SAARC
Disaster Management Centre (IU)

IWMI International Water Management Institute

CGIAR

GUJARAT INSTITUTE OF DISASTER MANAGEMENT
BUILDING RESILIENCE

ICAR

UNITED NATIONS
Office for Outer Space Affairs

Regional Workshop
on
Assessing Drought Risks using Earth Observation Data
&
Launch of South Asia Drought Management System (SADMS)

Utility of SADMS tool for operational drought decision support across South Asia

Date: 31st August to 2nd September, 2022

Gandhinagar, Gujarat, India

Earth Observation Data for Drought Monitoring

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Earth Observation Data for Drought Monitoring

Scope of this presentation

- ❑ Operational drought monitoring practices in India
- ❑ Indicators, crieteria and combinations
- ❑ EO data selection for drought monitoring
- ❑ Role of SAR data
- ❑ Composite drought indicator
- ❑ EO applications for SAARC countries
- ❑ Way forward

National Agricultural Drought Assessment and Monitoring System, NADAMS

INPUTS

- Multiple indices
- VI anomaly
- Rainfall deviation
- Sown area deviation

Challenges

- ❖ *Drought impact assessment*
- ❖ *Early warning systems*

2012+

- ❖ Country wide monitoring with moderate resolution AWiFS data
- ❖ Support from geo-stationery systems
- ❖ Utilisation of microwave data
- ❖ Process based indictors (energy balance)

2004+

- Use of multiple indices
- IRS AWiFS based sub-district level assessment
- AVHRR based regional/district level assessment
- Integration with ground data/multiple indices
- Decision rules for drought warning & declaration
- Enhanced content & frequency of reporting
- Institutional participation & Capacity building

2002

- IRS WiFS based district / sub district level assessment
- Supplementation of WiFS with MODIS
- AVHRR based regional/district level assessment
- Agricultural area monitoring

1998

- IRS WiFS based district / subdistrict level assessment
- AVHRR based regional/district level assessment
- Participation of user departments

1988

- NOAA AVHRR
- Regional/district level assessment

OUTPUTS

Drought warning: June, July, Aug.
- * Normal
- * Watch
- * Alert

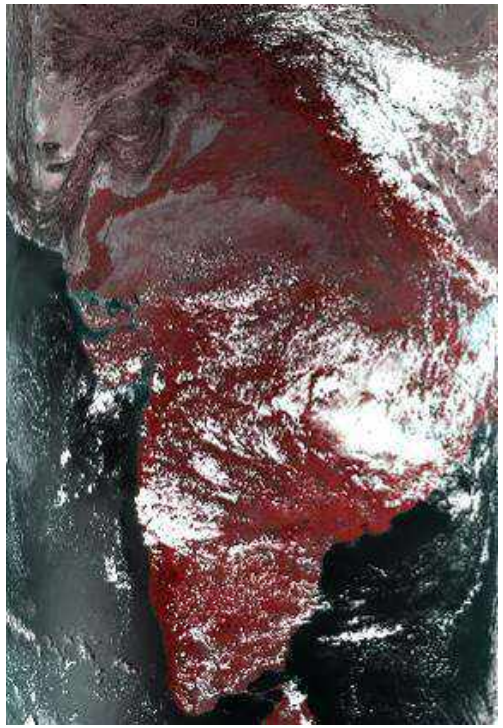
Drought declaration: Sept, Oct., Nov.
- * Mild
- * Moderate
- * Severe

USER DEPARTMENTS
(Union & State Govts.):
Agriculture Ministry
Relief Commissioners

Use of data from multiple satellites/sensors

NATIONAL

NOAA AVHRR



Wavelength range (µm)
0.58 – 0.68 (red)
0.725 – 1.1 (NIR)
3.55 – 3.93 (MIR)
10.3 – 11.3 (TIR)
11.5 - 12.5 (TIR)
Spatial Resolution
1.1 Km

Terra Modis

Wavelength range (µm)
0.62 – 0.67 (red)
0.841 – 0.876 (NIR)
Spatial Resolution
250m
Swath 2330 kms

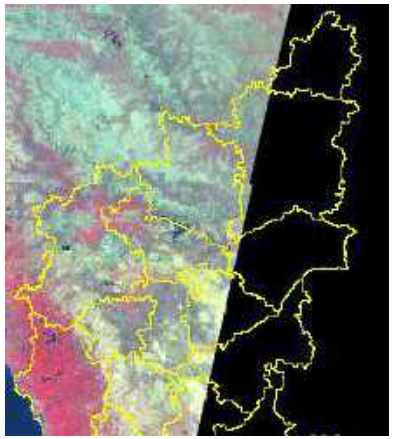
STATE

IRS-OCM2 /WiFS

Spatial resolution
360 /180 metres
Wave lengths 8/ 3 bands
Swath : 1400 / 700 km

DISTRICT

IRS P6 AWiFS



Spatial resolution
56 metres
Wave lengths 4 bands
(green, red, NIR and MIR)
Swath : 750 kms.

Spectral response of vegetation

Red – more absorption due to chlorophyll
Near Infra red – more reflection due to leaf structure

Normalized Difference Vegetation Index (NDVI)

NIR – Red / NIR+Red
Reflected radiation in Near infrared and red bands.
NDVI ranges from -1 to +1
Water – negative NDVI
Clouds – zero NDVI
Vegetation – positive NDVI represents density, vigor

Guidelines for drought management in India

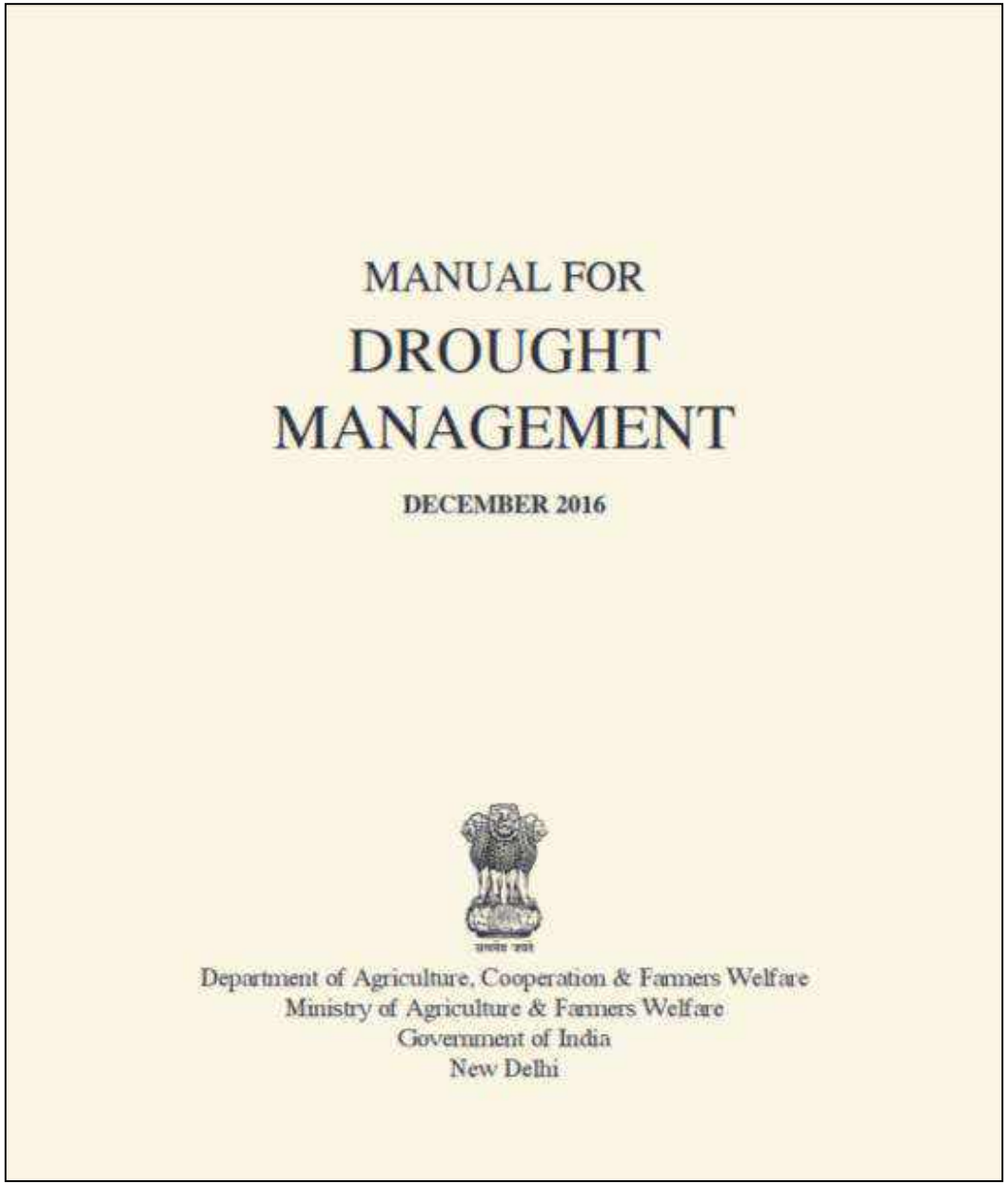
Department of Agriculture, Cooperation and Farmers Welfare (DACFW), Govt. of India is the Nodal agency for drought management

Guidelines to states

- National Drought Manual 2009
- **National Drought Manual 2016**
  (www.agricoop.nic.in)

Manual provides

- Indices for drought monitoring
- Drought declaration protocols
- Relief management
- Long term measures
- Training to states



Drought monitoring framework as per Manual

nrsc

Mandatory Indicators

Rainfall Related Indices

- Actual Rainfall
- Normal Rainfall
- Rainfall Deviation /SPI
- Dry Spell

Ground Truthing

- Real time field visits
- Validation of drought assessment

Impact Indicators

Satellite based Vegetation Indices

- NDVI (Normalized Difference Vegetation Index)
- NDWI/LSWI
- VCI of NDVI
- VCI of LSWI

Moisture based Indices

- MAI (Moisture Adequacy Index)
- PASM (Percent Available Soil Moisture)

Hydrological Indices

- RSI (Reservoir Storage Index)
- GWDI (Ground Water Drought Index)
- SFDI (Stream Flow Drought Index)

Crop planting/sowing status (manual collection)

- Area under crops

Criteria for declaration

Causative parameter: Mandatory indicator

1. Rainfall reduction
2. Dry spell (dry week if rainfall is <50% of normal)

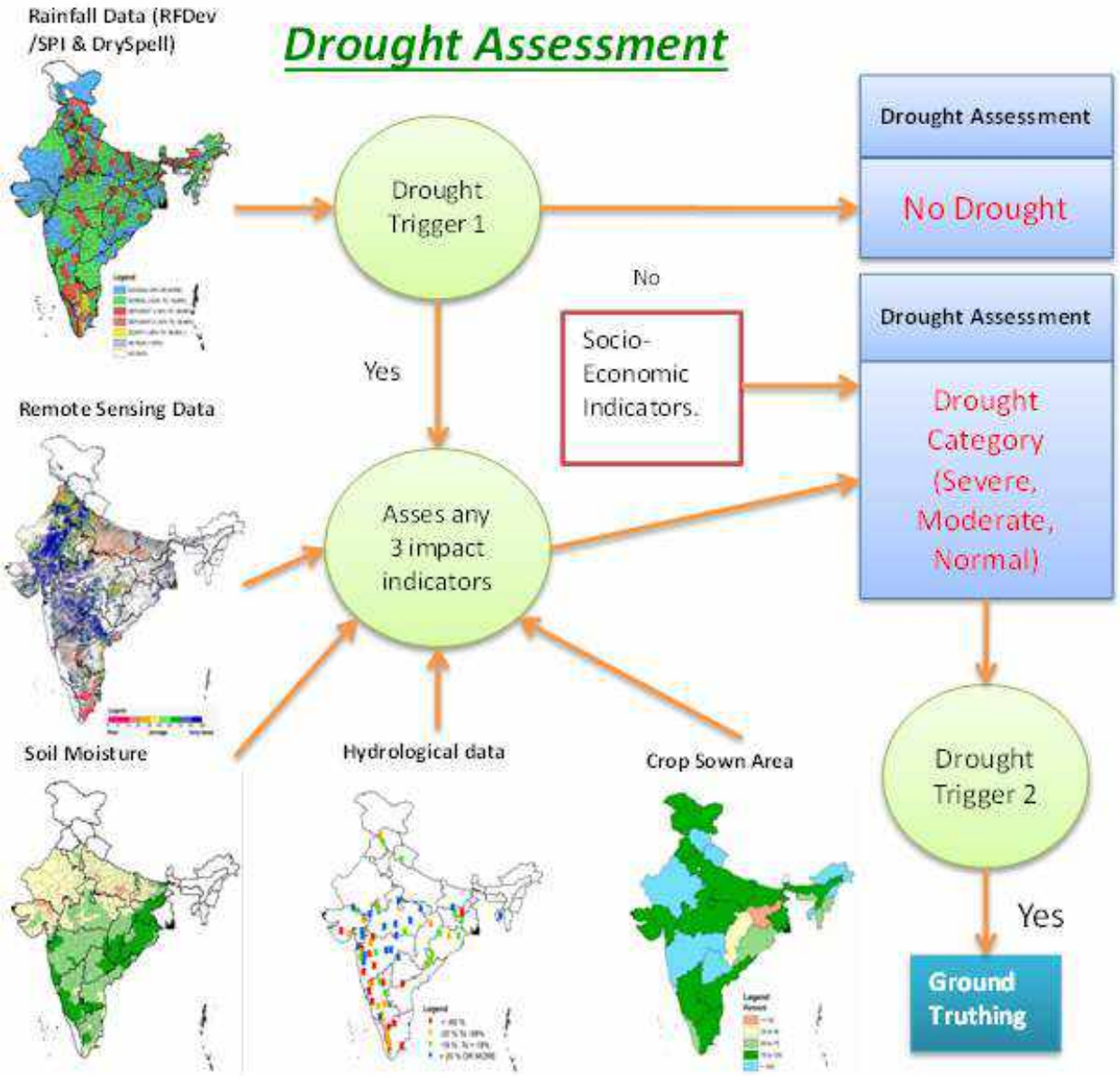
Impact parameters

1. Soil moisture
2. Crop area reduction
3. Moisture Adequacy Index (MAI)
4. Satellite based crop condition _ NDVI/NDWI/LSWI reduction
5. Crop yield reduction
6. Reservoir storage reduction

3 to 4 of 6 impact indicators are to be satisfied

NADAMS

- NADAMS project, developed by National Remote Sensing Centre, provides near real-time information on prevalence, severity level and persistence of agricultural drought at state/ district/sub-district level.
- Covers 17 states of India, which are predominantly agriculture based and prone to drought situation
- Since 2017, the drought assessment is done using the methodology prescribed in "New manual for Drought Management 2016"
- MNCFC carries out the assessment using rainfall, Remote Sensing Vegetation Index and Moisture adequacy Index during the Kharif season.
- Following statistics are generated regularly (fortnightly/monthly) under NADAMS project



Institutionalization of NADAMS Project

About MNCFC

Mahalanobis National Crop Forecast Centre (NCFC) is an attached office of Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. It was inaugurated on 23rd April, 2012 by Hon'ble Agriculture Minister.

The Centre has been established to provide in-season crop forecasts and assessment of drought situation using state of the art techniques and methodologies developed by Indian Space Research Organisation (ISRO).

www.ncfc.gov.in

Datasets for drought related studies

Ground Data (with geolocation)

- Field points: crop type, conditions, soil, managements, etc. collected through mobile app
- Crop stress (biotic/abiotic) locations with photographs

Satellite Data (Medium resolution)

- Multi-temporal, multispectral Optical, SAR data
- Biophysical data collected through space platform, eg., FAPAR
- Satellite derived weather parameters like rainfall, PET etc

Weather Data (Disaggregated level)

- Daily Rainfall
- Daily Max, Min temperature
- Humidity
- Wind speed
- Solar radiation
- Hail/frost/snow

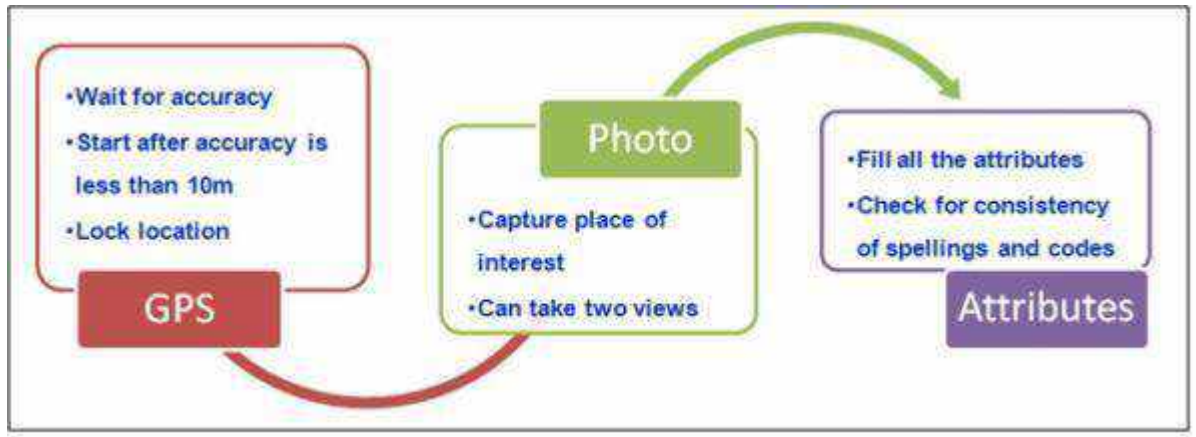
Gridded

Point

Ancillary Data

- Soil Texture
- Agro-ecological regions
- Soil water holding capacity
- Agril sown area
- Crop specific area
- Insurance coverage
- Crop yield (historical) at disaggregated level

Mobile Apps for crop field data collection

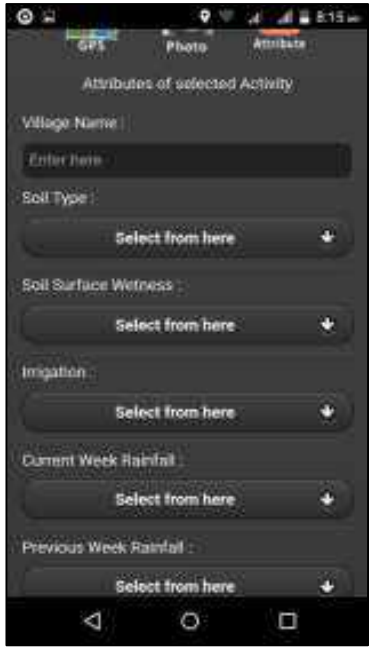


Improved field data collection system

- Real-time field data collection, robust & versatile system, automation etc.
- Surveillance of events, automated alerts generation and dissemination
- Objective enumeration system
- Localised crop damages

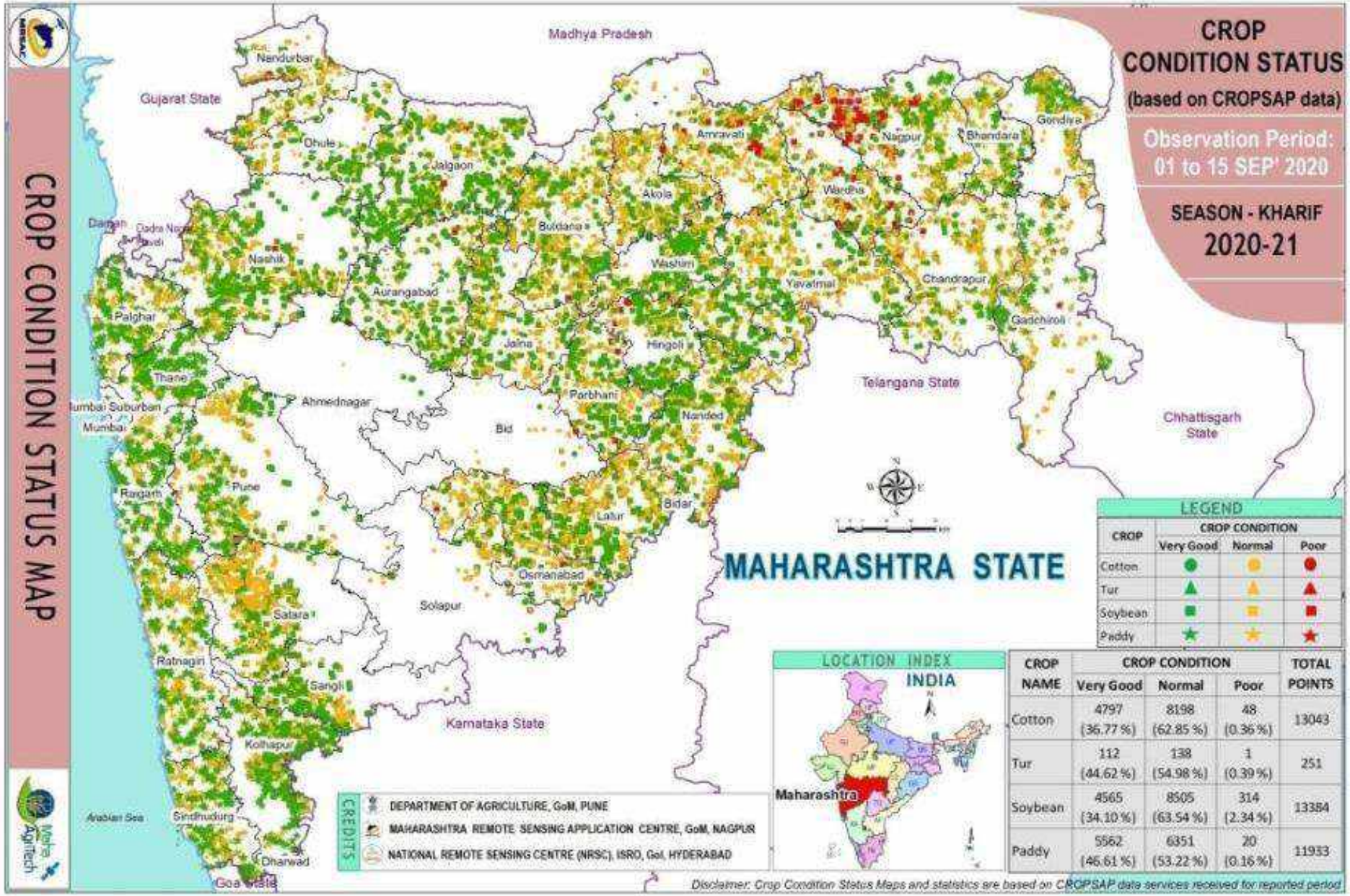
Field Data Collection using Geo-ICT

Observation → Information → Transmission → Decision → Action



Value addition and information products from field data

Mobile App based field data for crop surveillance



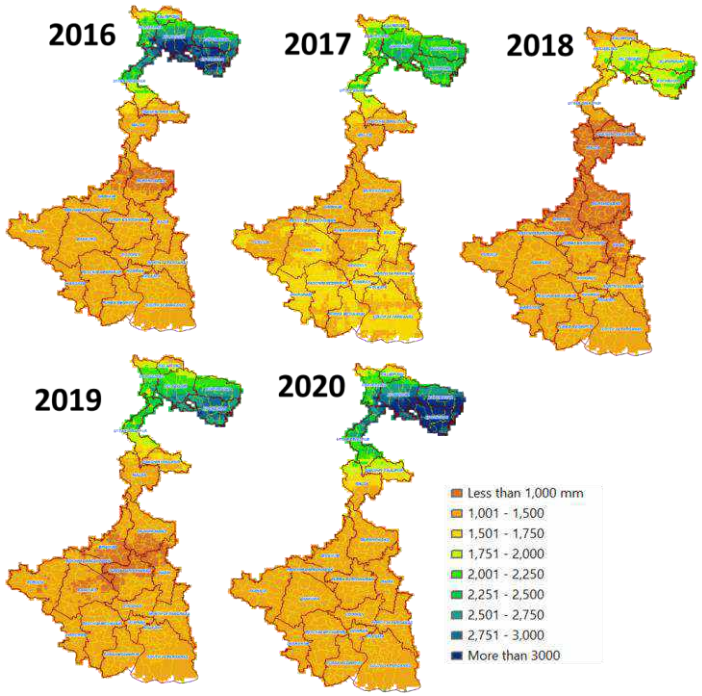
CROP NAME	CROP CONDITION			TOTAL POINTS
	Very Good	Normal	Poor	
Cotton	4797 (36.77 %)	8198 (62.85 %)	48 (0.36 %)	13043
Tur	112 (44.62 %)	138 (54.98 %)	1 (0.39 %)	251
Soybean	4565 (34.10 %)	8505 (63.54 %)	314 (2.34 %)	13384
Paddy	5562 (46.61 %)	6351 (53.22 %)	20 (0.16 %)	11933

Weather: Rainfall products

IMD data

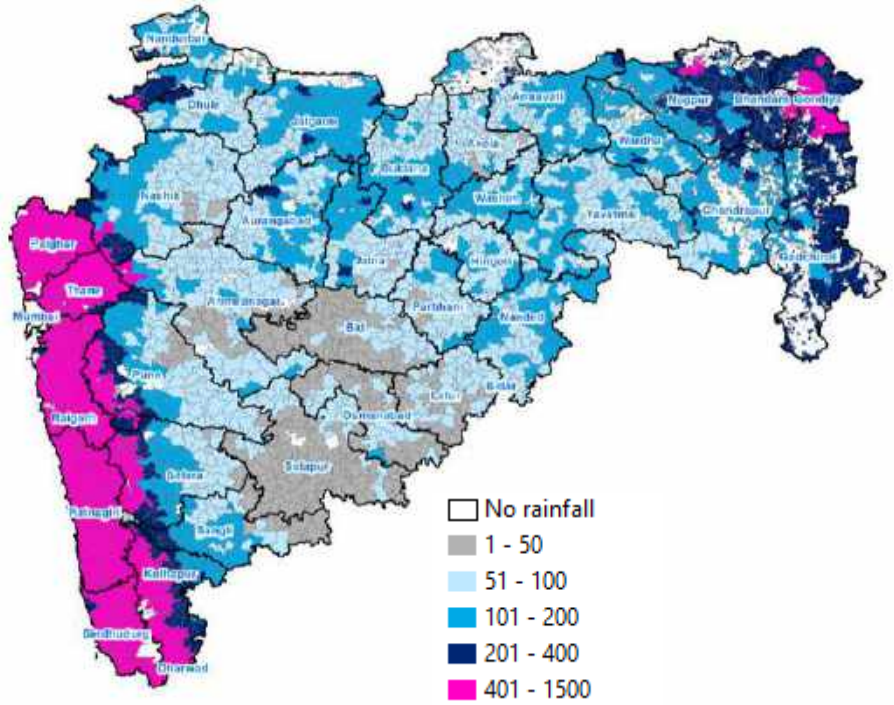
- IMD AWS/ARG data: Daily, More than 600 locations, Hourly
- IMD gridded data: 0.5/0.25 Deg
- State Agril/Revenue departments: at block level
- AWS maintained by private agencies: eg Skymet

