemporary information on the state of water resources of the country.**
- ✓ **Successful implementation of INDIA-WRIS lead to formation of National Water Informatics Centre (NWIC) as part of National Hydrology Project**

Telangana Water Resources Information System - TWRIS

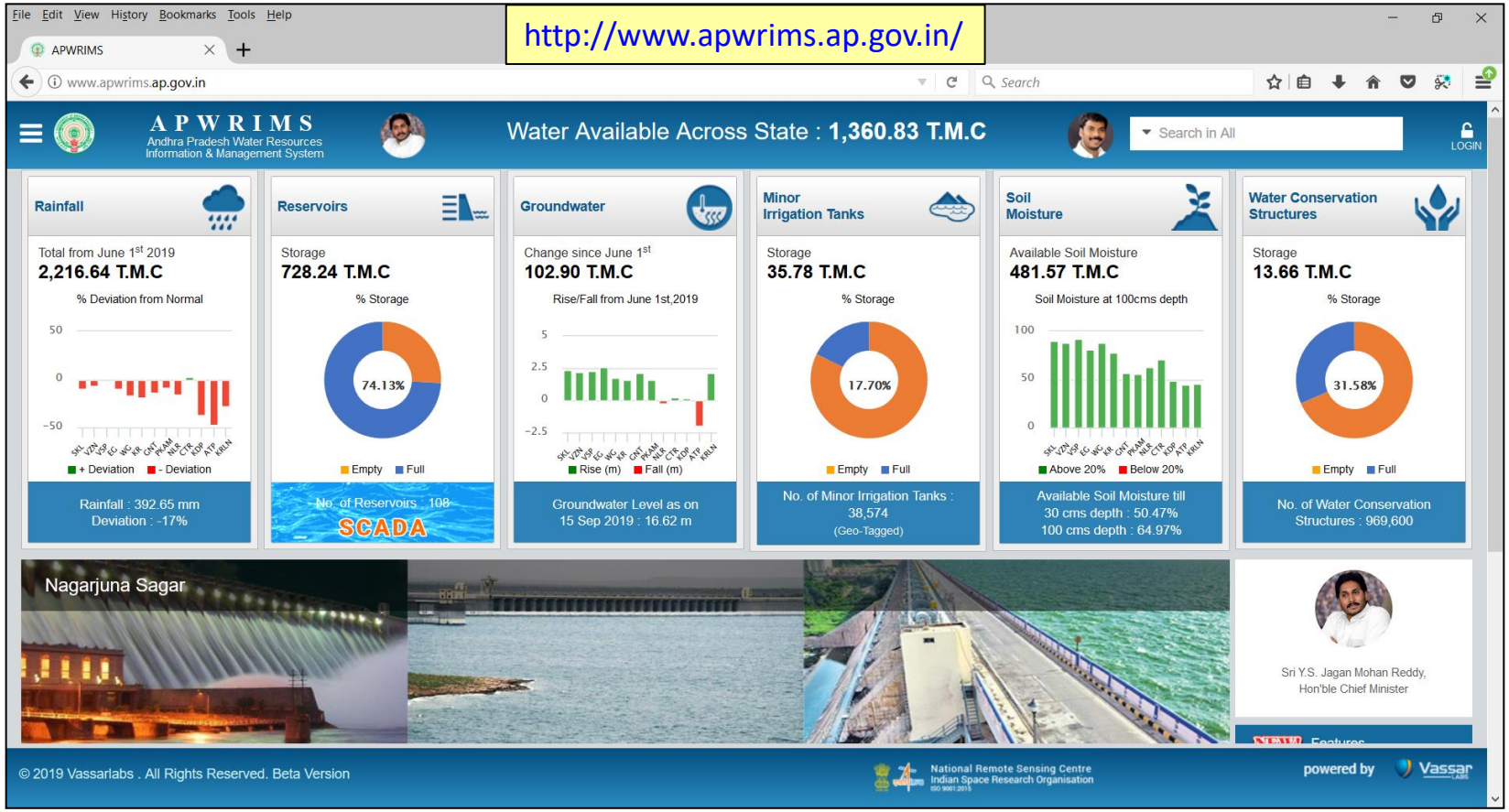
- Developed a web-based geoportal “Telangana Water Resources Information System (TWRIS)” for effective management of Water Resources in the State.
- Providing online tools and support for geospatial data creation, visualization and integration of water resources data from different sources.



- *Beta version of the TWRIS geoportal was launched on 6th August, 2016.*
- *Portal is updated with geospatial datasets on base map, natural resources, water resource projects, water bodies information, irrigation project details, cropping pattern and groundwater level data.*
- *Daily updates of AWS Data and reservoir water level data.*
- *Command area boundary identifcation for about 12,000 Minor Irrigation tanks using online tools.*
- *Geospatial data of 42 major & medium irrigation projects created & published till date.*

✓ **Geospatial information on all water resources projects in the state is available in public domain. These baseline information will be used by Irrigation Dept. for monitoring and performance assessment of irrigation projects in the state.**

Andhra Pradesh Water Resources Information & Management System (APWRIMS)



- *Geo-spatial technology for development of geo-portal in support of water resources management*
- *Integration of in-season data (climate, satellite, field)*
- *In-season root zone soil moisture modelling using weather observation data*
- *Daily Water audit at State/District/Mandal/Village level*
- *Soil moisture stress forecast (7-10 days) supporting life saving irrigation interventions*
- *Stream flow forecast*
- *....*

www.nrsc.gov.in

www.bhuvan.nrsc.gov.in

www.india-wris.nrsc.gov.in

Thank you