CHIRPS



- Daily rainfall data by Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
- Spatial resolution : 5 km
- CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series

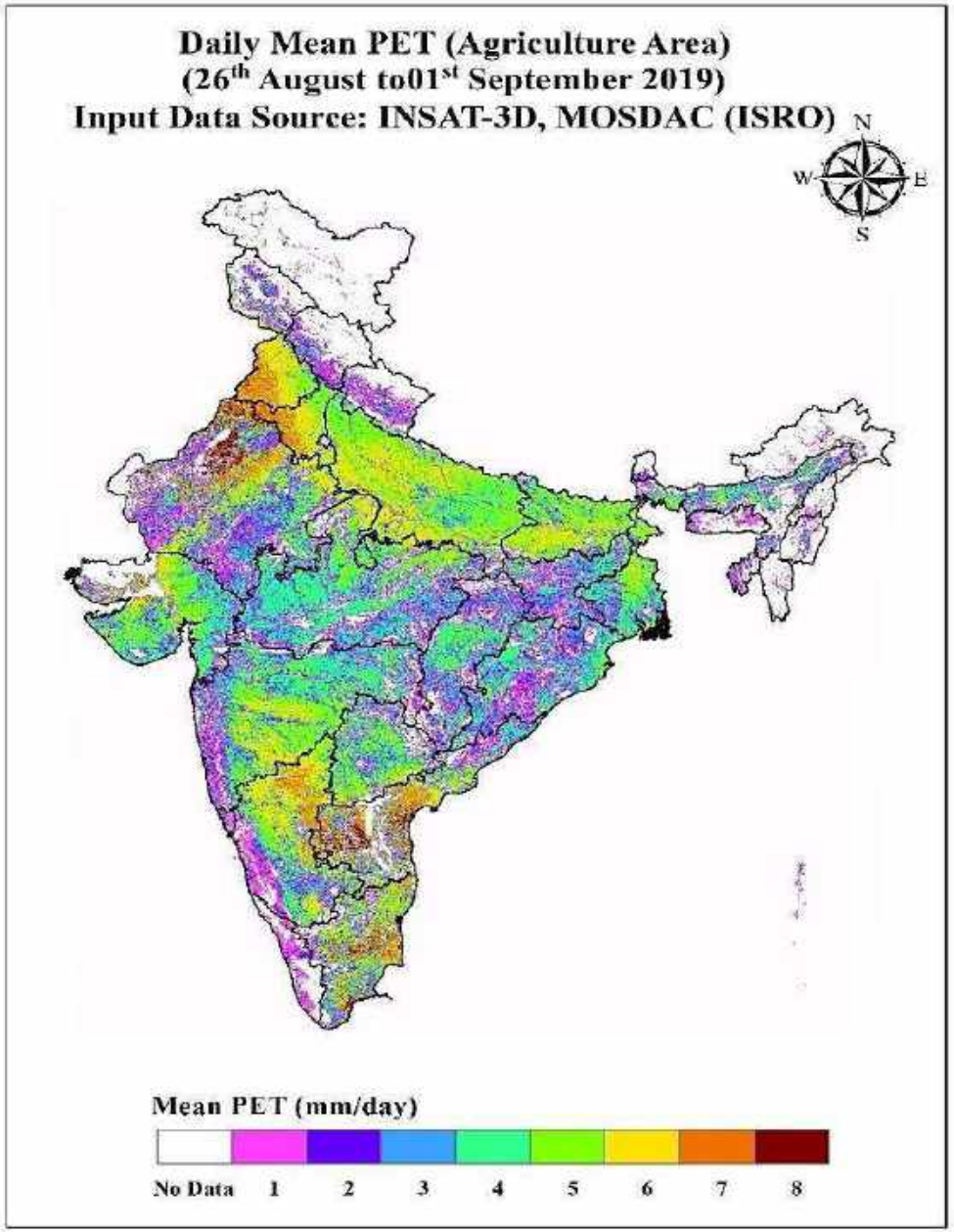
Skymet



- Skymet Raing gauges station across 2558 circles in Maharashtra
- Useful product in relation crop insurance studies

Weather data: PET/Reference ET

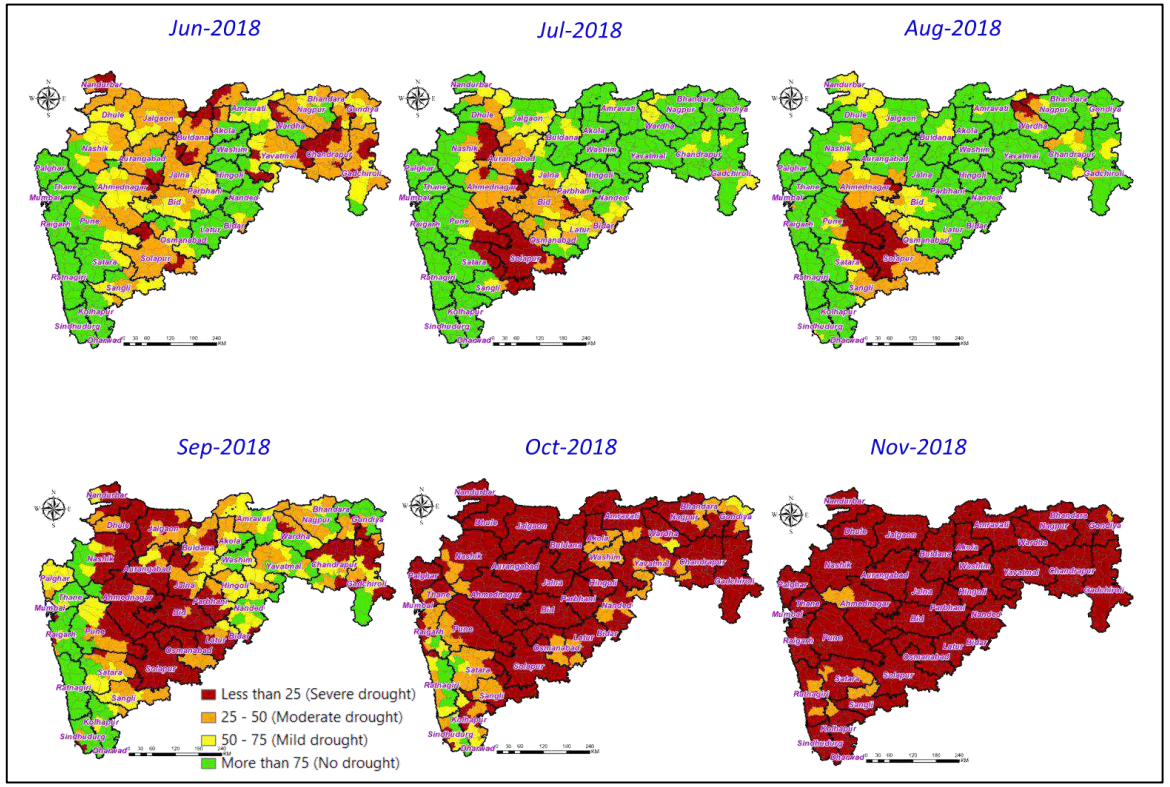
- Evapotranspiration (ET) is one of the important processes in the terrestrial water cycle. About 65% of rainwater is lost to the atmosphere due to the combined processes of evaporation and transpiration.
- In a given climate, reference evapotranspiration (ET0) is defined as the maximum evaporative demand of the atmosphere from a well-watered surface independent of crop type, crop development, and management practice.
- INSAT-3D derived daily PET is available at 4KM resolution.



Organization	Meteorological Data	Parameter	Data Availability	Spatial Resolution	Temporal Resolution
IMD	IMD-AWS	RF, Temperature, WS	-	Point Data	Hourly
	IMD-ARG	RF, Temperature, WS	-	Point Data	Hourly
	IMD-WRF	RF, Temperature, WS	3 day Forecast	9 km	3-Hourly
	IMD-Gridded Product	RF, Temperature, WS	2016 - Present	0.25 deg	Daily
	IMD-GPM merged Product	RF	2016 - Present	0.25 deg	Daily
SAC-ISRO	SAC-WRF	RF, Temperature, WS	3 day Forecast	5 km	3-Hourly
Satellite/Reanalysis data	CPC	RF	2002 - Present	0.1 deg	Daily
	GPM	RF	April, 2015 - Present	0.1 deg	30 min
	CHIRPS	RF	1981 - Near Present	0.05, 0.5 deg	Daily
	CMORPH	RF	December 2002 - Present	0.25 deg	3-Hourly
	PERSIANN	RF	March 2000 - Present	0.25 deg	6-Hourly
	TRMM/TMPA	RF	Jan 1998 - April, 2015	0.25 deg	3-Hourly
	GsMap	RF	December 2008 - Present	0.1 deg	Hourly
	GEFS	RF, Temperature	7 day Forecast	0.46 deg	3-Hourly
AP State	APSDPS AWS Data	RF, Temperature	2012 - Present	Point Data	Hourly
Local Chapter IMD	High Density AWS - Godavari/Mahanadi	RF, Temperature		Point Data	Hourly
Climate preduction centre	CPC	Temperature	1979 - Present	0.5X0.5	Daily
ECMWF	ERA- INTERIM	Temperature	1979 - Present	0.75X0.75, 0.25X0.25, 0.125X0.125	Daily
NCEP REANALYSIS II	NCEP	Temperature	1979-2019	1.875X1.875	Daily
Gobal forecant system NCEP	GFS	Temperature	2016-09 - Present	0.5X0.5	Daily
Climate forecant system reanalysis V2	CFSR v2	Temperature		0.205X0.204	Daily
Climate research unit- Time senes	CRU-TS	Temperature	1901 - 2017	0.5X0.5	Daily
	IMD	Temperature	1901-2015	1X1	Daily
Modern- Era Retrospective anallysis for Research and Application	MERRA-2	Temperature	1980-2019	0.5X0.5	Daily
Torrertrial Hydrology Research group	PRINCETON	Temperature	1948-2008	1X1, 0.5X0.5, 0.25X0.25	Daily

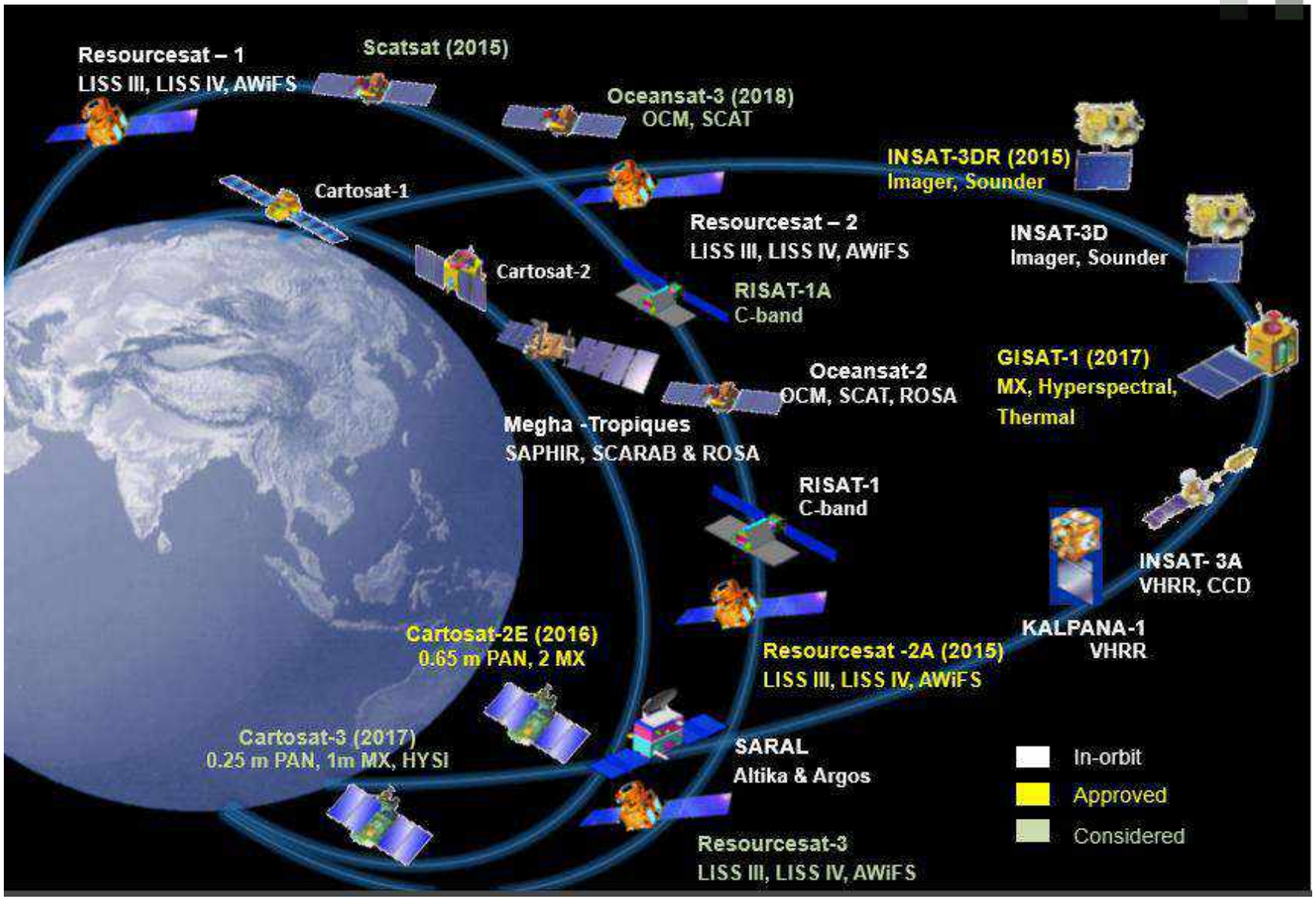
Rainfall-PET derived products: MAI

- One of the identified soil moisture based indicator in National drought manual 2016.
- Till now no soil moisture based indicator is being used for agricultural drought assessment in Maharashtra and many states.
- Moisture Adequacy Index (MAI) is equal to the ratio of Actual Evapo-transpiration (AET) to the Potential/Reference Evapo-transpiration (PET or RET) following a soil water balancing approach during different phenological stages of a crop.
- MAI were computed based on the book keeping climatic water balance approach (Thornthwaite & Marther 1955)



MAI (%)	Agricultural Drought Class
76 – 100	No drought
51-75	Mild drought
26-50	Moderate drought
0-25	Severe drought

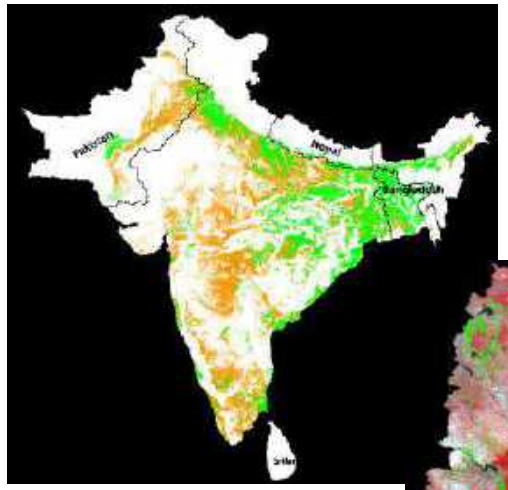
Satellite data: Selection of Data



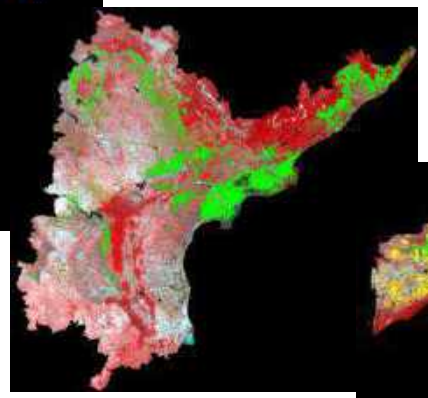
Satellite data: Selection of Data

Satellites	Sensor	Spatial resolution	Temporal resolution	Swath
Resourcesat 1 ,2, 2A	AWiFS	56 m	5 days	750 km
	LISS III	23 m	26 days	140 km
	LISS IV	6 m	48 days	70 km
LANDSAT 8	OLI	30 m	16 days	185 km
Sentinel-2	MSI	10m	5 days	300 km

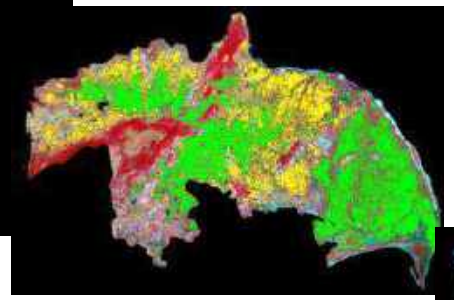
180 m National level



180m State level



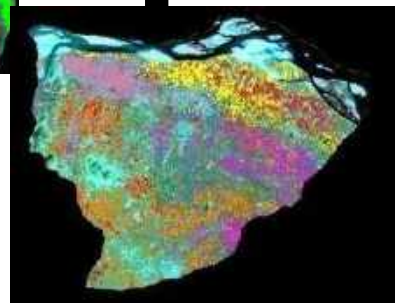
60 m District level



IRS WIFS

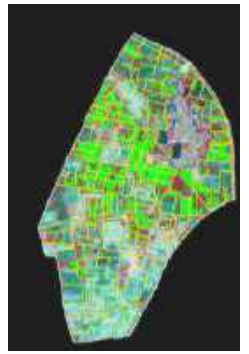
Rice Cotton

20-30m block level



BANANA
MAIZE
TOBACCO
CHILLIES

6m Village level



LISS-IV data

AWiFS IRS LISS-III

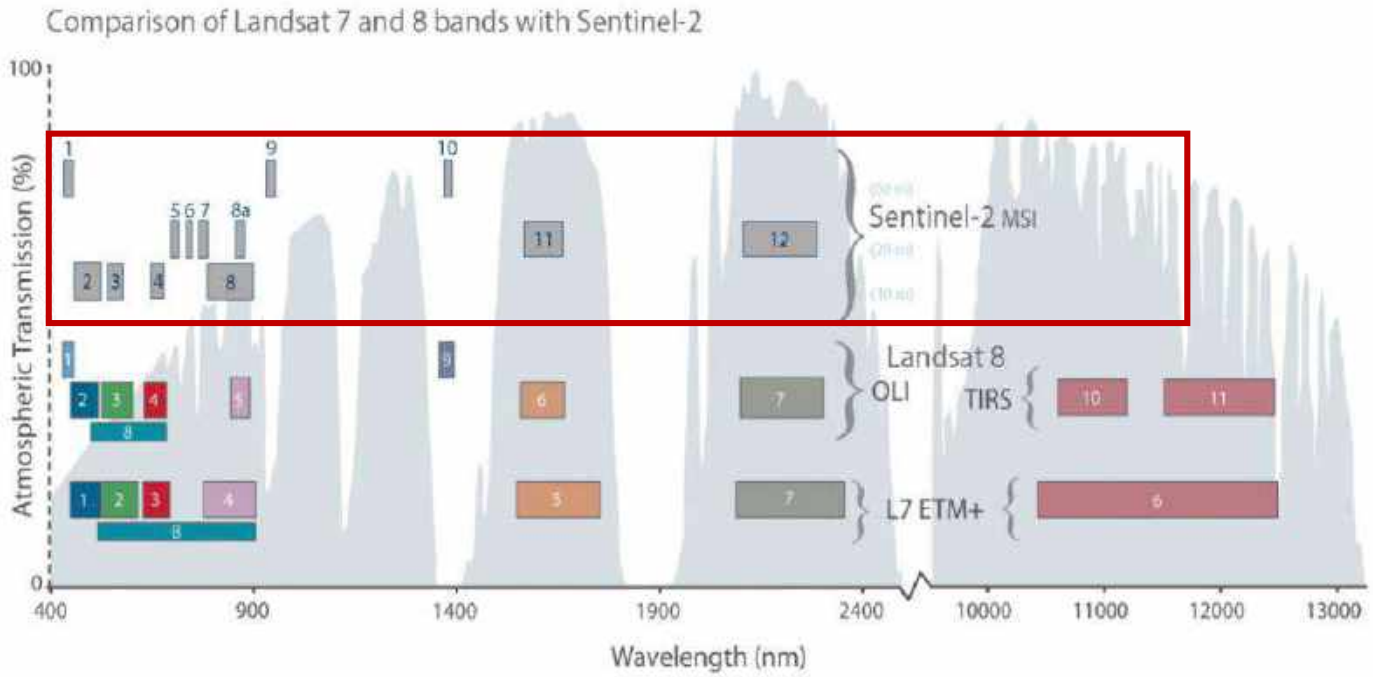
- Moderate resolution
- Easily accessible (either free or low cost)
- Most suitable for sub-district level assessments

Sentinel-2 data

Optical mission for the monitoring of land and coastal regions.

Main Features:

- Constellation of two satellites (Sentinel-2A and Sentinel-2B)
- Multi-Spectral Instrument (MSI)
- Polar, sun-synchronous orbit at 786km
- 10 days repeat cycle (5 days with both Sentinels 2A and 2B operational) Swath of 290km

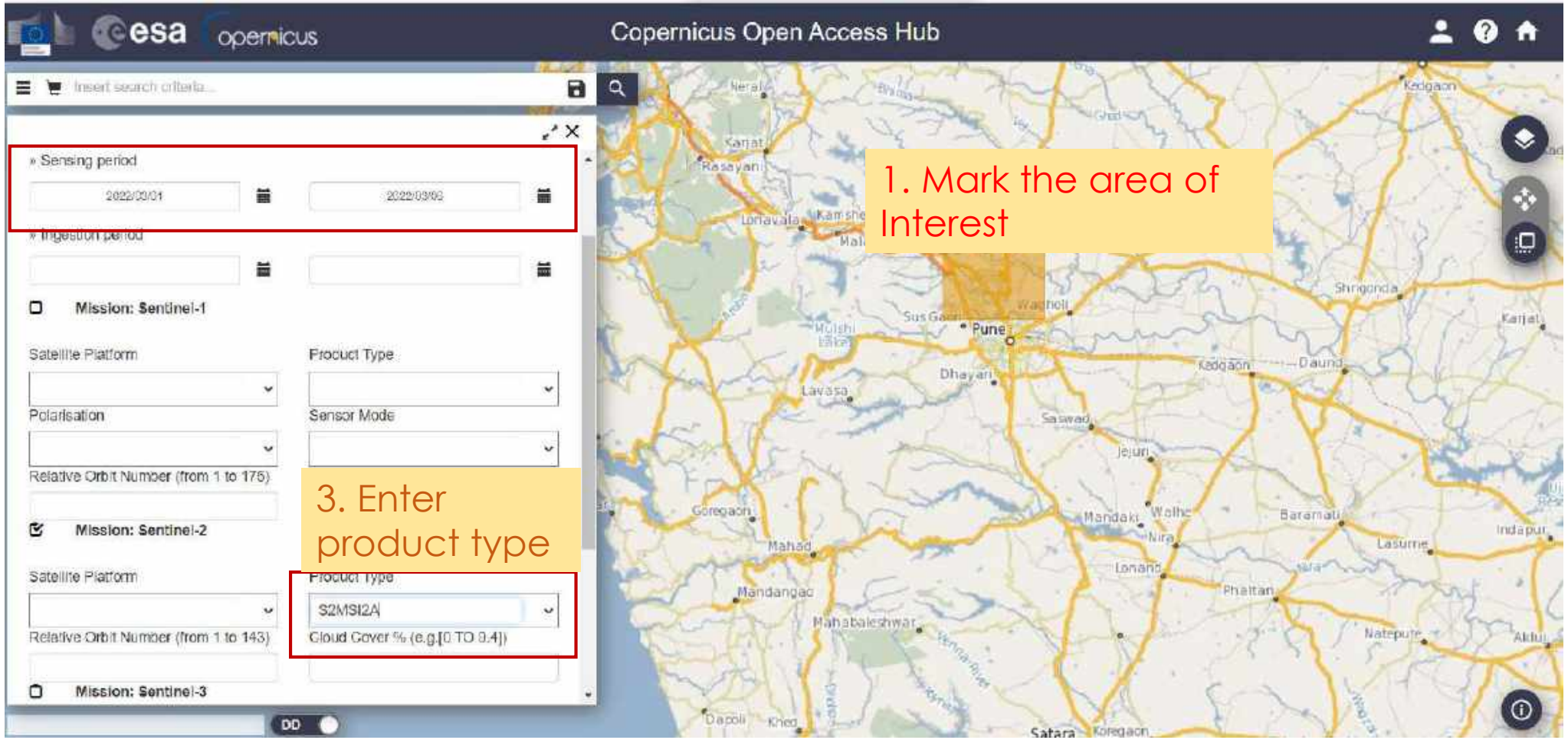


Level-1C
Top-Of-Atmosphere reflectances in cartographic geometry

Level-2A
Bottom-Of-Atmosphere reflectances in cartographic
geometry

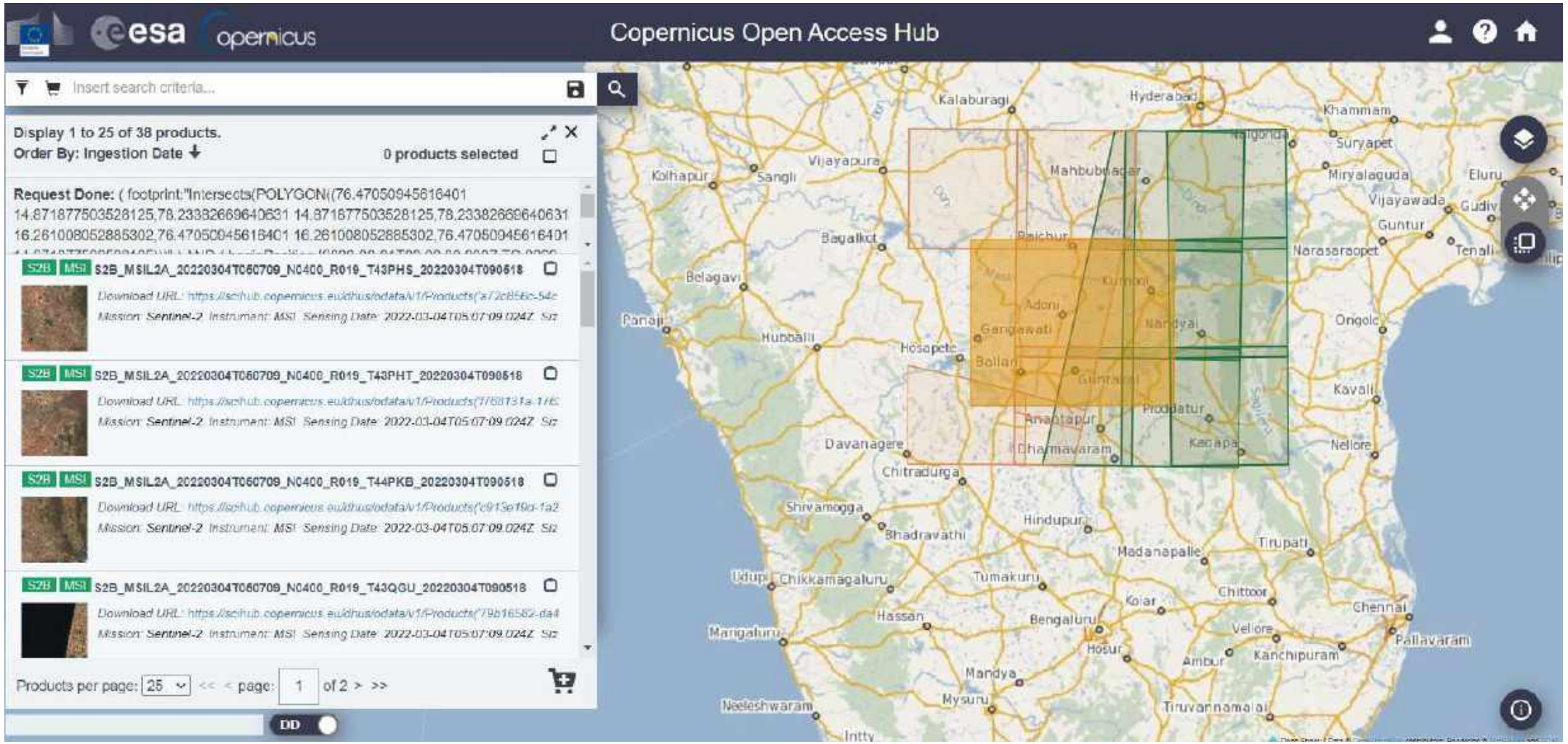
Sentinel-2 data: How to download

2. Enter Sensing period



https://scihub.copernicus.eu/dhus/

Sentinel-2 data: How to download



https://scihub.copernicus.eu/dhus/

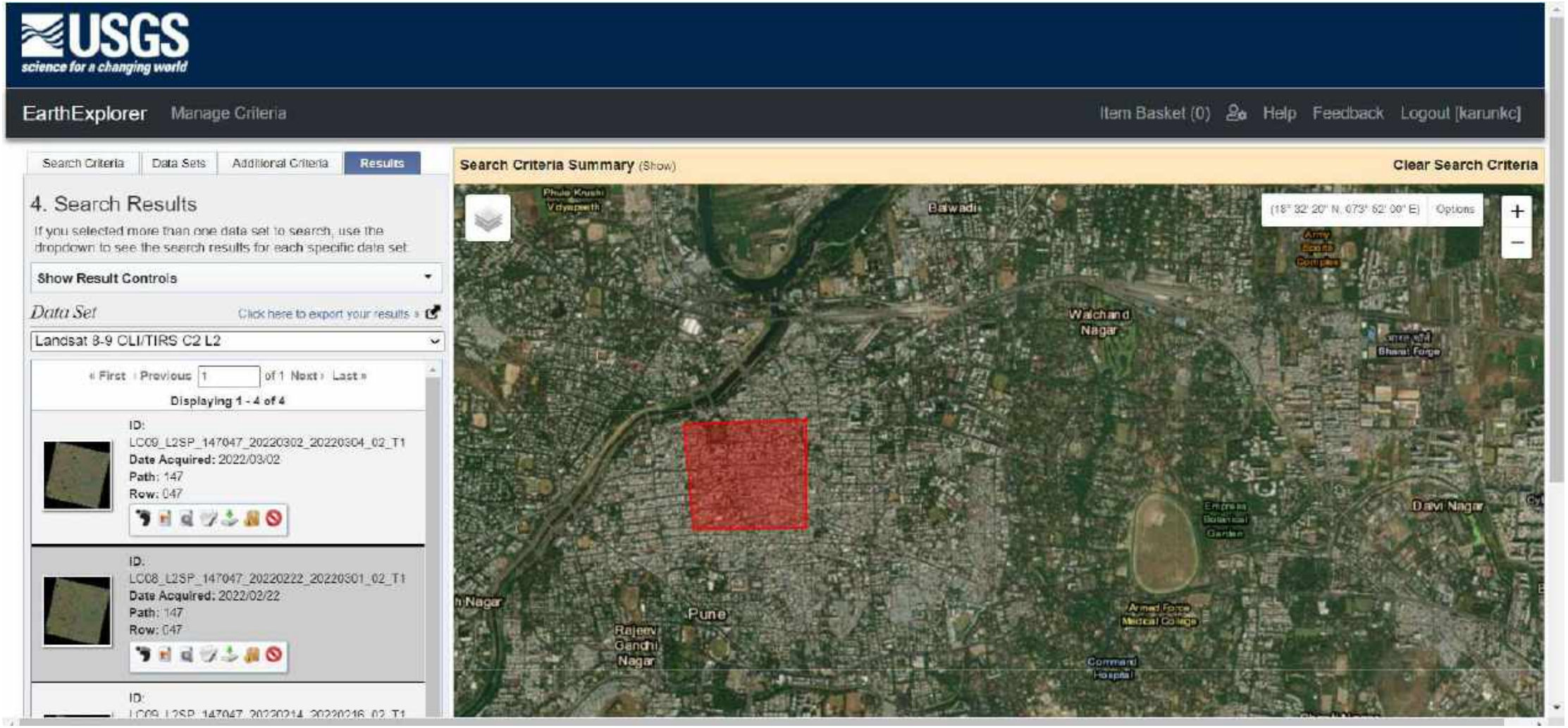
Landsat-8/Landsat-9

- Landsat 8 orbits the the Earth in a sun-synchronous, near-polar orbit, at an altitude of 705 km (438 mi), inclined at 98.2 degrees, and completes one Earth orbit every 99 minutes. The satellite has a 16-day repeat cycle with an equatorial crossing time: 10:00 a.m.
- Since 2013

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

- Product type: Level 1/Level2
- Output format: GeoTIFF
- Pixel size: 15 meters/30 meters/100 meters (panchromatic/multispectral/thermal)
- Map projection: UTM (Polar Stereographic for Antarctica)
- Datum: WGS 84
- Orientation: North-up (map)
- Resampling: Cubic convolution

Landsat-8/Landsat-9: Downloading



[EarthExplorer (usgs.gov)]

Resourcesat-2/2A

Sensor	Spatial Resolution (m)	Swath (km)	Re-visit (days)
LISS-IV	5.8	70 km	48
LISS-III	23.5	141 km	24
AWiFS	56	750 km	5/25

LISS-III & AWiFS

Band 2 – Green (0.52 – 0.59 µm); Band 3 – Red (0.62– 0.68 µm)

Band 4 - Near Infrared (0.77 – 0.86 µm); Band 5 - SWIR (1.55 – 1.70µm)

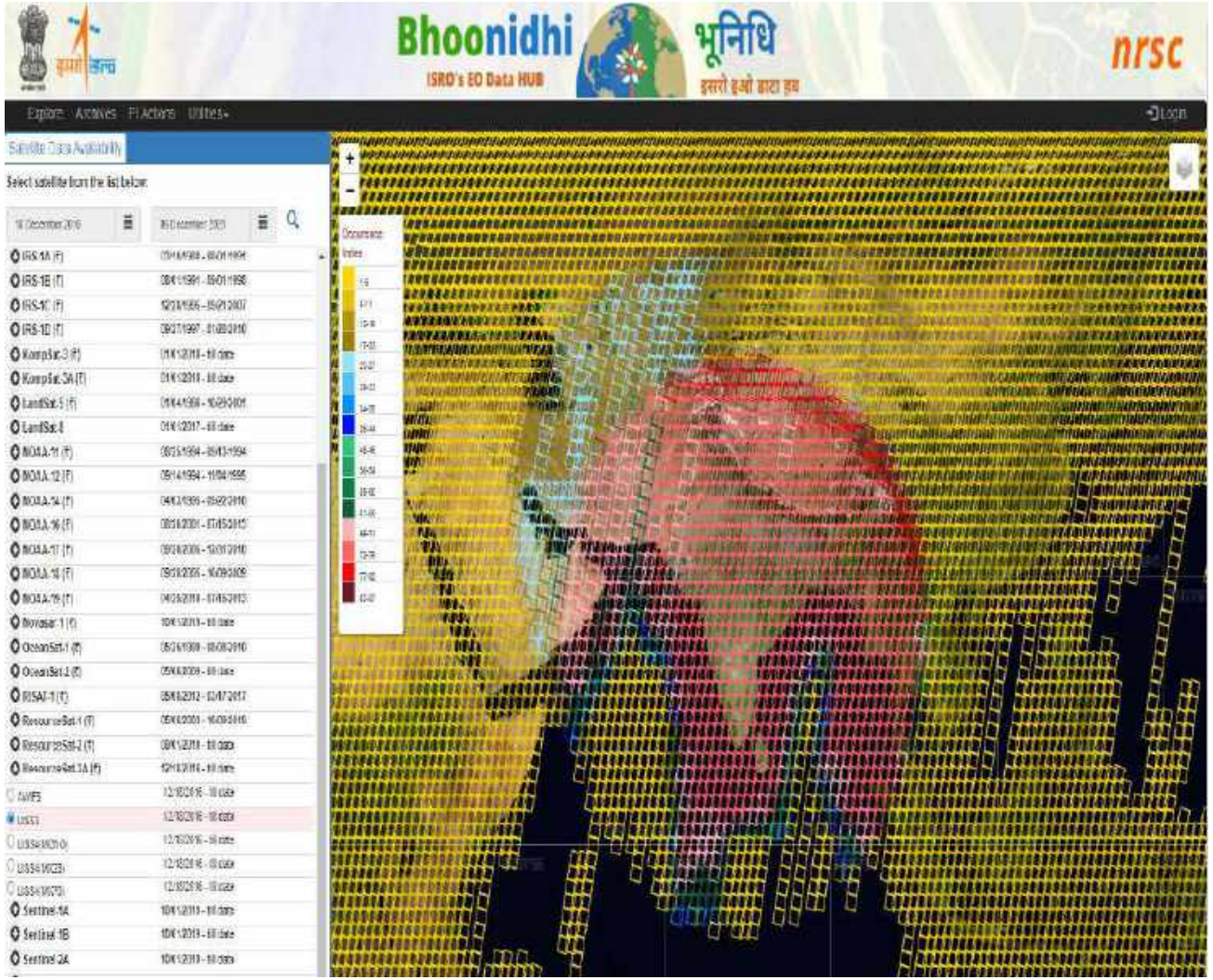
LISS-IV

Bands -2,3 and 4, as above

Resourcesat-2/2A: Procurement

Bhoonidhi: ISRO EO Data Hub

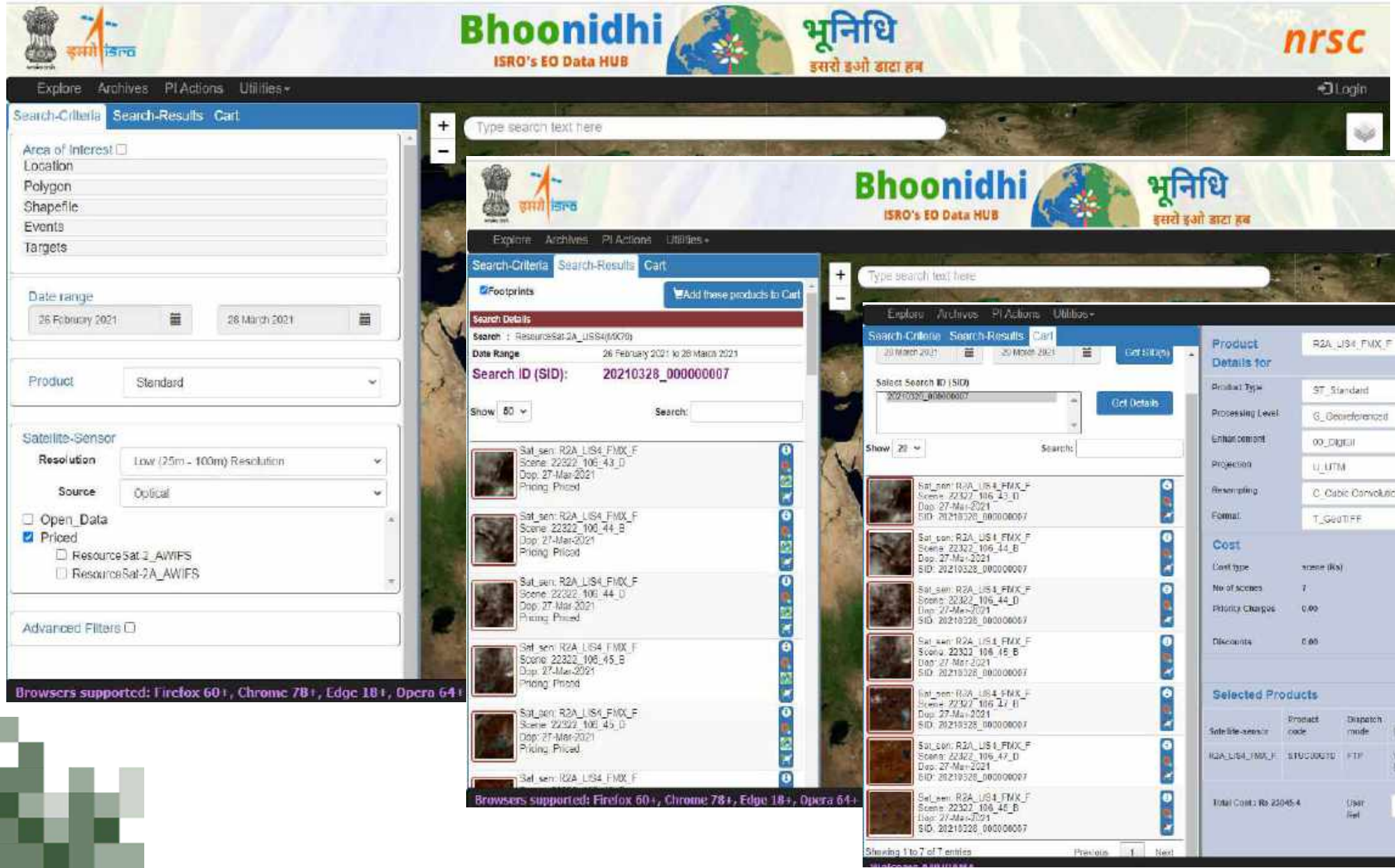
- Single-window quick-look catalogue for ISRO's EO data archive
- Indian and non-Indian remote sensing sensors archives
- New technologies providing seamless ordering and dissemination of Open & Paid satellite data products
- Faster, simplified 3-step process to download open satellite data.
- Serves as a regional data hub for the Sentinel data products *(< 1.30 hour data on-boarding time for all Sentinel datasets)*



https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html

Bhoonidhi: ISRO EO Data Hub

Tutorial Videos:
https://bhoonidhi.nrsc.gov.in/bhoonidhi/htmls/help.html



Spectral Indices

Spectral indices are quantitative measures of features that are obtained by combining several spectral bands.

Greenness Index

- RVI
- NDVI, GNDVI, TNDVI, WDVI
- SAVI, TSAVI, MSAVI
- ARVI
- MTCI, MCARI
- REP, IRECI

Wetness Index

- NDWI
- NDWI-2
- LSWI
- NDTI

Indices for Crop residue and bare soil

- BI
- CAI
- NDTI

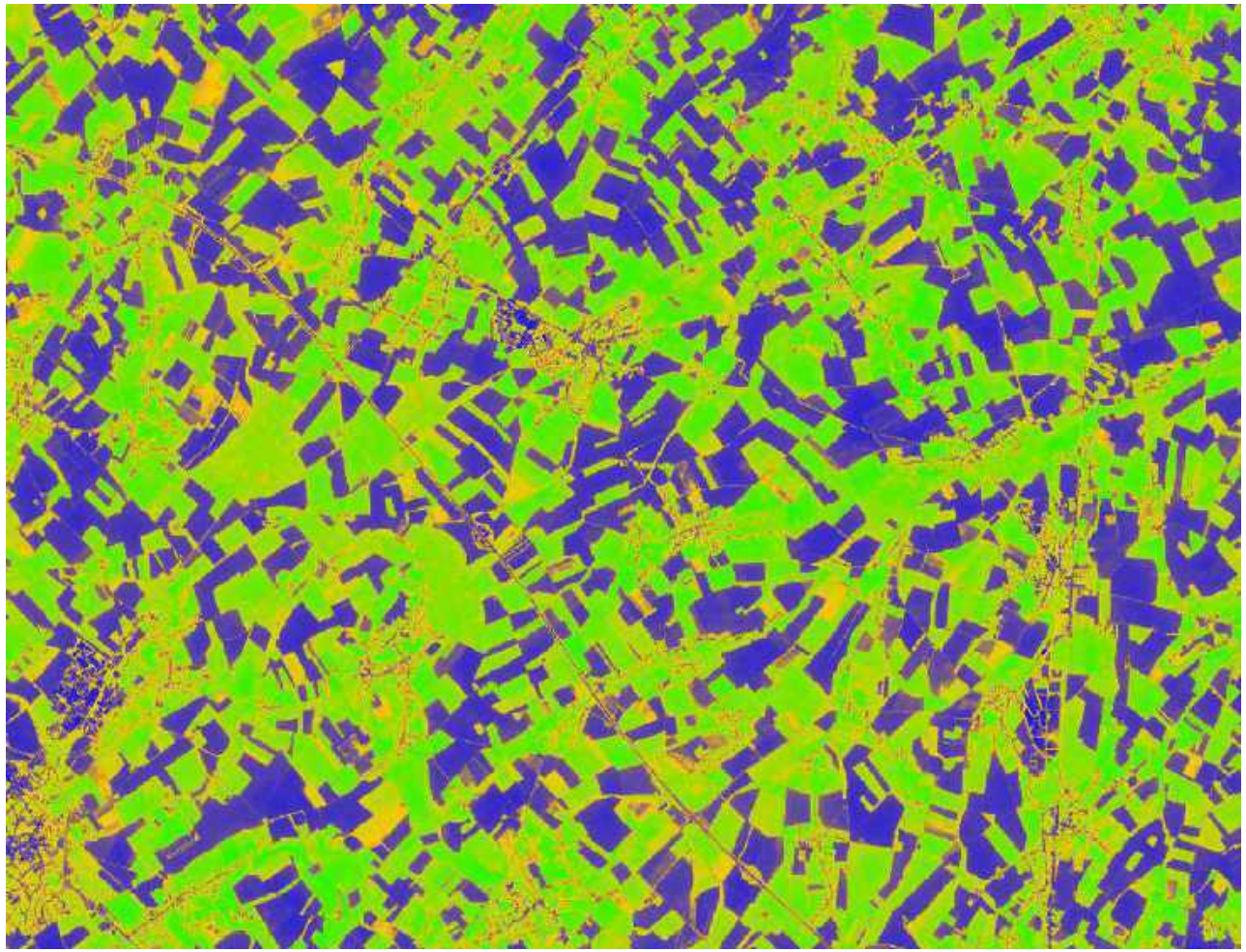
NDVI: Normalized Difference Vegetation Index

- NDVI is a dimensionless index that is indicative for vegetation density and is calculated by comparing the visible and near-infrared sunlight reflected by the surface (reflectance)
- Old and classic method, heavily used to estimate the health of green vegetation and
- post-processed, high-definition images for precision agriculture.

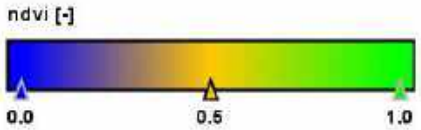
$$\frac{(NIR - RED)}{(NIR + RED)}$$

$$\frac{(B8 - B12)}{(B8 + B12)}$$

For Sentinel-2



NDVI values range between -1 and +1, with dense vegetation and healthy having higher values (e.g., 0.4 - 0.7), and lightly vegetated regions having lower values (e.g., 0.1 - 0.2).



LSWI: Land Surface Wetness Index

✓Based on reflectance in Short Wave InfraRed (SWIR) and NIR bands

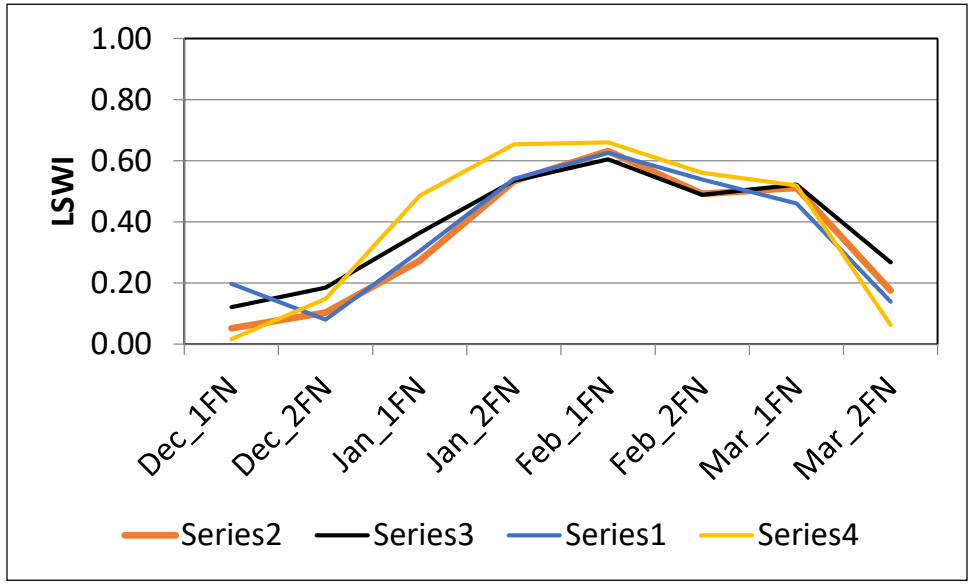
✓Sensitive to surface wetness/ vegetation moisture

✓Agriculture – crop stress detection, crop yield, classification of succulent crops, surface moisture

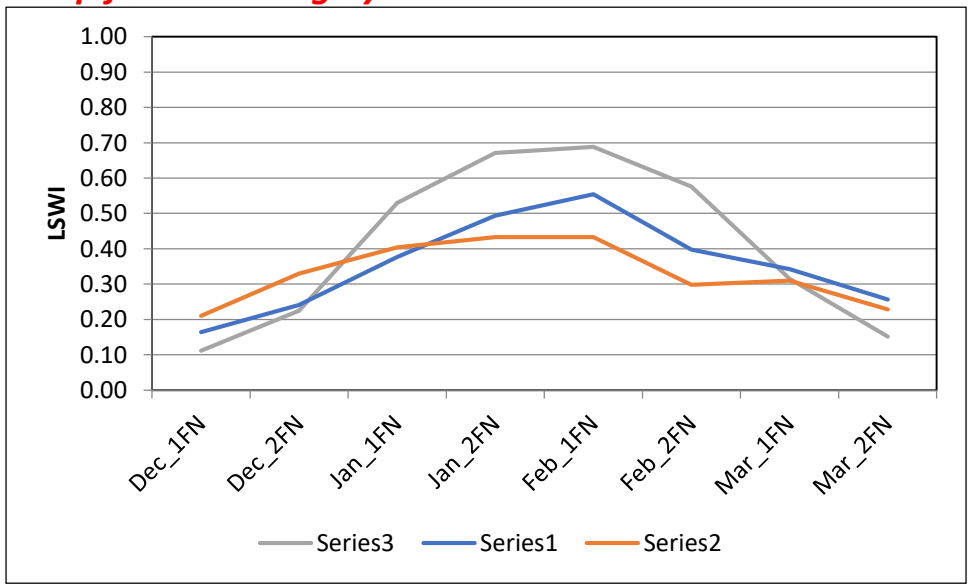
$$\frac{(NIR - SWIR)}{(NIR + SWIR)}$$

$$\frac{(B8 - B12)}{(B8 + B12)}$$

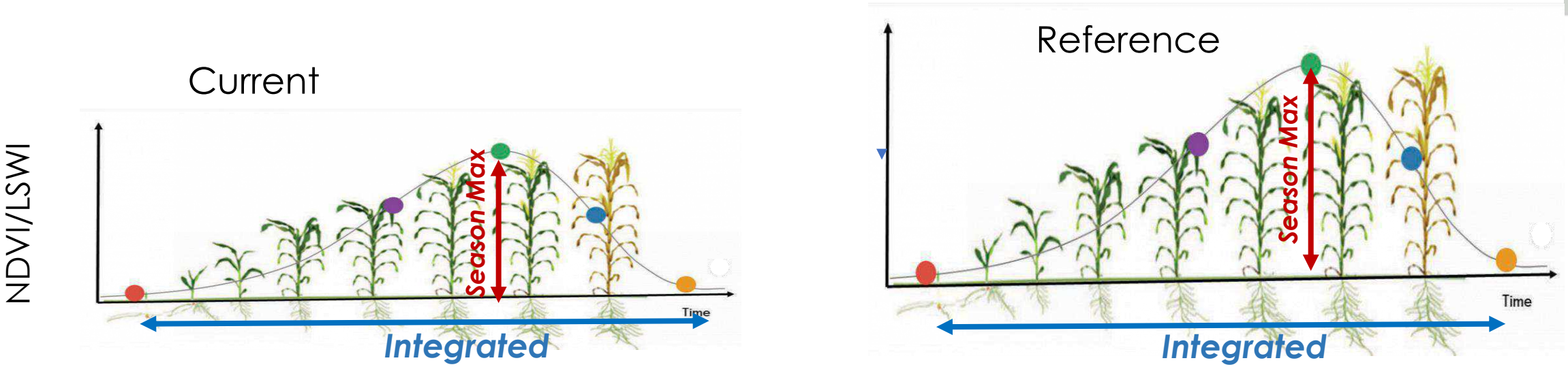
For Sentinel-2



LSWI profiles discriminating good and poor Potato crop fields in Hooghly dist.

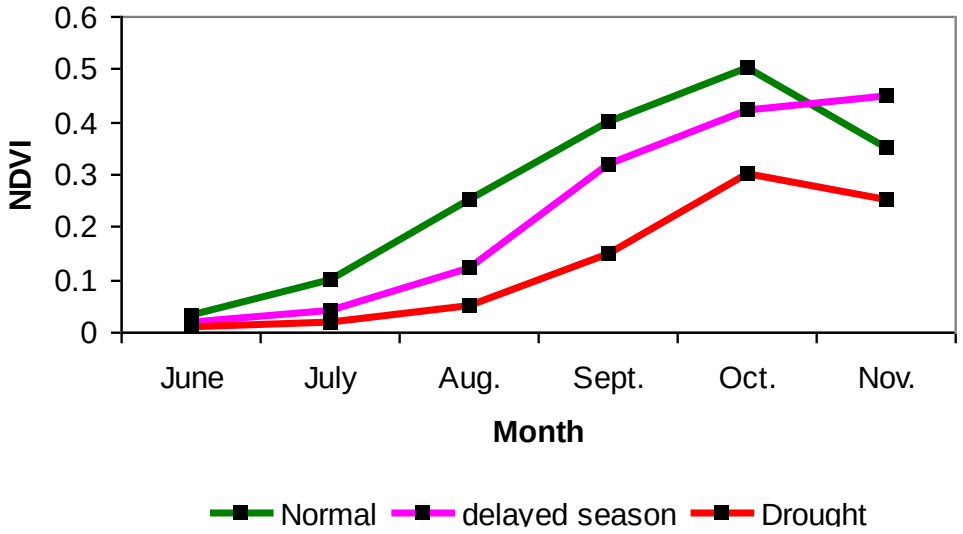


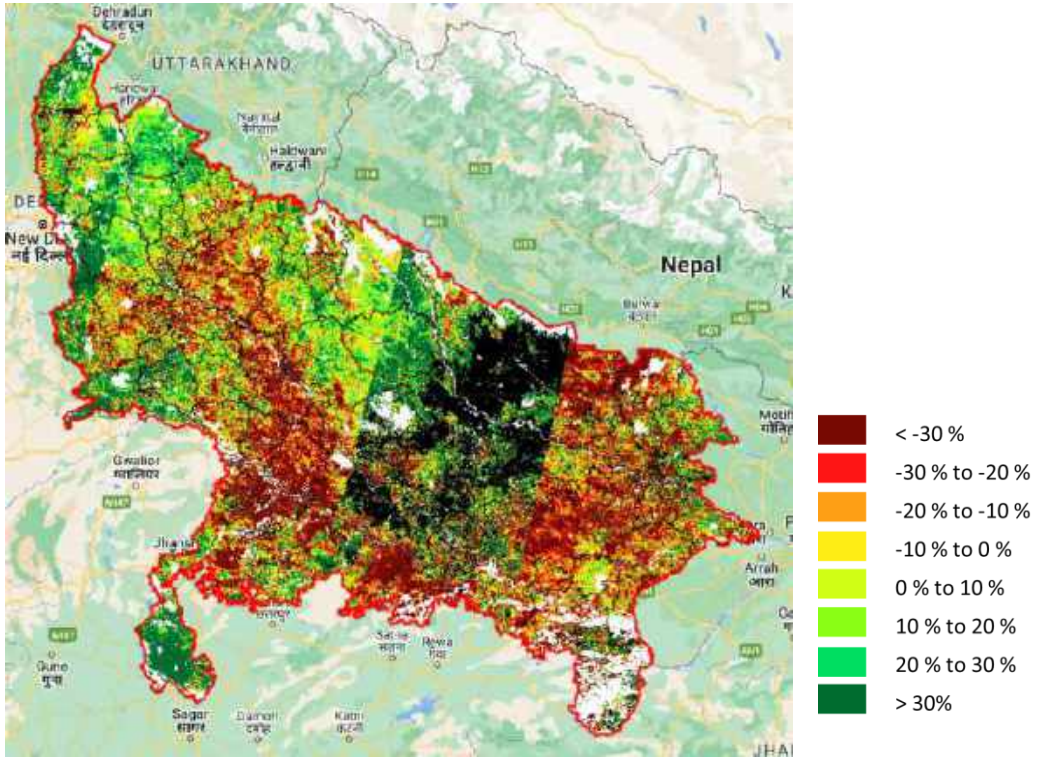
Derived products from VI



- *Season Maximum*
- *Integrated*
- *% Anomaly Map = (Current NDVI – Reference NDVI) x 100 / (Reference NDVI)*

Interpretation of NDVI/LSWI changes





NDVI anomaly: % dev. from normal

(actual NDVI-normal NDVI)/normal NDVI*100

Selection of normal year – average of recent past normal years

NDVI is a conservative indicator and hence anomalies are not very high

Thumb rule:
> 20% reduction in NDVI – drought conditions

>30% reduction indicate moderate to severe drought conditions

Limitation of NDVI

- ✓Chlorophyll based index – saturates with LAI (=3)
- ✓Limited capability to detect vegetation water content
- ✓Over-estimation when the veg. density is less
- ✓Saturation at peak vegetative phases
- ✓Conservative index
- ✓Time lag

Combination of NDVI and LSWI anomalies

nrsc

Deviation classes

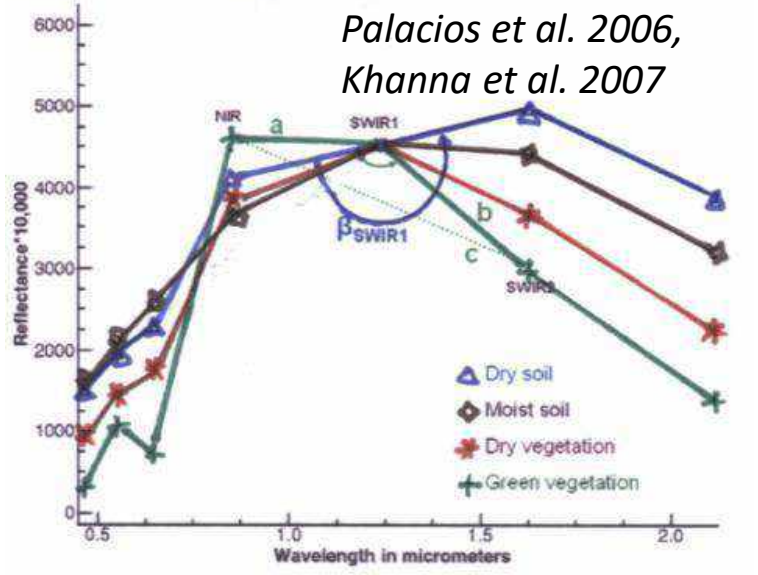
- Class 1 -10% and above - Normal
- Class 2 -10 to -20 % Mild
- Class 3 -20 to -30% Moderate
- Class 4 <-30% Severe

LSWI/NDWI deviation class

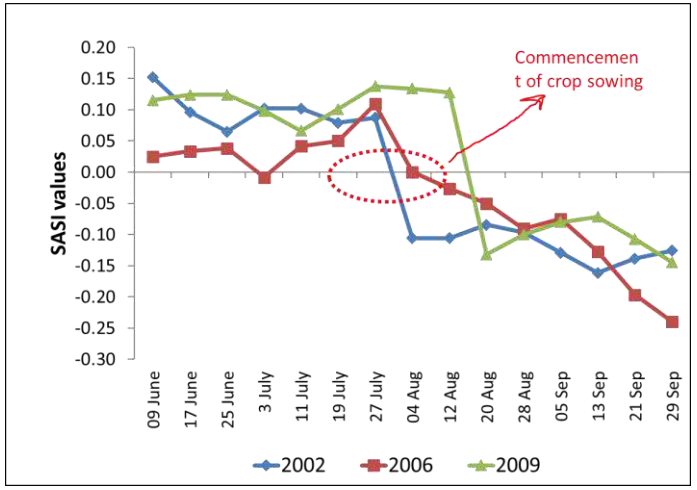
NDVI deviation class	Class 1	Class 2	Class 3	Class 4
Class 1	no drought	no drought	Moderate drought	Severe drought
Class 2	no drought	no drought	mild drought	Moderate drought
Class 3	moderate drought	mild drought	Moderate drought	Severe drought
Class 4	moderate drought	Moderate drought	Severe drought	Severe drought

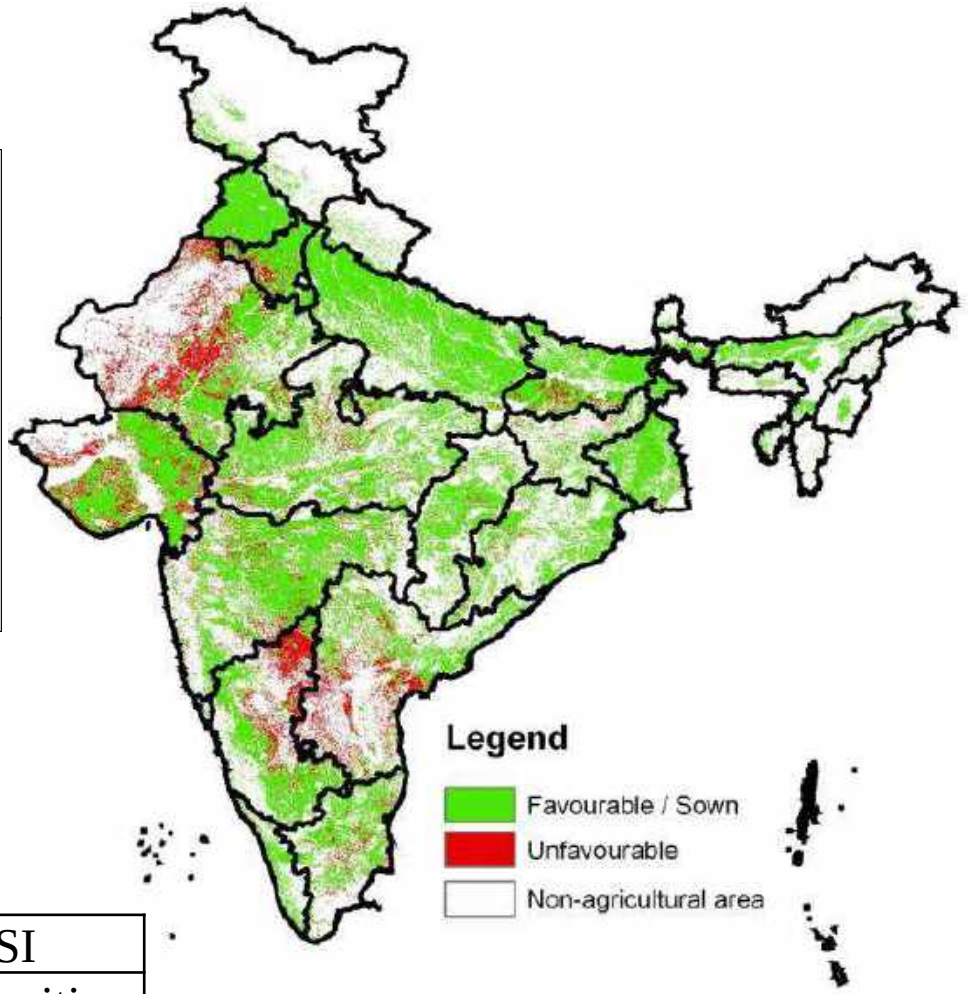
Area Favourable for Crop Sowing (AFCS)

Shortwave Angle Slope Index (SASI)



Palacios et al. 2006, Khanna et al. 2007





$$\beta_{SWIR1} = \cos^{-1} [(a^2 + b^2 + c^2) / (2*a*b)]$$

$$\text{Slope} = (\text{SWIR2} - \text{NIR})$$

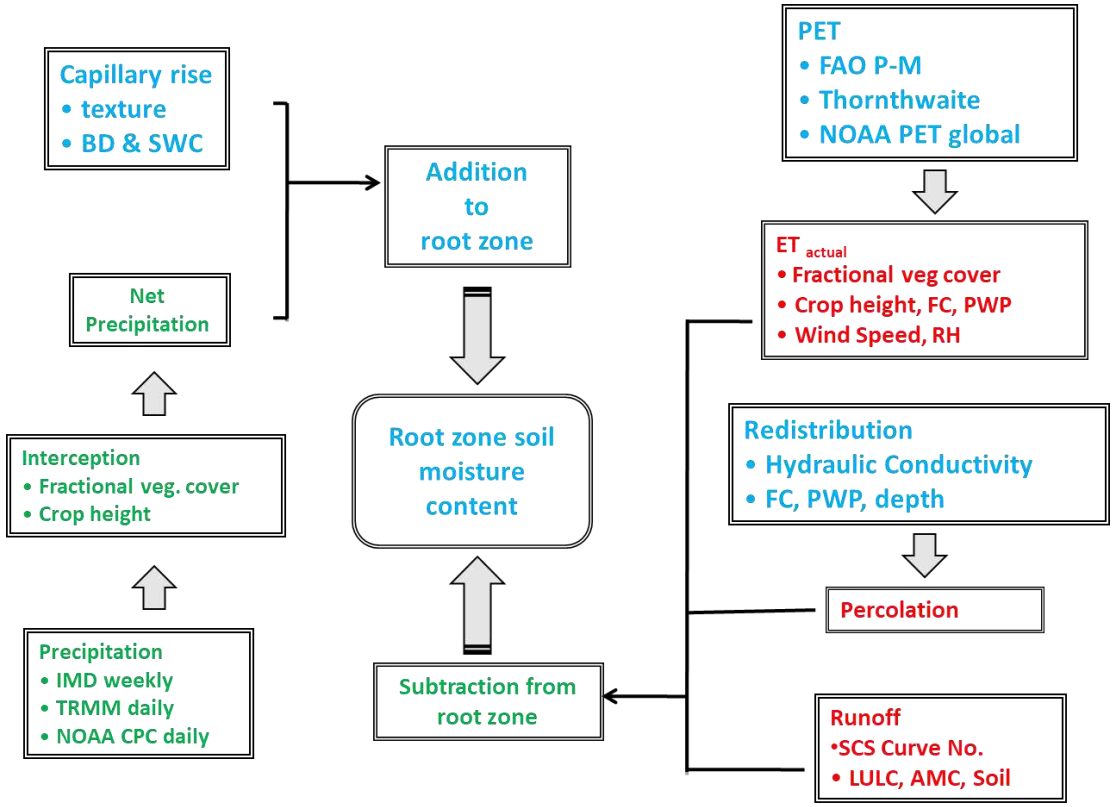
$$\text{SASI} = \beta_{SWIR1} * \text{Slope (radians)}$$

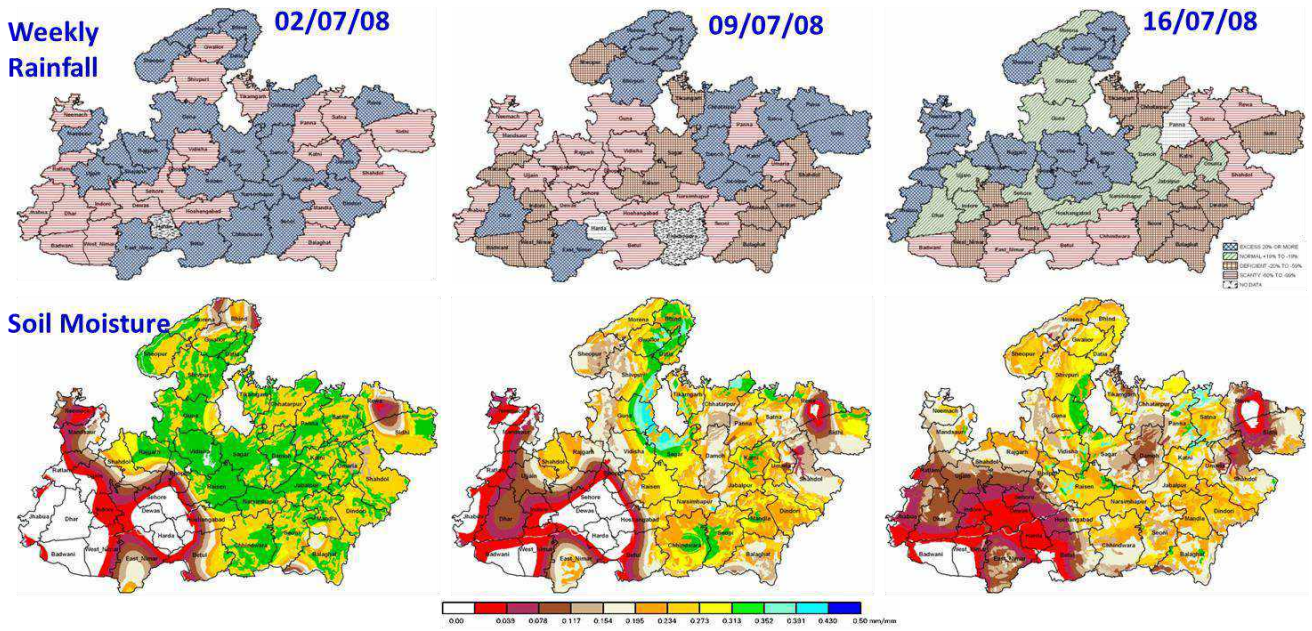
where a, b and c are Euclidian distances between vertices NIR and SWIR1, SWIR1 and SWIR2, and NIR and SWIR2, respectively

Features	β_{SWIR1}	Slope	SASI
Dry soil	high	high and +ve	highly positive
Wet soil	low	small and +ve	low positive
Dry vegetation	low	small and -ve	low negative
Moist vegetation	high	high and -ve	highly negative

Root zone soil moisture

Semi- empirical water balance approach for root zone soil moisture estimation





Upper Layer depth = 30 cm

Satellite based soil moisture

- Large area, daily coverage
- 25-50 km resolution
- Increasing popularity

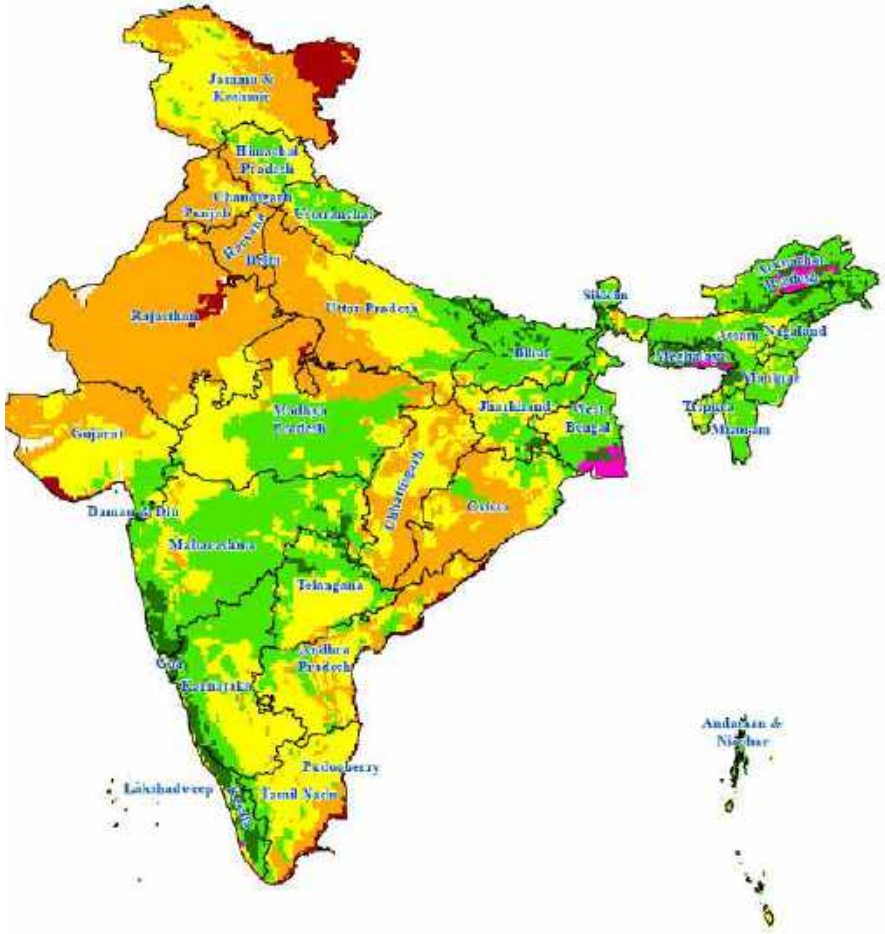
Several microwave sensors

- SMRR – 1978-1987
- TRMM – TMI since 1997
- Scatterometer – ERS 1 & 2
- ASCAT – MetopA
- AMSRE – 2002-2011
- SMOS – 2009
- SMAP - 2015

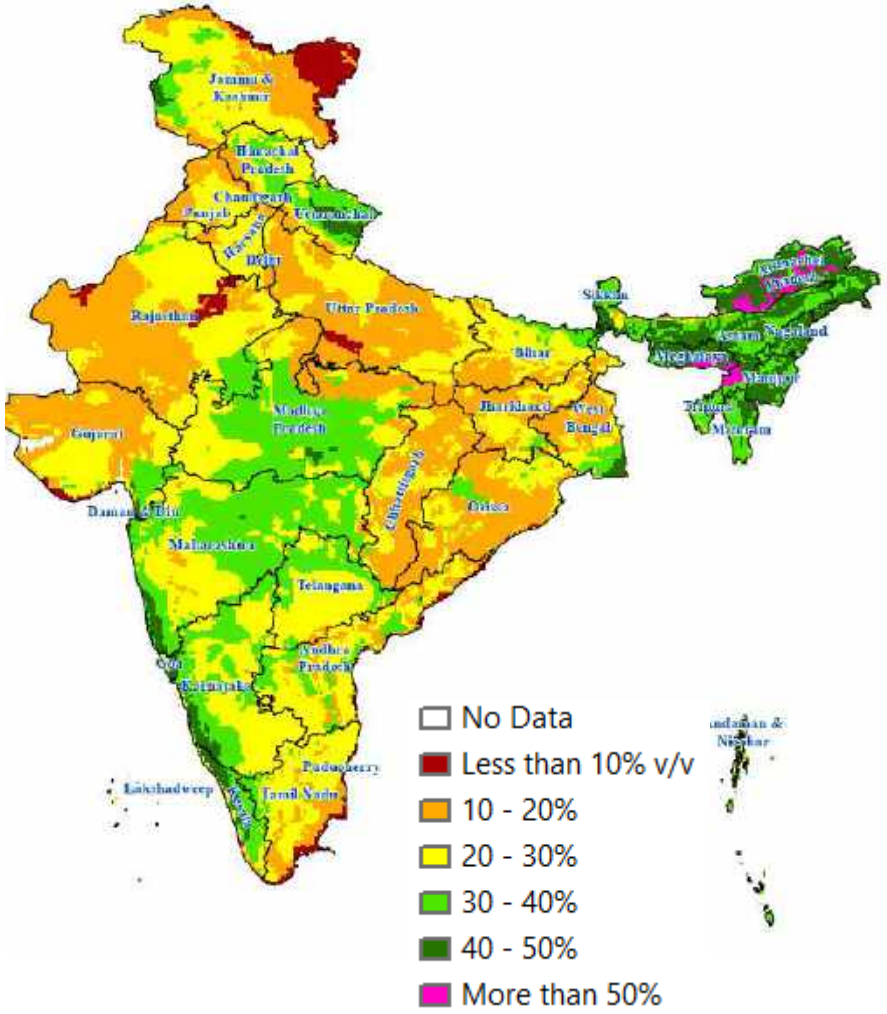
Retrieval algorithms from passive systems

- NASA
- LPRM

2021 July Week 01



2022 July Week 01



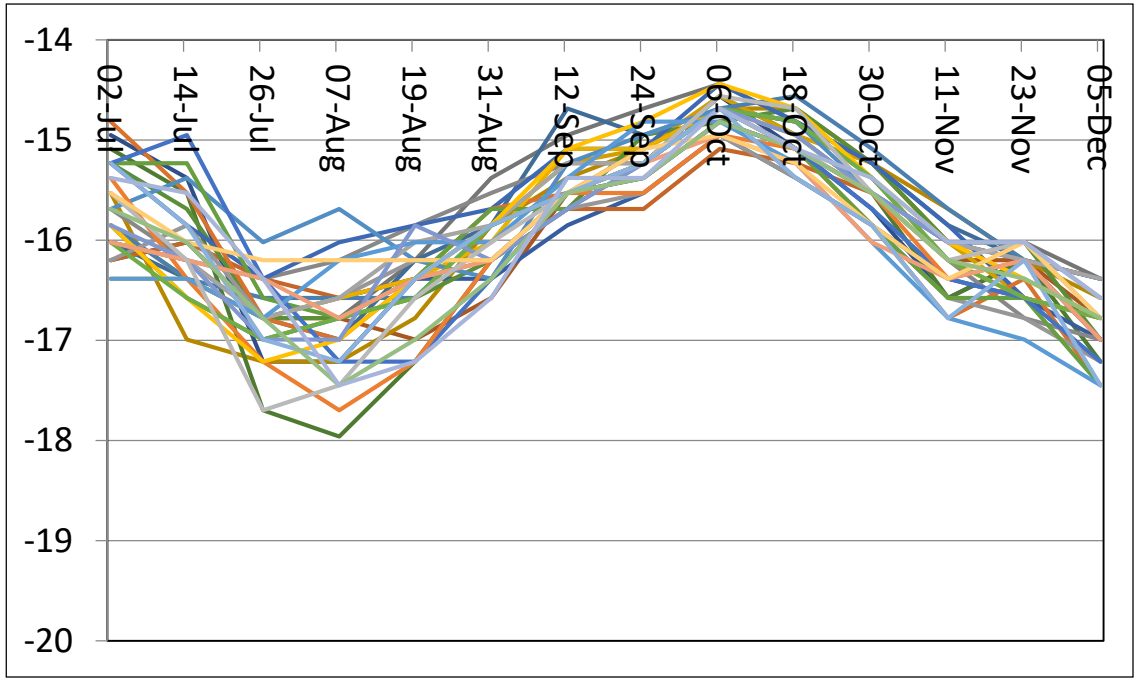
- SMAP L4 Global 3-hourly 9 km gridded Root Zone Soil Moisture Data
- Averaged value composite for week

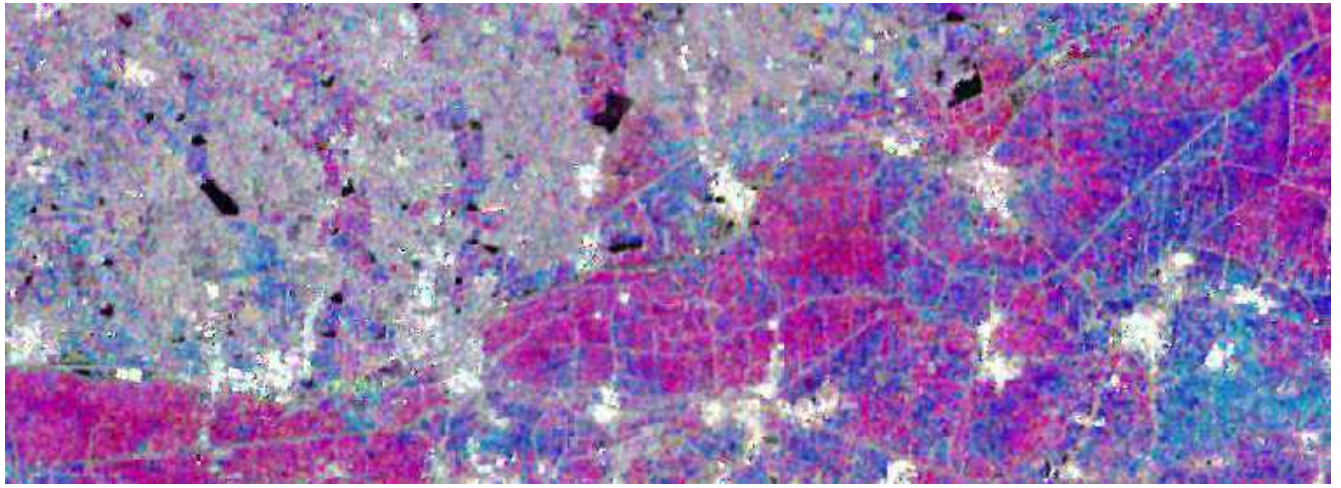
Synthetic aperture Radar (SAR) data

As the dielectric constant for water is at least 10 times that for dry soil, the presence of water in the top few centimeters of bare, unvegetated soil can be detected in radar imagery, particularly apparent at longer wavelengths

- ***RADAR backscatter*** – Responsive to crop growth due to volumetric scattering caused by canopy geometry, roughness and wetness, represents biophysical crop condition

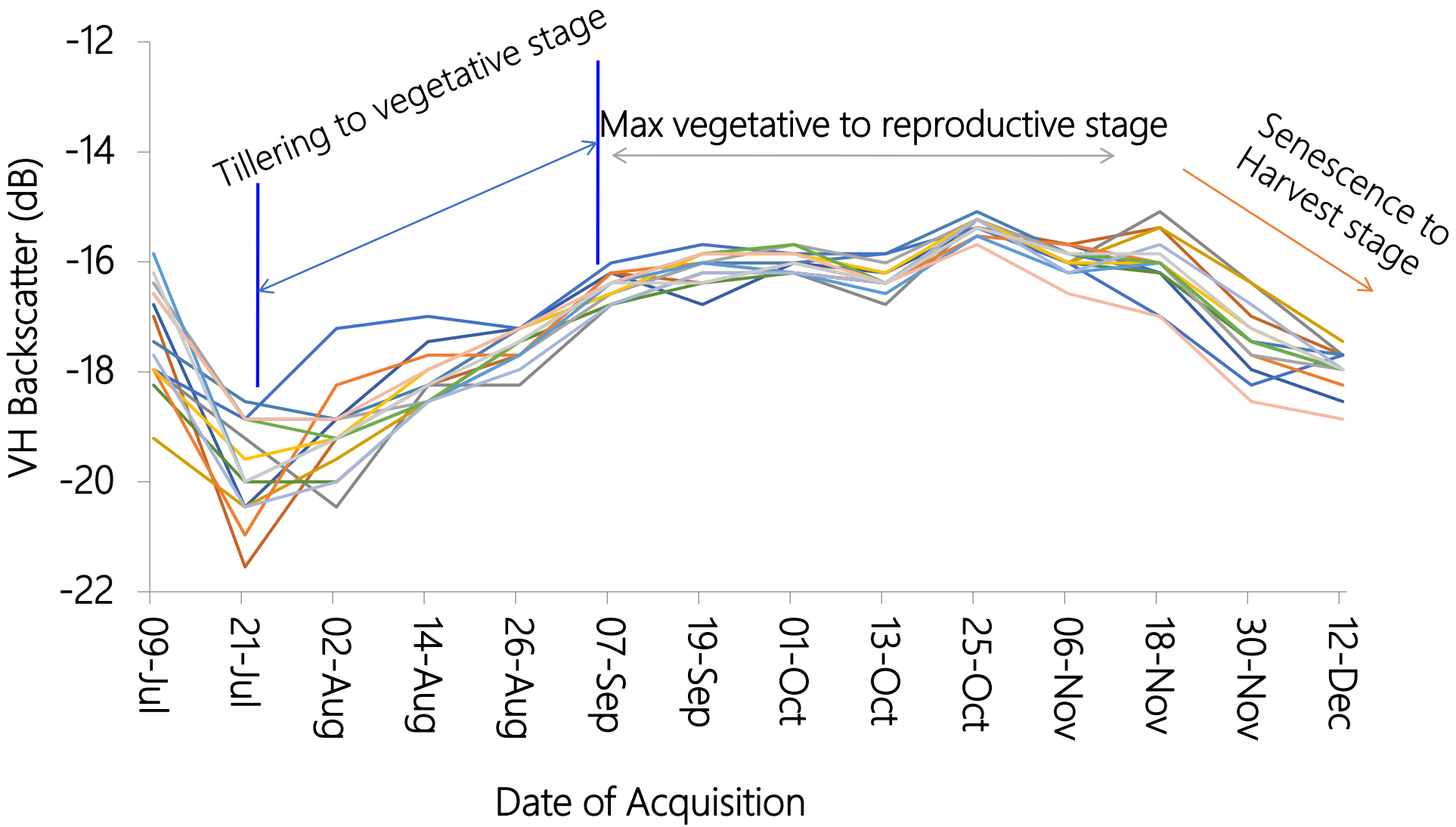
Sentinel derived VH Back scatter profiles of Paddy crop



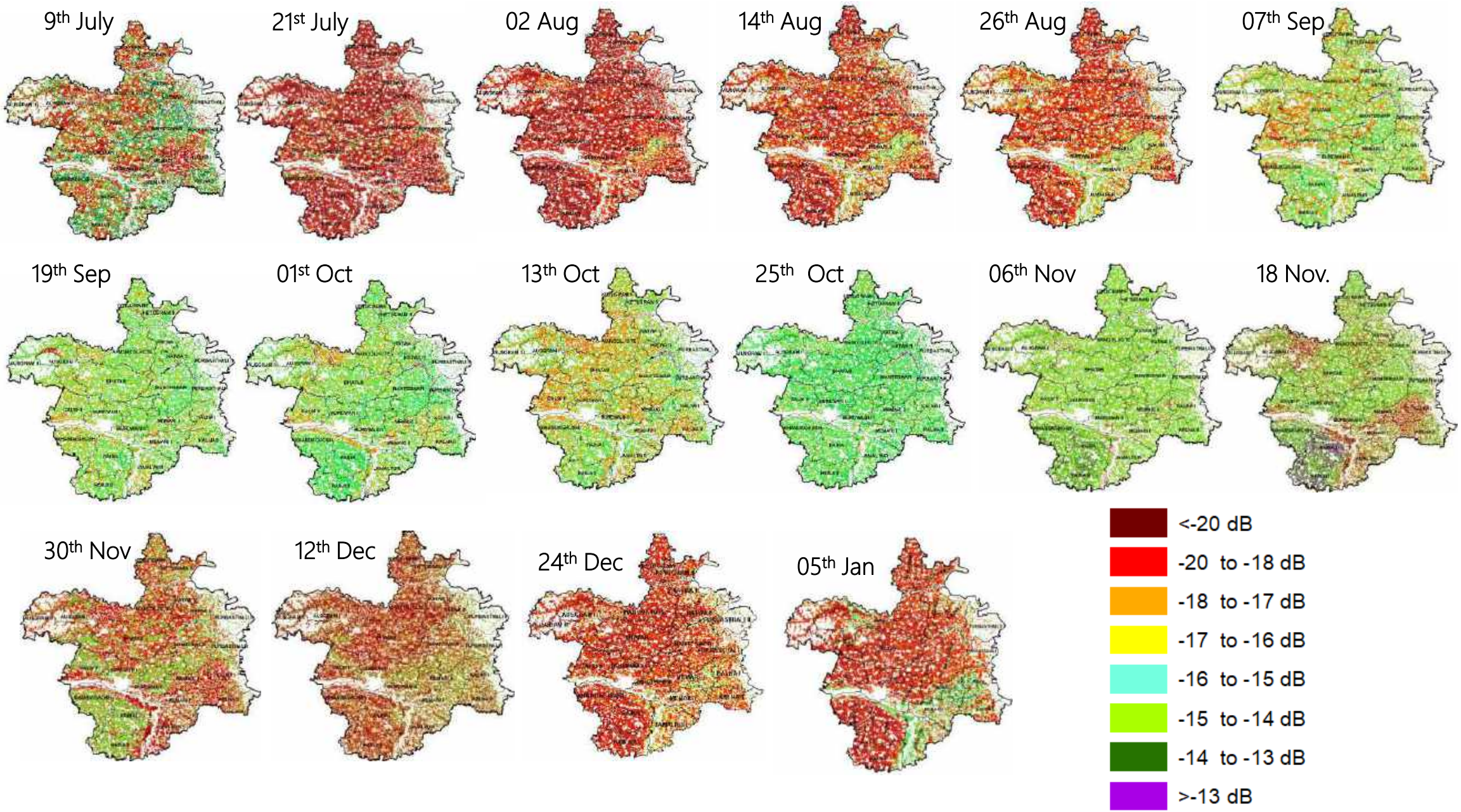


Temporal Backscatter profiles of rice crop

(Improved Repetivity)



Temporal Backscatter-Purba Bardhaman

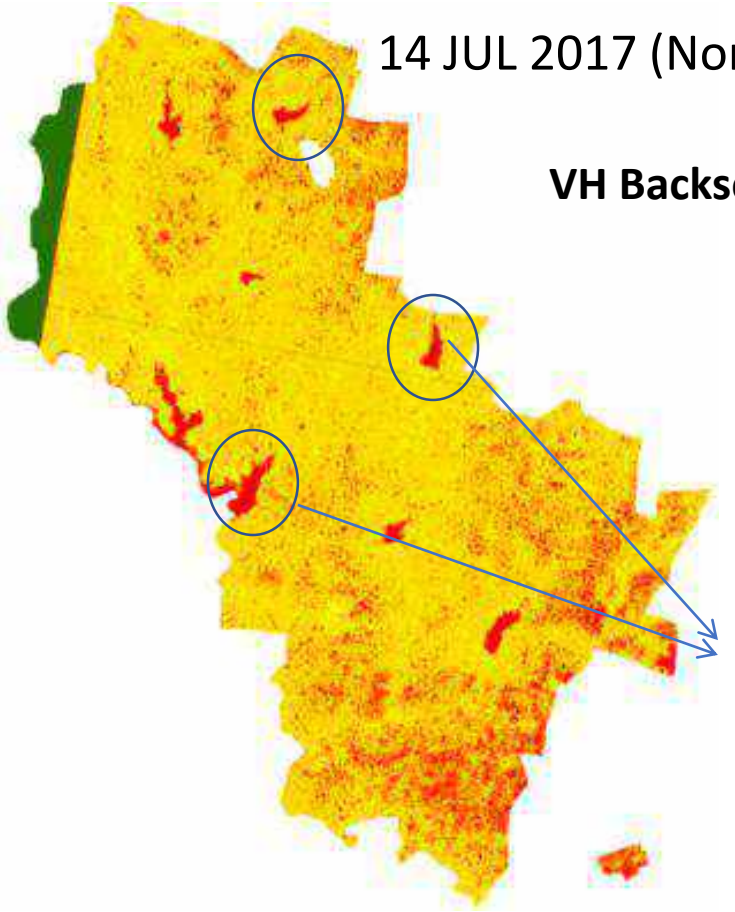


Sown area detection using RADAR data

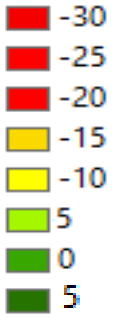
Recent initiatives

14 JUL 2017 (Normal situation)

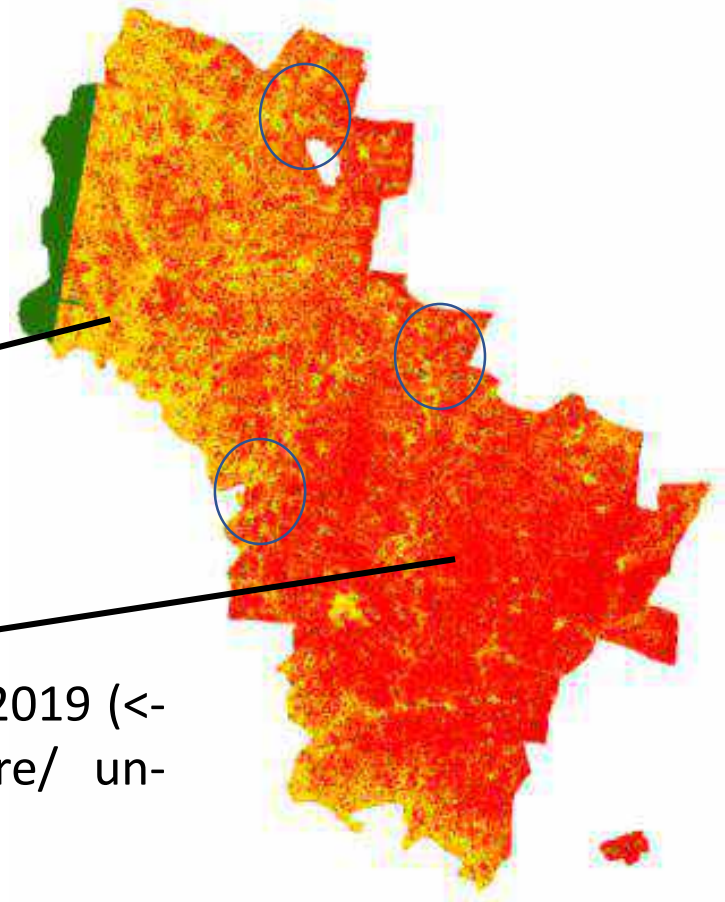
Paranda tehsil, Osmanabad district, Maharashtra



VH Backscatter (dB)



16 JUL 2019 (Drought situation)

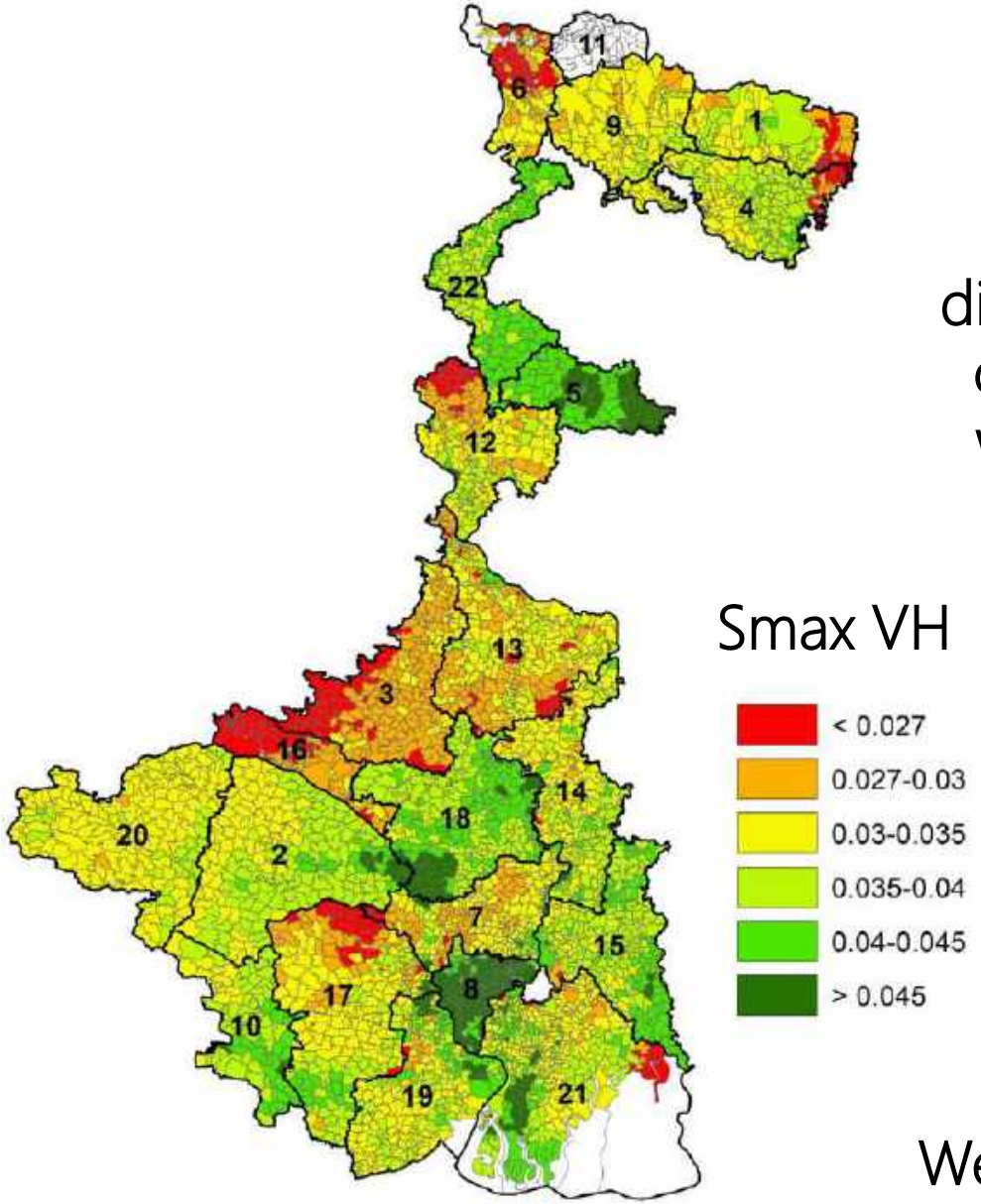


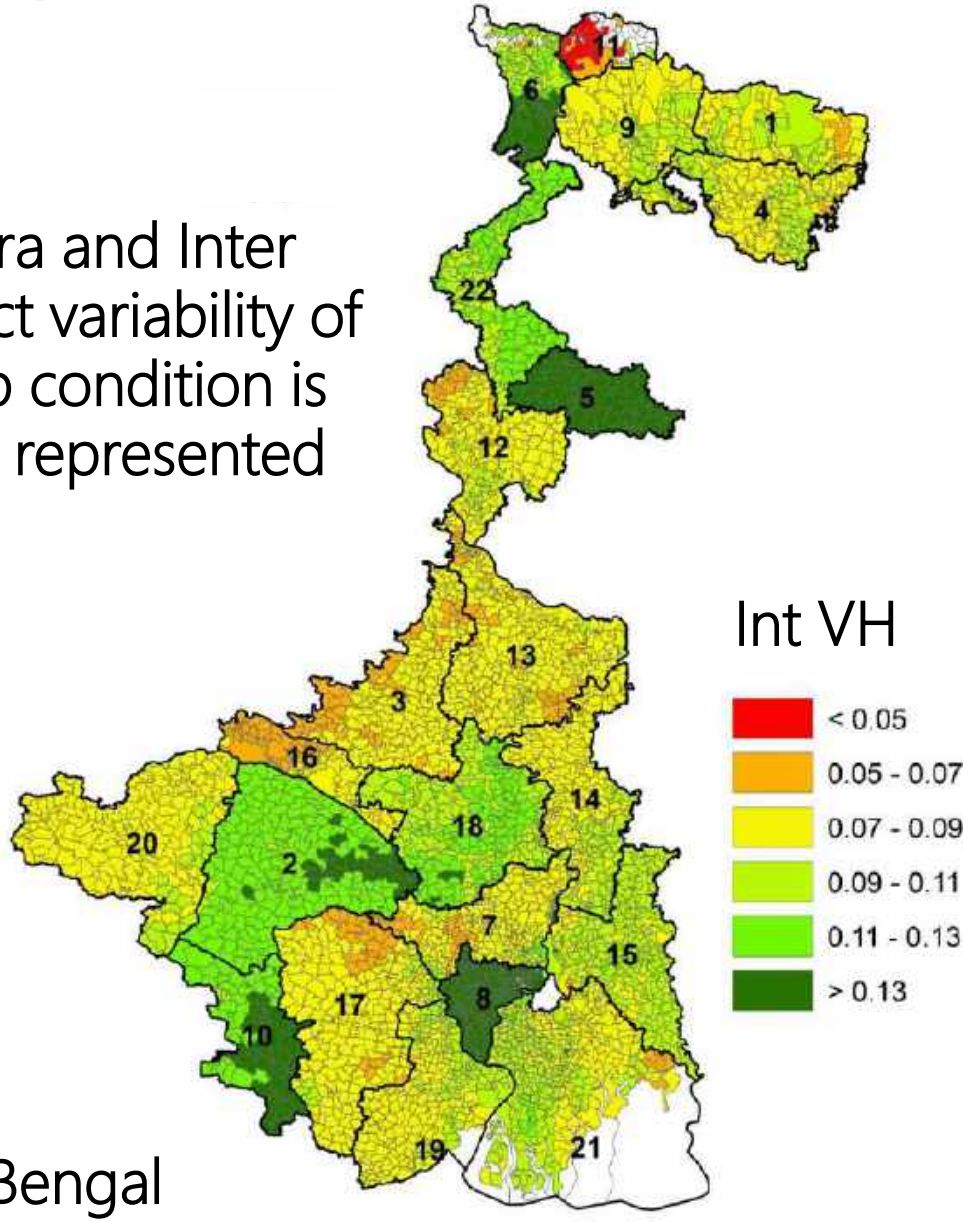
Signatures of water bodies not visible in June/July 2019 due to drought

Crop fields showing very low Backscatter values in 2019 (<-20 dB in VH polarization) due to less moisture/ un-ploughed, unsown fields.

SAR based rice crop health indicators

Intra and Inter district variability of crop condition is well represented





West Bengal

Biophysical Variables

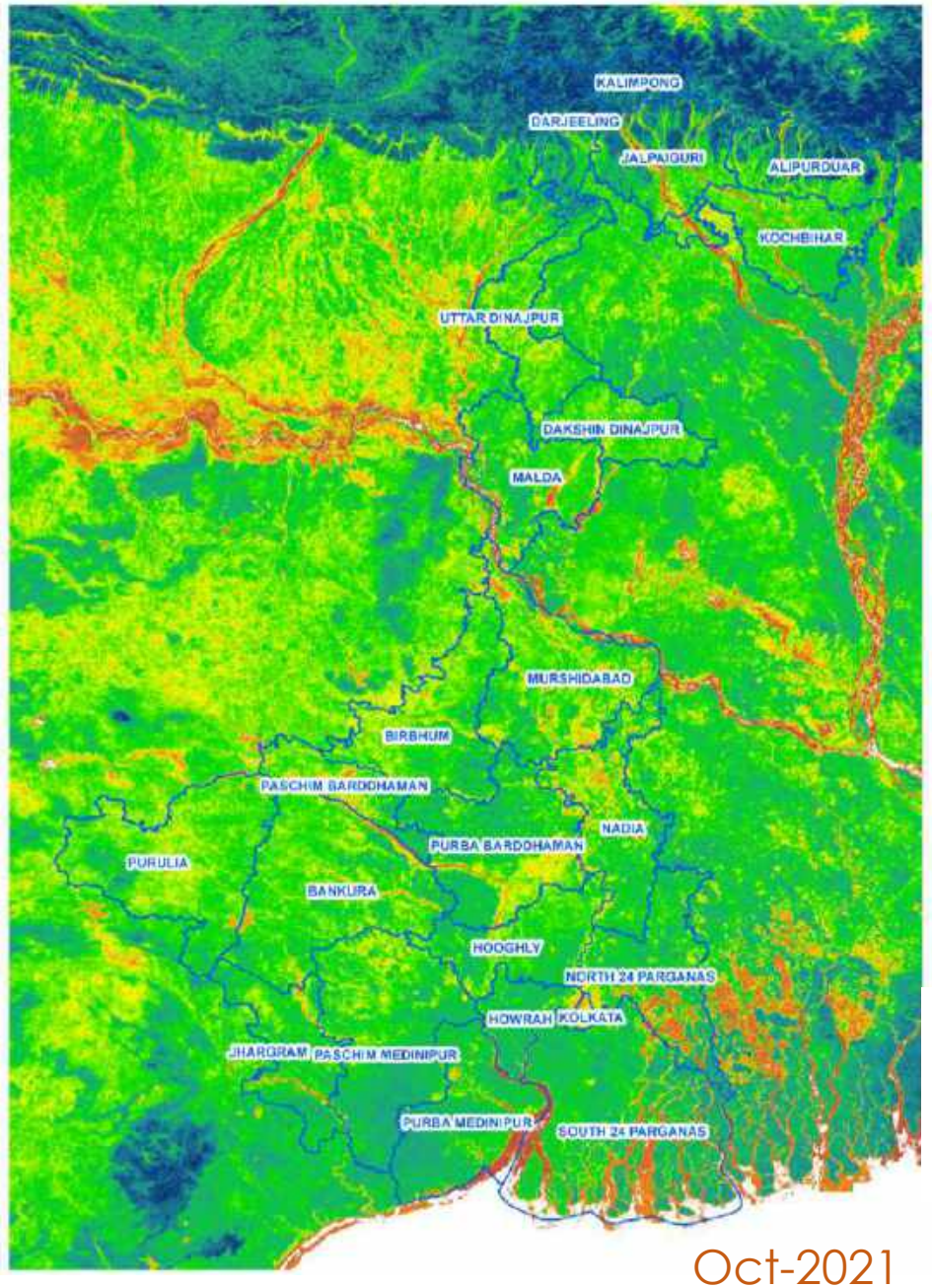
Biophysical variables are plant traits or characteristics of interest, which can be measured on the ground and possibly estimated by remote sensing at various scales depending on the sensor's spatial resolution (at leaf, plant, canopy, and landscape level).

Crop Processes	LAI	FAPAR	Albedo	Chlorophyll	Canopy Water content	Land surface Temperature
Photosynthesis	✓	✓		✓		
Evapotranspiration	✓	✓	✓		✓	
Respiration	✓					
Nitrogen	✓			✓		
Phenology	✓	✓				
Impact of Pests	✓					

Biophysical Variables: FAPAR

- The FAPAR quantifies the fraction of the solar radiation absorbed by live leaves for the photosynthesis activity.
- Represents the green and alive elements of the canopy.
- FAPAR is an integral feature in LUE based Crop yield model
- FAPAR is recognized as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS).
- Proba-V/Sentinel-3 provide a near-real time (10-daily) estimate at 300m and successive updated estimates until a consolidated value is reached after about 2 months

Proba-V/Sentinel-3 derived FAPAR



Oct-2021

Biophysical Variables: FAPAR

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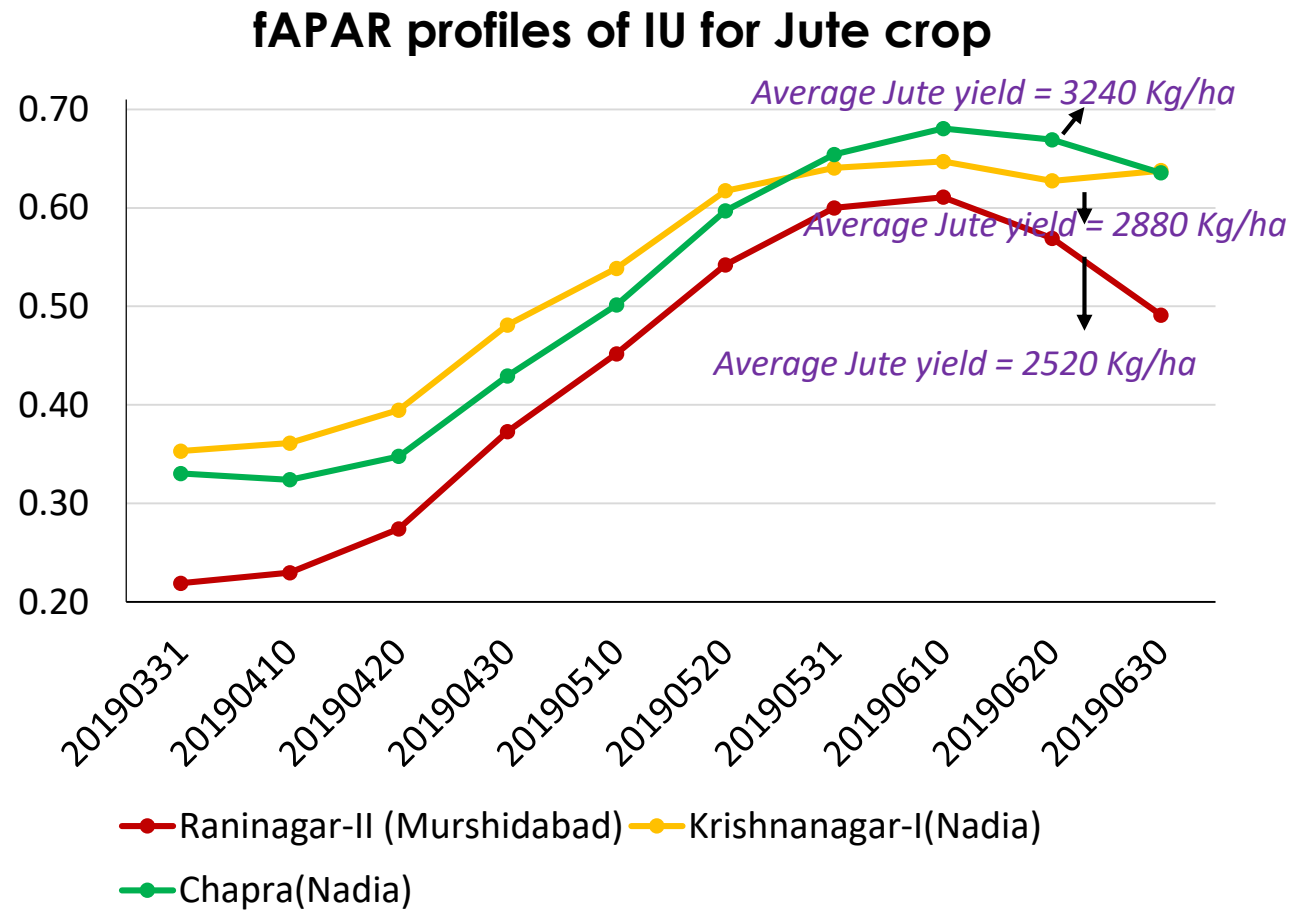
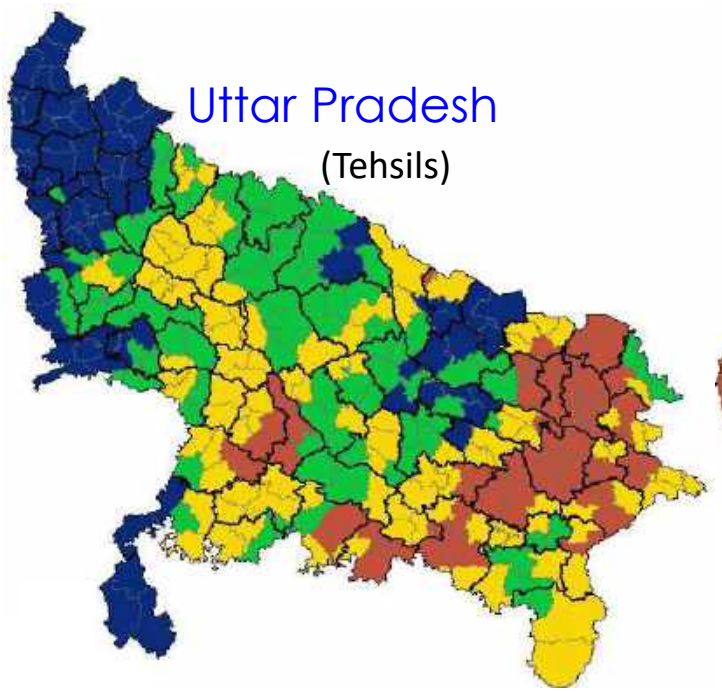
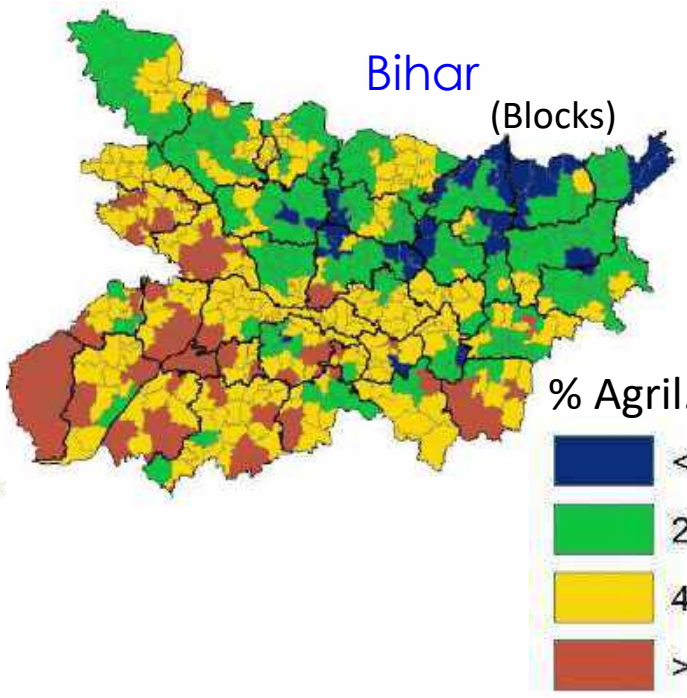
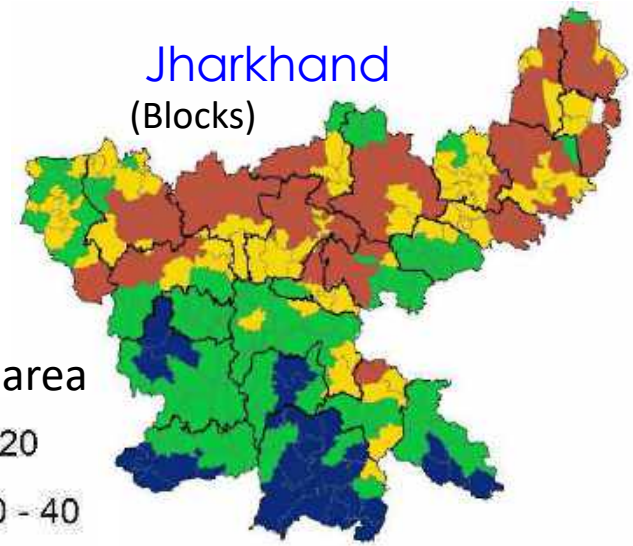
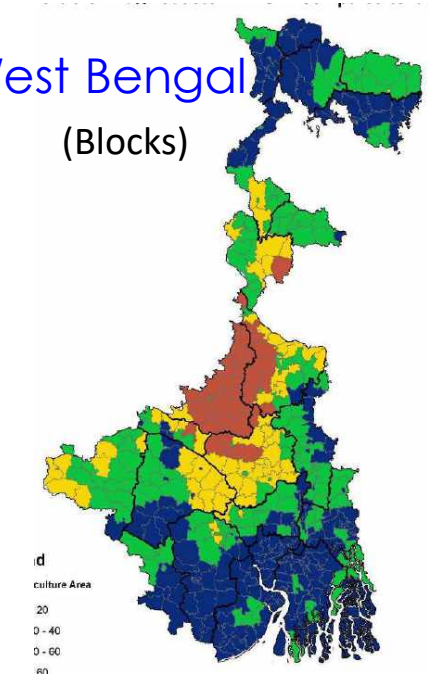


% Agriculture area experiencing drought conditions, July 2022

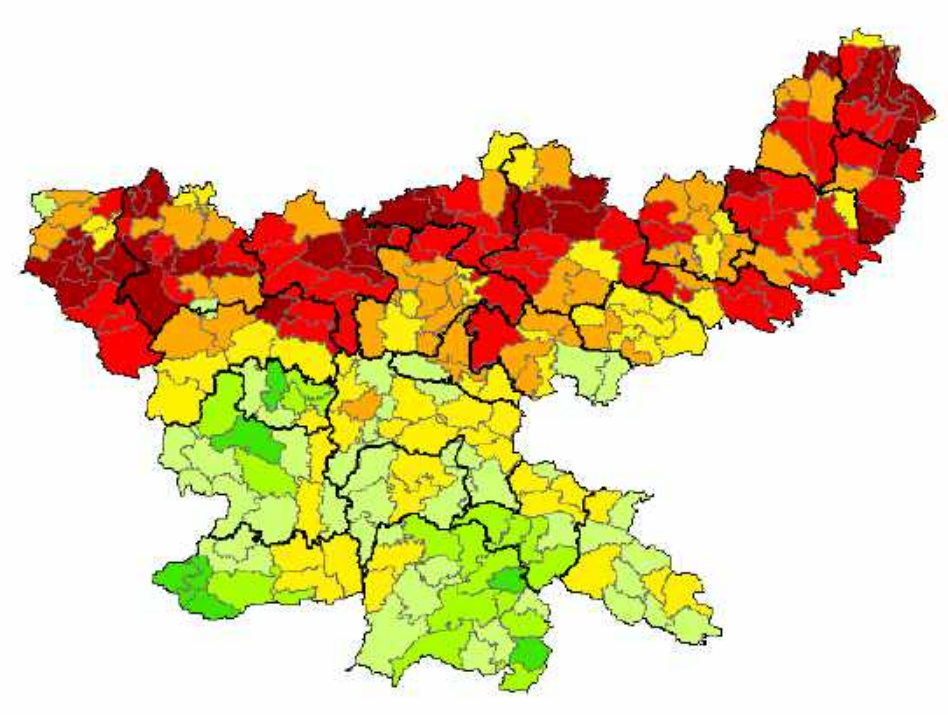








Assessment – Jharkhand state



District	No of Blocks	
	Affected	Likely Affected
GARHWA	12	4
PALAMU	12	5
CHATRA	11	1
DUMKA	7	2
SAHIBGANJ	8	0
GIRIDIH	8	3
HAZARIBAG	6	7
PAKUR	5	1
GODDA	5	4
JAMTARA	4	1
KODERMA	4	1
LATEHAR	3	2
BOKARO	1	4
DEOGHAR	2	6

Drought manual criteria over the above blocks

Mandatory indicator - rainfall

- District wise data of IMD satisfied
- Block wise rf data with State to be checked

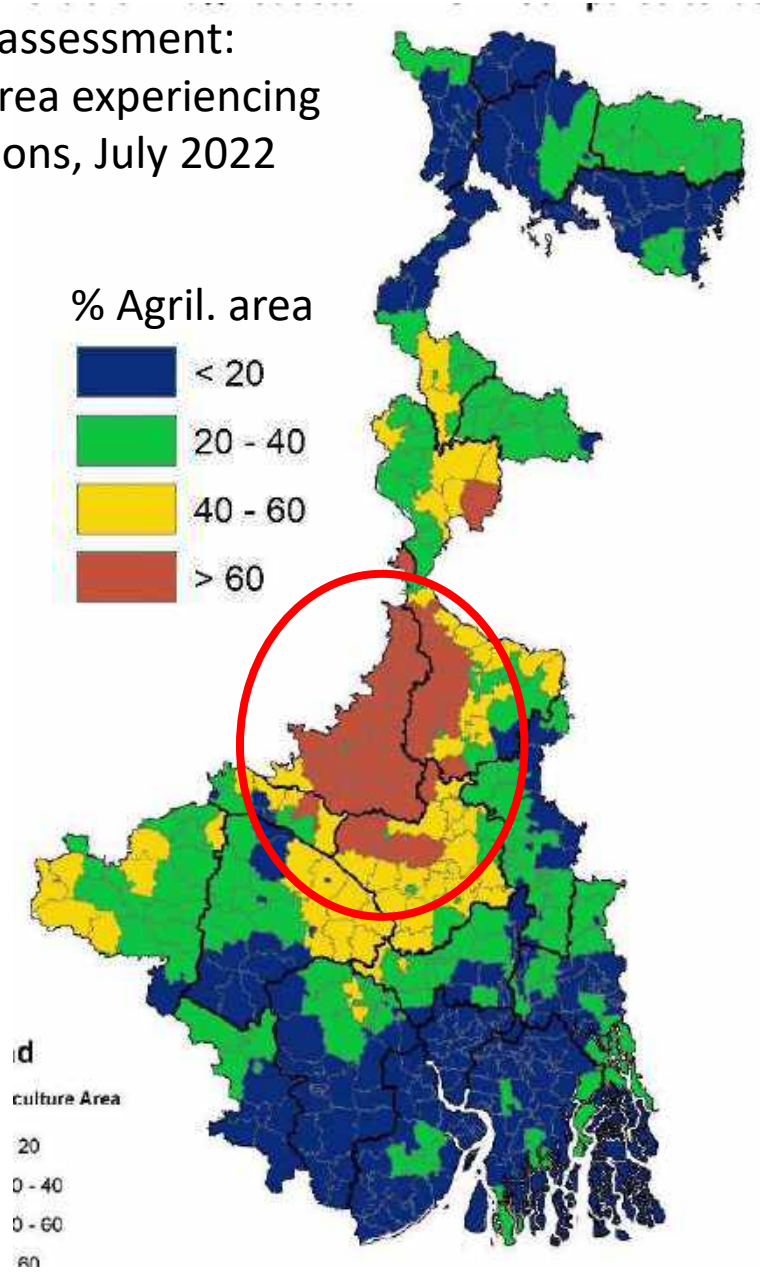
Impact indicators –

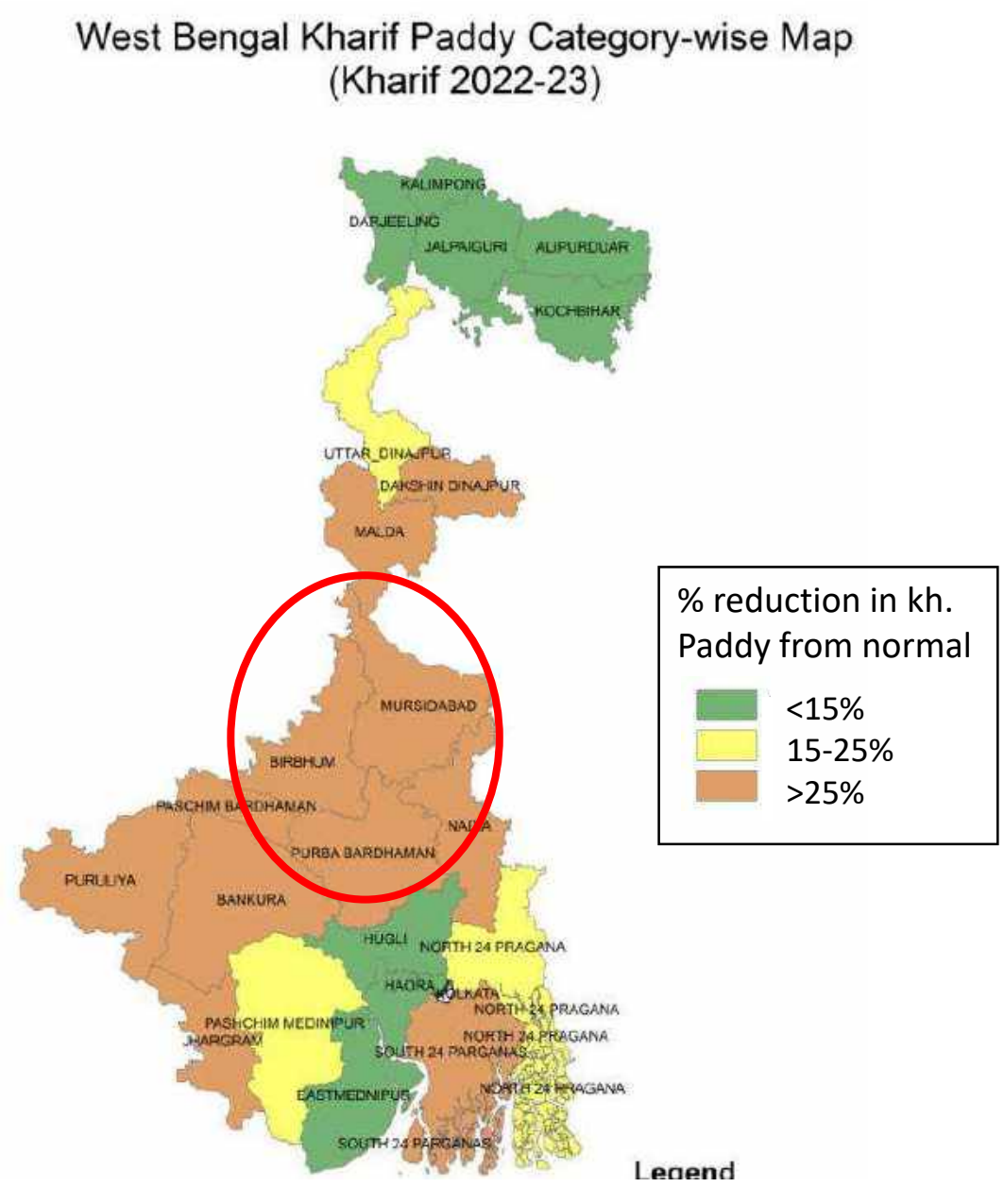
- NDWI/LSWI deviations - satisfied
- root zone soil moisture - satisfied
- Crop sown area data is to be checked
- Ground water data is to be checked
- Hydrological indices data to be checked

- Assessment is carried out using the Kharif Rice crop layer of last year

Comparison with field reports

Satellite based assessment:
% Agriculture area experiencing drought conditions, July 2022



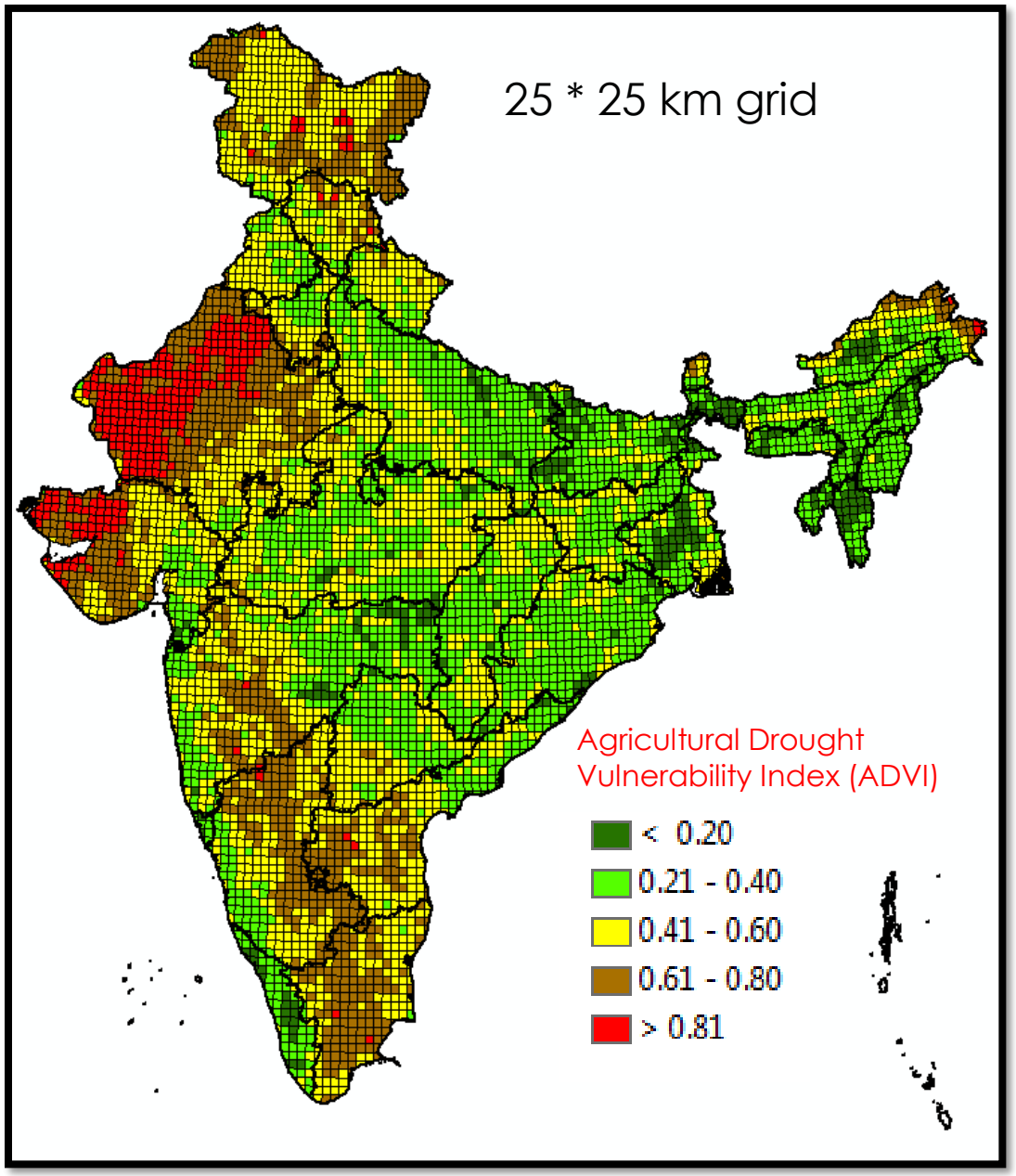


Jute crop condition in Murshidabad district, West Bengal

4th Week July 2022

Agricultural drought vulnerability assessment

- Degree of susceptibility of an area to agricultural drought due to variable exposure and coping abilities
- Vulnerability map helps visualize the hazard and act before potential damage
- Vulnerability information is crucial for long term drought management
- Drought prone area classification needs revision
- No agriculture component in the existing drought prone area classification
- A quantitative and multi-dimensional approach for measuring crop-generic agricultural drought vulnerability status at sub-district level



Agricultural drought vulnerability assessment

Agricultural Drought Vulnerability Index (ADVI)

ADVI = EI+SI-AI

Component wise analysis

Exposure

Sensitivity

Adaptive Capacity

- Identification of factors
- Collection of data
- Analysis of data
- Construction of composite Index

Exposure Index (EI)

Sensitivity Index (SI)

Adaptive Capacity Index (AI)

A. Exposure component

1. Total season rainfall
2. Sowing period rainfall
3. Total season rainy days
4. Sowing period rainy days

B. Sensitivity component

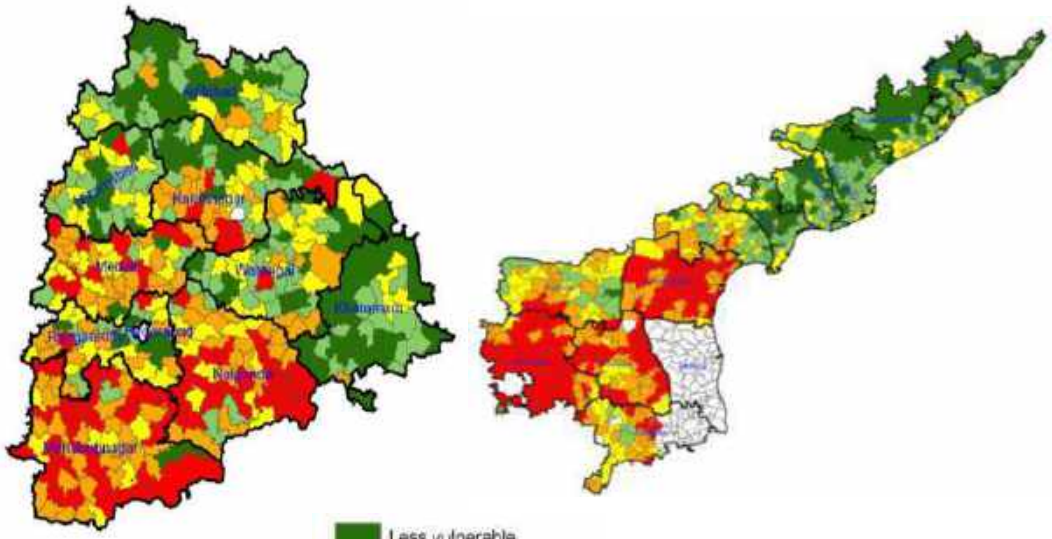
1. Season's Integrated NDVI
2. Season's Maximum NDVI
3. August NDVI
4. Cropping pattern

C. Adaptive capacity component

1. Soil
2. Irrigation support
3. Land holdings

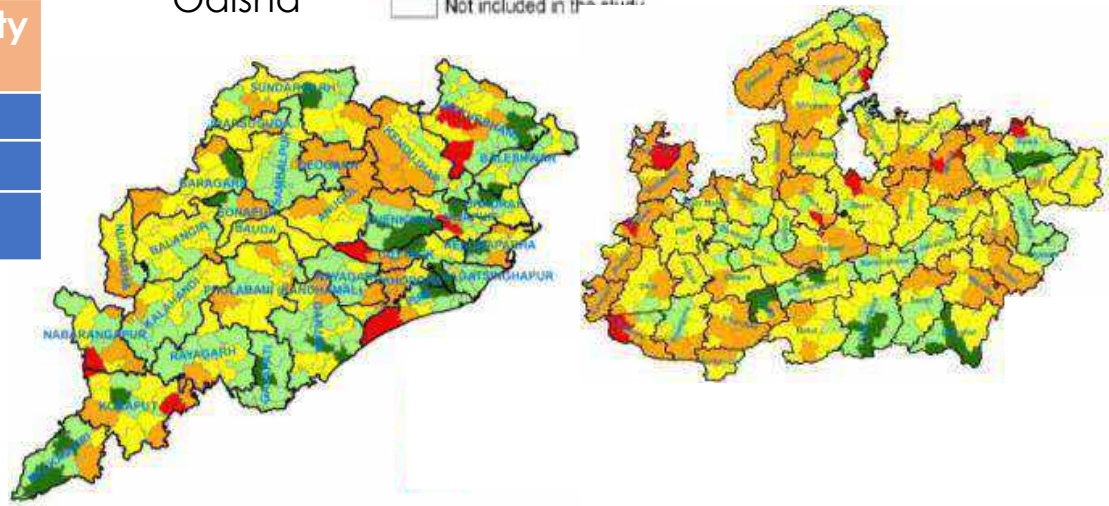
Telangana

Andhra Pradesh



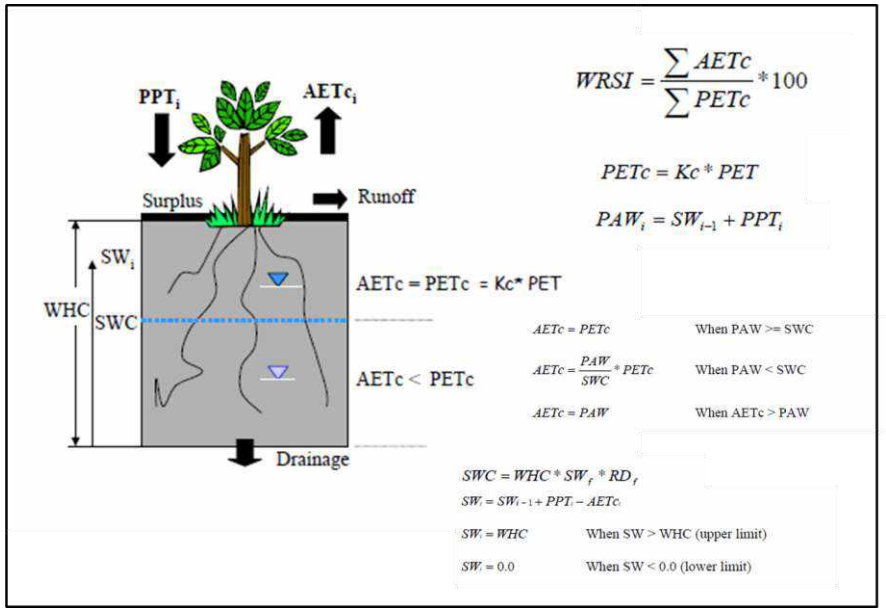
Odisha

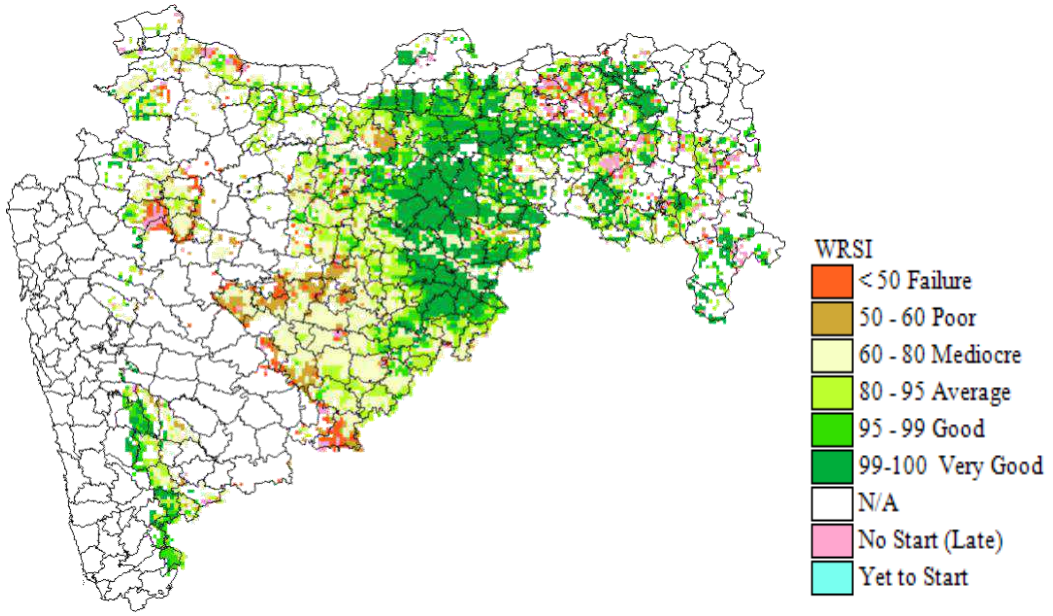
Madhya Pradesh



Crop specific drought assessment: GeoWRSI

- Crop specific water balance
- Indicator of crop performance based on the availability of water
- Tool developed by FAO: *GeoWRSI*
- Useful for crop specific drought monitoring, early warning
- WRSI can be related to crop production and yield gap analysis for rained areas
- Operational in many countries



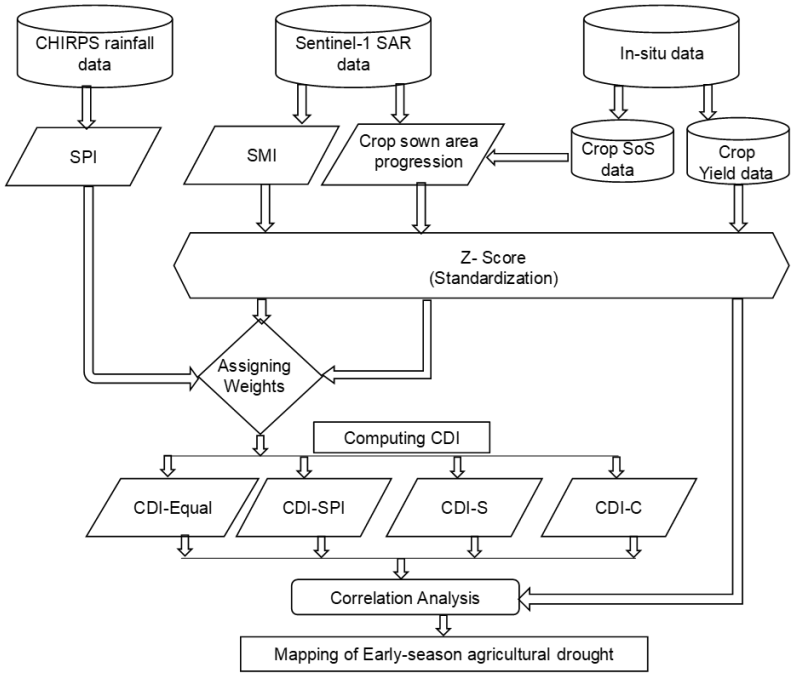


Maharshtra (cotton)
21-30 Sep 2018

Monitoring Early season Drought: Composite Drought Indicator

nrsc

Methodology

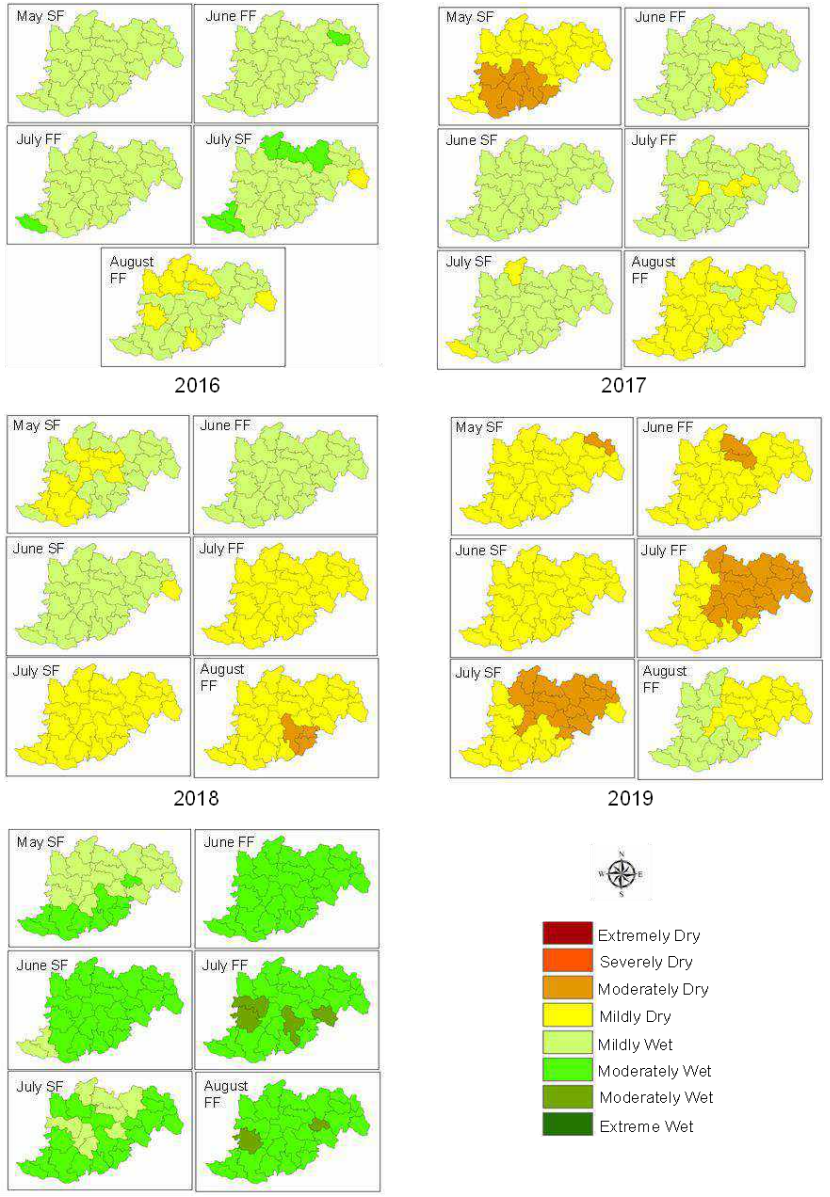


$$CDI = wt_1 * SPI + wt_2 * SMI_a + wt_3 * Area_a$$

Weight sets label	SPI	SMI_a	$Area_a$
CDI-Equal	1/3	1/3	1/3
CDI-SPI	2/4	1/4	1/4
CDI-S	1/4	2/4	1/4
CDI-C	1/4	1/4	2/4

CDI Values	Drought Category
2 or more	Extremely Wet
1.5 to 1.99	Severely Wet
1.0 to 1.49	Moderately Wet
0 to 0.99	Mildly Wet
0 to -0.99	Mildly Dry
-1.0 to -1.49	Moderately Dry
-1.50 to -1.99	Severely Dry
-2 or less	Extremely Dry

Spatio-Temporal variation of Combined Drought Index Maps



Satellite based Evaporative Flux Estimation over indian region

nrsc

- Estimation of daily evaporative fluxes for Indian region
- Creation of long term database
- Web based ET monitoring system

GRID Resolution : 5.5 x 5.5 Km² & 0.75 x 0.75 Km²

Temporal resolution : Daily

Latency : 3 days

Satellite Based Input parameters

- NDVI, LST, Albedo, Cloud mask, Insolation, Outgoing LW radiation

Weather Parameters

- Air and dew point temperature

Energy Balance Approach

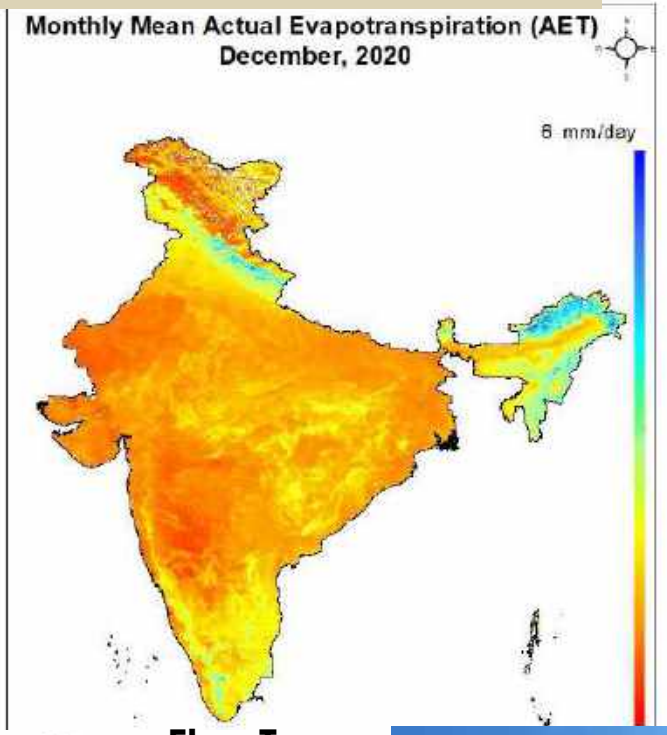
$$R_n = \lambda E + H + G$$

Priestley Taylor Alorithm

$$\lambda E = \alpha.(R_n - G).\left(\frac{\Delta}{\Delta + \gamma}\right)$$

Need for Evapotranspiration

- ✓ ET is the major component of Hydrological cycle
- ✓ ET needs to be monitored in light of evolving climate change scenario
- ✓ Water accounting procedures, Input for water balance models
- ✓ Performance evaluation of Irrigation projects
- ✓ Water productivity studies & Drought studies



Flux Tower Network

Current activities

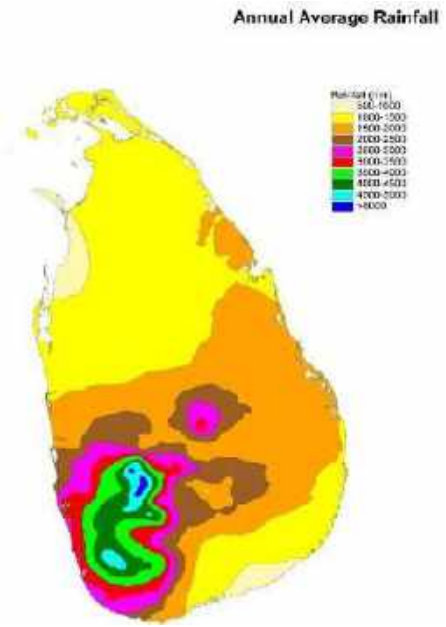
- Validation and ensemble ET product generation
- Application of ET for Irrigation management and drought assessment

WRG, RSA, NRSC

Drought Monitoring for SAARC countries: Srilanka

- 80% of population lives in rural area
- Agriculture is one of the most important sectors for the Sri Lankan economy
- Agriculture makes approximately 13% of Sri Lanka GDP
- Major crops are Rice, Tea, Rubber, Cinnamon, Coconut, Tobacco, Fish, Sugar, Spices and Minor Crops
- Sri Lanka has the benefit of two monsoon seasons. The two seasons are locally called 'Maha' season from September to March and 'Yala' season from May to end of August respectively
- Annual rainfall recordings ranging from 750 mm to over 5500 mm

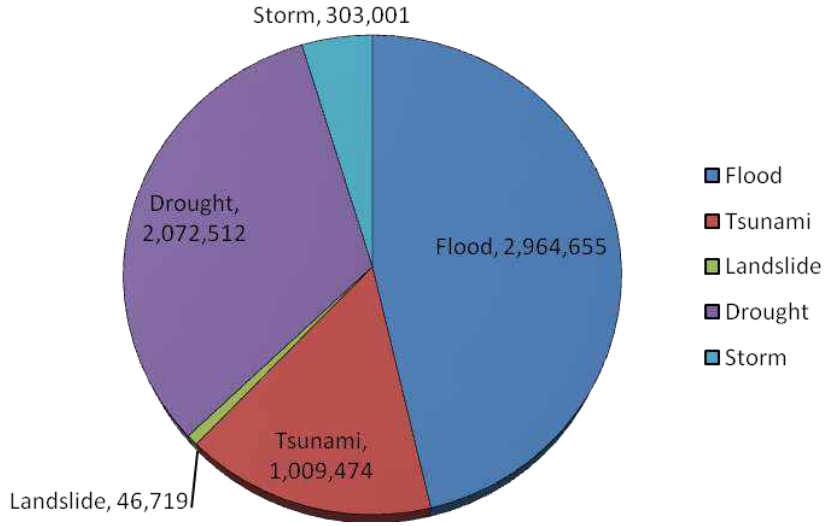
Annual Average Rainfall



http://www.saarc-sadkn.org/countries/srilanka/hazard_profile.aspx

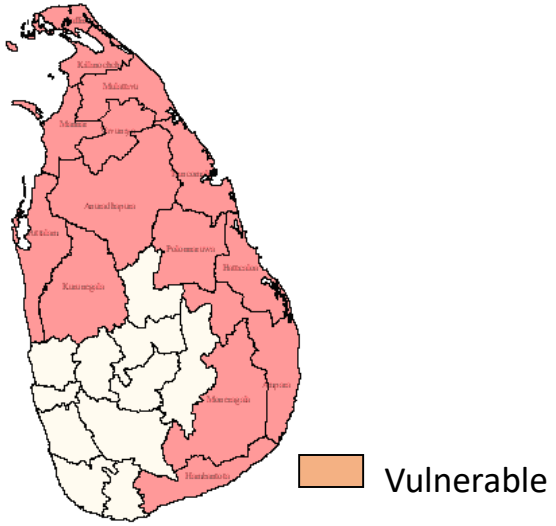
Disaster Profile of Sri Lanka

People affected by different disasters in Sri Lanka (1974-2004)



http://www.princepcapital.com/sri-lanka/agribusiness/

Districts Vulnerable to Drought



Workflow of Drought Monitoring system: Srilanka

1	Data Ingest Module	• Sensor data retrieval for AWiFS, MODIS, NOAA etc. • Panoramic correction, calibration
2	Pre Processing	• ELP correction • Radiance Products generation, Cloud Removal
3	Geometric Correction	• Automated GCP collection • Rectification
4	Indices Generation	• Generate NDVI, NDWI, radiance and Color coded products
5	Ancillary Data Preparation	• Automated Rainfall, AET and MODIS data downloads • Rectification and preprocessing, Model inputs preparation
6	Soil Water Balance Model	• Generate RunOff, PET, Upper and Lower Soil Moisture • SMI, MAI & AFCS products, Time Composites
7	SASI	• Generate SASI products from MODIS data • Generate AFCS from cropping area, soil types and Area Sown.
8	Statistics	• Automated statistics extraction from indices, ROI based sampling at State, District and Mandal scales
9	Reports	• Generate Anomalies, Prepare Graphs and Reports as per defined templates
10	Help	• Detailed Manuals for application software usage ,work flow and methodologies.`

First Training Programme at Hyderabad, India

- the first training program was held at National Remote Sensing Centre , Hyderabad, Indian between 28 July to 01 August 2014
- 10 officers of Sri Lankan Government, representing various line departments participated

- Highlights of training content included
  - Introduction to Satellite Bhuvan Geoportal, QGIS & hands on
  - Agricultural Drought Assessment and Monitoring - Concepts & work flow
  - Processing of Satellite data and its hands on
  - Data Processing and Analysis for Agricultural Drought Assessment & hand on
  - Field Data Collection and Uploading into Bhuvan
  - Training on DMS-SL software and lab sessions
  - Other related topics like the water storage assessment, rice crop inventory, Land use land cover mapping etc
  - The participants were asked to present about their country and their project work
  - Feed back session were scheduled a the end of each day to dynamically modify the contents of the training as per their requirements

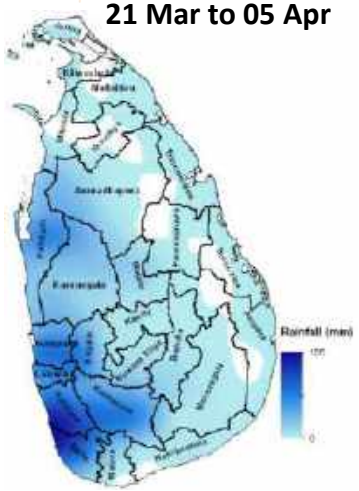
Second Training Programme at Colombo-Sri Lanka

- the second training program was held at ACCIMT, Colombo, Sri Lanka between 24 to 27 February 2015
- The second training programme gave more emphasis on **hand on training** on DMS-SL software and drought assessment
- 25 officers of Sri Lankan Government, representing various line departments participated
- DMS-SL software CD and Manual was released during the training programme
- Highlights of training content included
  - -Demonstration of DMS-SL Software
  - -Hands-on exercise on DMS-LS Software
  - -Demonstration of Bhuvan Data Viewer and Field Data Collection-Mobile application
  - -Trial run of the entire cycle of drought assessment using DMS-SL by the participants

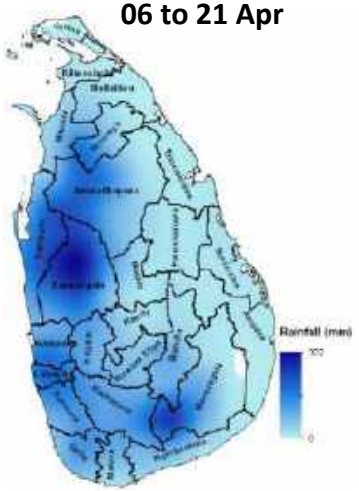
TRMM Rainfall Scenario of Sri Lanka Yala 2014

Weekly Rainfall during June 2014

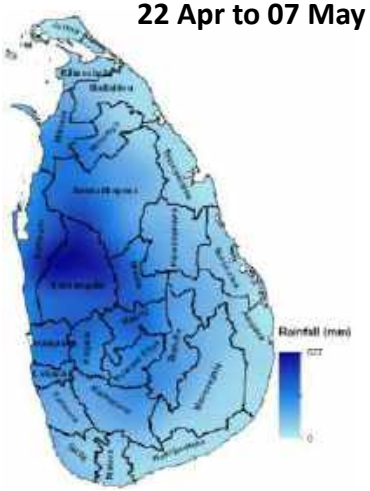
21 Mar to 05 Apr



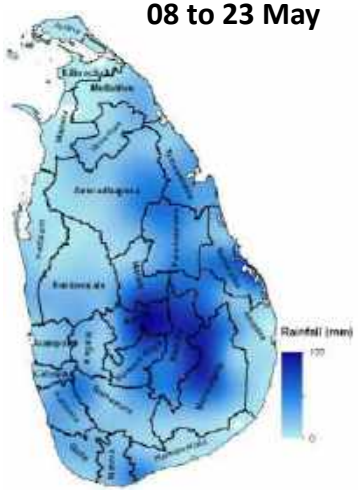
06 to 21 Apr



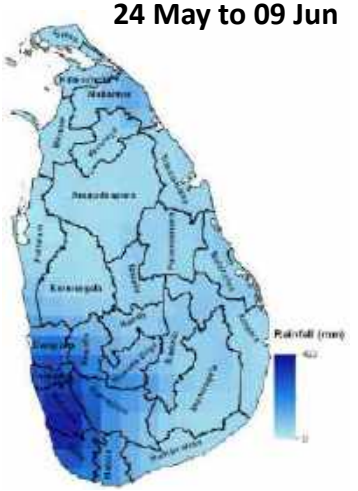
22 Apr to 07 May



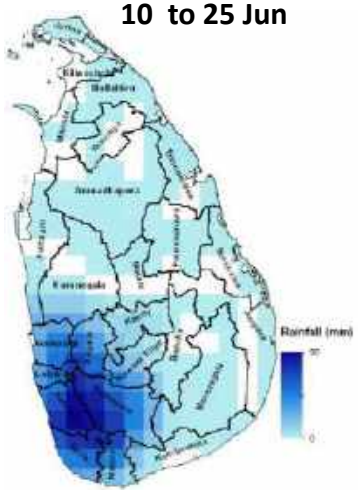
08 to 23 May



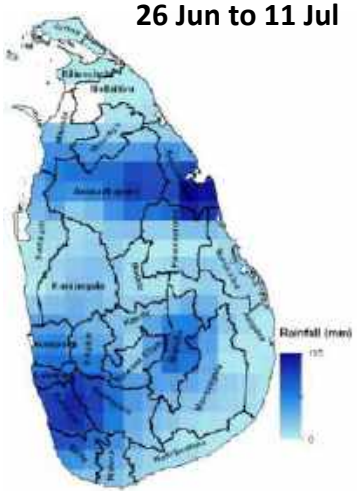
24 May to 09 Jun



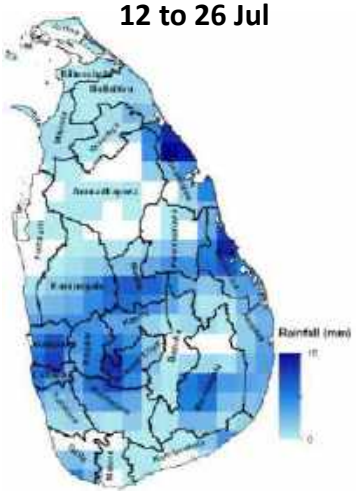
10 to 25 Jun



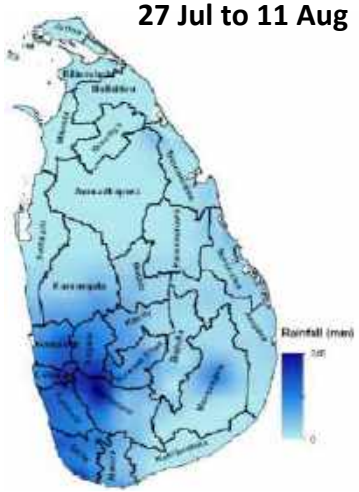
26 Jun to 11 Jul



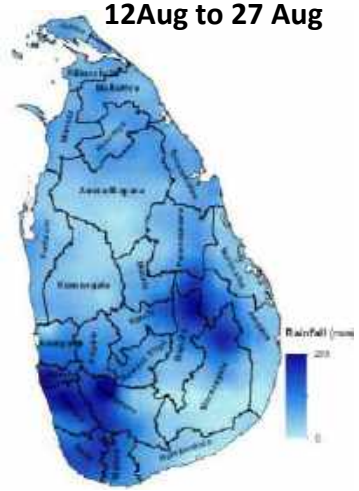
12 to 26 Jul



27 Jul to 11 Aug

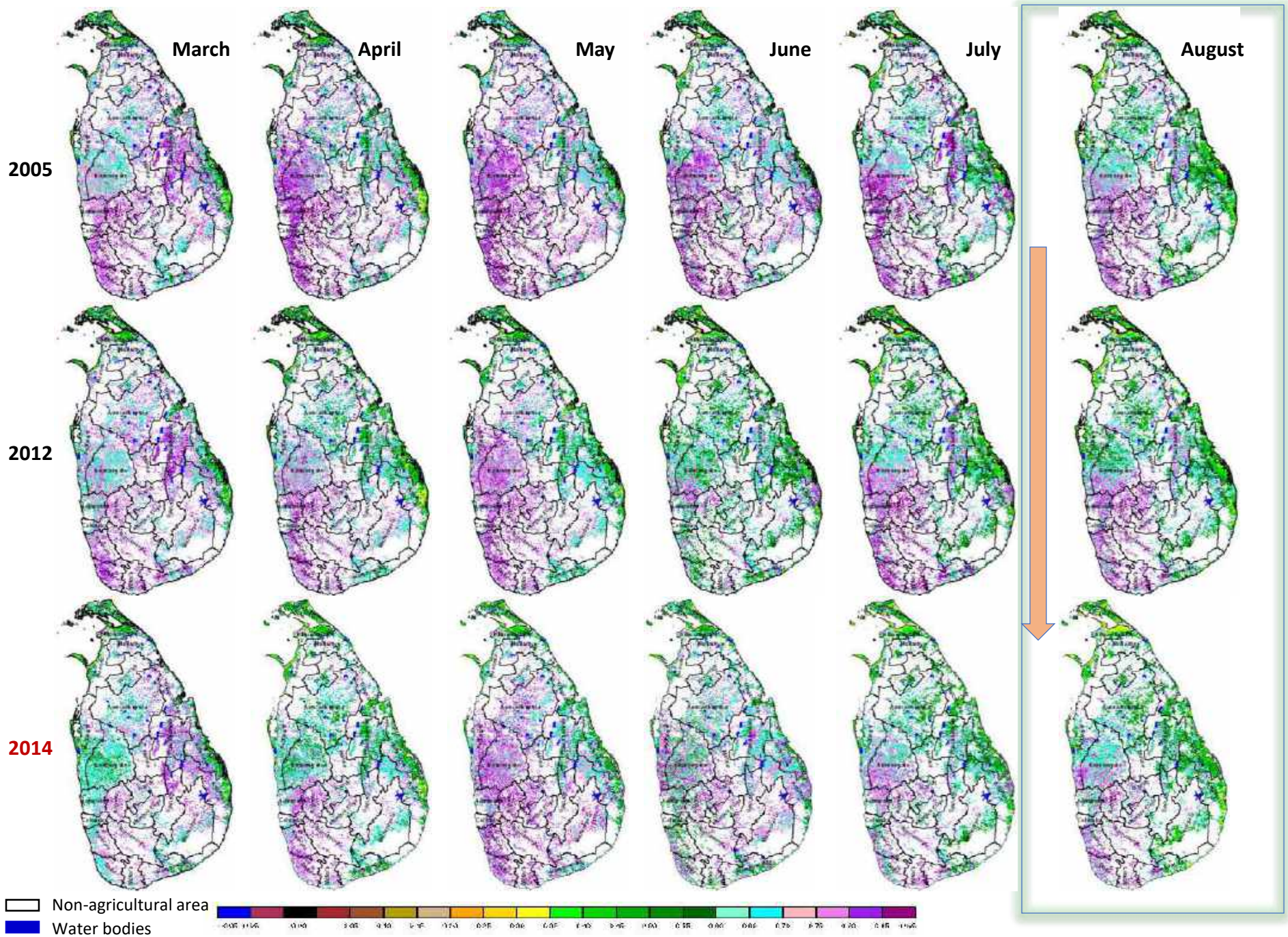


12Aug to 27 Aug

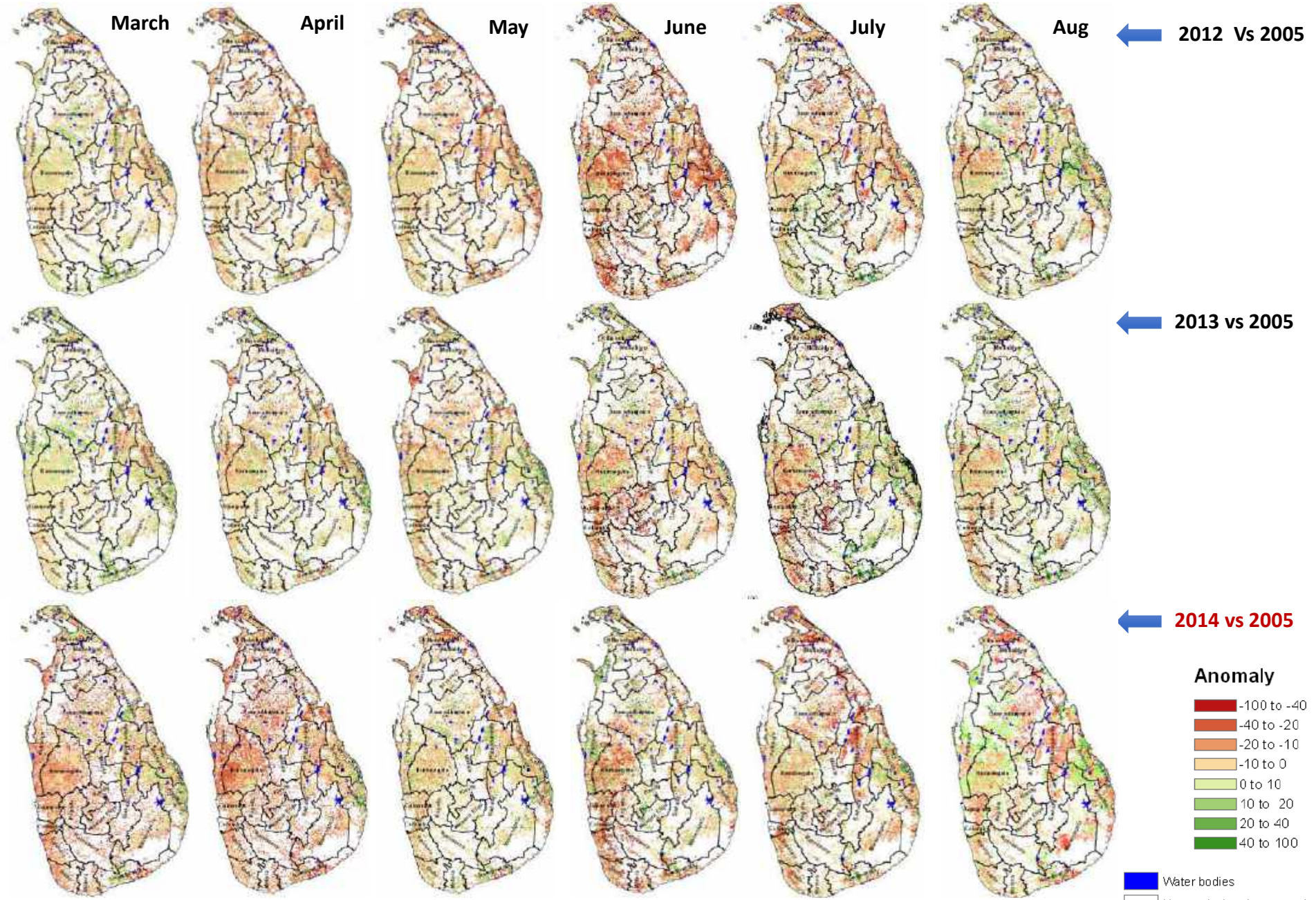


It can be observed that the south western parts of Sri Lanka has received heavy rainfall during Yala 2014. The country received maximum rainfall during April, May and first half of June. Only in three fortnights during April and May the northern part of the country received good rainfall. In the rest of the season only the south western part received good rainfall. The districts of Gampaha Colombo, Kegalle, Kalutara, Ratnapura, Galle and Matara received very heavy rainfall.

NDVI OF SRI LANKA DURING 2005, 2012 & 2014



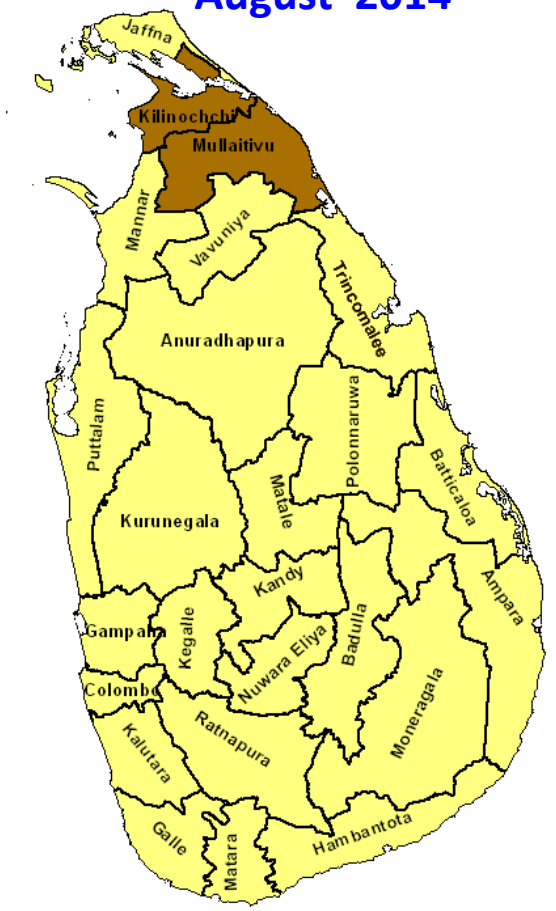
NDVI Anomaly (%) during March, to Aug 1FN relative to 2005 (Normal Year)



NDVI ANOMALY BETWEEN 2014 VS 2005 (Normal Year)

S.No.	Districts	% deviation upto						Drought Condition
		Mar	Apr	May	Jun	Jul	Aug	
1	Ampara	1	0	0	7	-5	-1	Normal
2	Anuradhapura	-4	-6	1	-3	-7	-3	Normal
3	Badulla	0	-3	0	3	-3	-5	Normal
4	Batticaloa	-1	-2	-3	10	-7	4	Normal
5	Colombo	-12	-9	-4	0	1	-4	Normal
6	Galle	-6	-3	-4	5	2	-7	Normal
7	Gampaha	-11	-7	-6	3	20	-9	Normal
8	Hambantota	-4	-11	2	1	5	-3	Normal
9	Jaffna	2	-6	-13	6	0	-8	Normal
10	Kalutara	-8	-5	-4	7	6	-5	Normal
11	Kandy	-4	-4	0	2	13	-7	Normal
12	Kegalle	-6	-3	-1	-2	15	-3	Normal
13	Kilinochchi	1	-2	-15	0	-6	-15	Mild
14	Kurunegala	-11	-13	-3	1	9	1	Normal
15	Mannar	-5	-13	-11	7	22	1	Normal
16	Matale	-2	0	-1	1	1	-2	Normal
17	Matara	-3	-3	2	6	2	-3	Normal
18	Moneragala	-3	-7	1	0	-5	-6	Normal
19	Mullaitivu	-6	-8	-12	-7	-12	-9	Mild
20	Nuwara Eliya	-4	-2	2	-5	4	-3	Normal
21	Polonnaruwa	-5	-6	0	5	-6	-12	Normal
22	Puttalam	-9	-11	-3	4	10	3	Normal
23	Ratnapura	-2	-4	-1	2	2	-2	Normal
24	Trincomalee	-1	-8	-10	-1	-12	-6	Normal
25	Vavuniya	-4	-4	-4	-5	-2	-1	Normal

Observations upto August 2014



NDVI Anomaly

- Normal (+10% to -10%)
- Mild negative anomaly (-11% to -20%)
- Moderate negative anomaly (-21% to -40%)

Note:

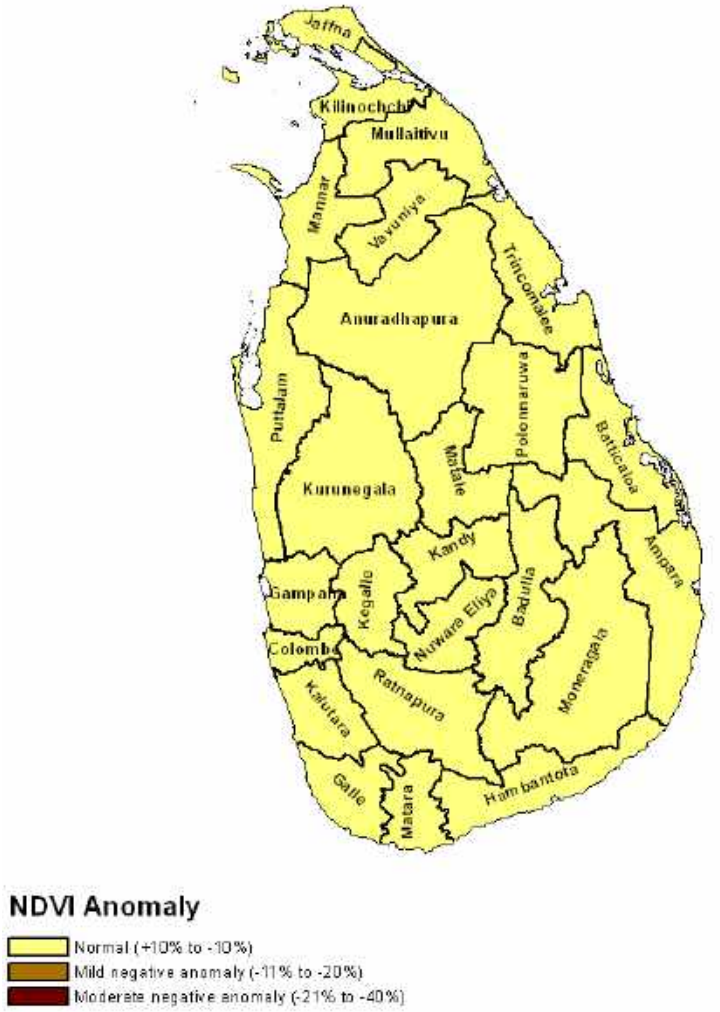
1. The district level ndvi anomaly is indicated, which needs to be corroborated with: a) crop calendar and b) ground information on irrigation, soil type etc.
2. On analyzing the NDVI profile and its deviation through out the *Yala* season it was observed that the districts of Kilinochchi and Mullaitivu have mild drought

NDVI ANOMALY BETWEEN 2014-15 VS 2005-06 (Normal Year)

Monthly NDVI Anomaly 2014-15 vs 2005-06

S.No.	Districts	% Deviation (2014-15 vs 2005-06)					Drought Condition
		Oct	Nov	Dec	Jan	Feb	
1	Ampara	8	1	-2	-1	-2	Normal
2	Anuradhapura	10	-6	-4	2	-6	Normal
3	Badulla	2	1	3	2	0	Normal
4	Batticaloa	-1	-8	-5	0	-3	Normal
5	Colombo	4	3	-2	-5	-3	Normal
6	Galle	4	8	-2	-4	-2	Normal
7	Gampaha	5	1	-1	-5	-5	Normal
8	Hambantota	1	-4	0	-2	-1	Normal
9	Jaffna	0	-1	-1	9	-13	Normal
10	Kalutara	3	4	-3	-4	-4	Normal
11	Kandy	5	5	0	-1	-1	Normal
12	Kegalle	9	2	-1	-4	-1	Normal
13	Kilinochchi	8	-2	0	12	-12	Normal
14	Kurunegala	17	5	2	-6	-6	Normal
15	Mannar	20	6	-15	-6	-11	Normal
16	Matale	5	1	-1	4	-4	Normal
17	Matara	3	6	0	-2	-5	Normal
18	Moneragala	2	0	3	0	-1	Normal
19	Mullaitivu	5	-2	-2	7	-5	Normal
20	Nuwara Eliya	-3	2	4	3	2	Normal
21	Polonnaruwa	11	-1	-15	-5	3	Normal
22	Puttalam	11	2	3	-5	-7	Normal
23	Ratnapura	6	1	-1	-3	-1	Normal
24	Trincomalee	6	-1	-7	-5	-7	Normal
25	Vavuniya	10	-2	-7	3	0	Normal

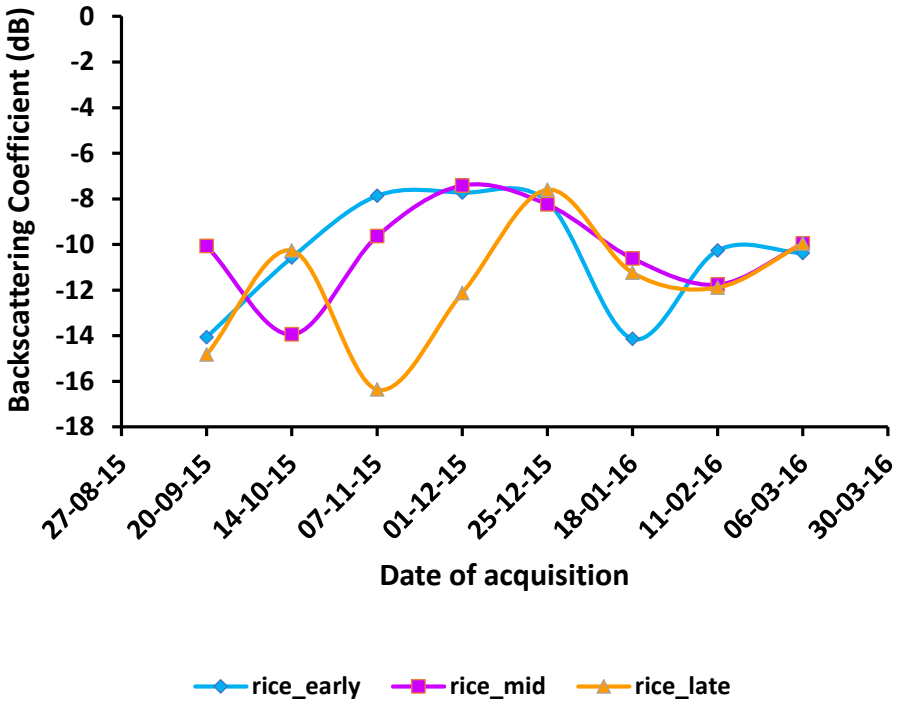
District Level Drought Condition as on February 2015



Note:

1. The district level ndvi anomaly is indicated, which needs to be corroborated with: a) crop calendar and b) ground information on irrigation, soil type etc.
2. On analyzing the NDVI profile and its deviation through the Maha season indicates that all the districts of the Country has normal agricultural condition.

Rice Cropped Area Estimation Using Microwave Data: Srilanka

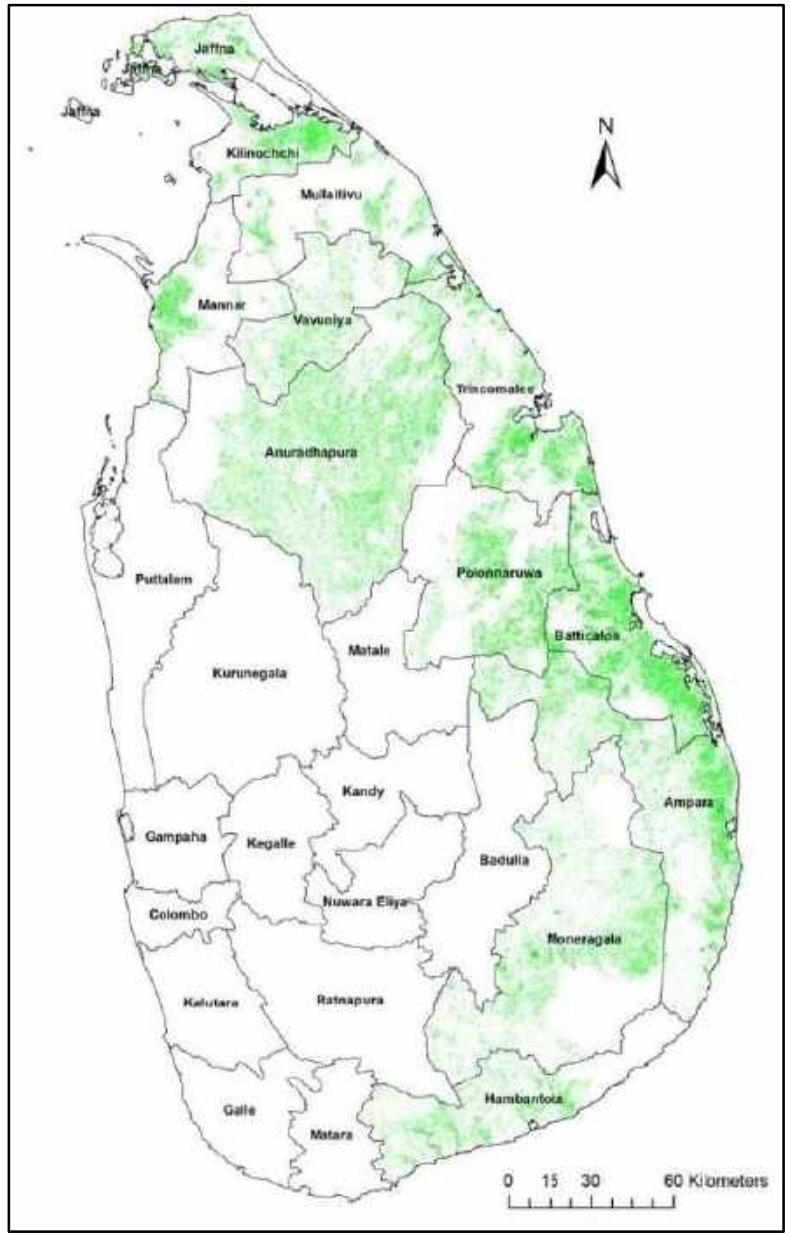


1. Anuradhapura
2. Ampara
3. Batticaloa
4. Monaragala
5. Trincomalee
6. Polonnaruwa
7. Hambantota
8. Kilinochchi
9. Mannar
10. Vavniya
11. Mullaitivu
12. Jaffna

Spatial distribution of the rice cropped area in 12 districts of Sri Lanka

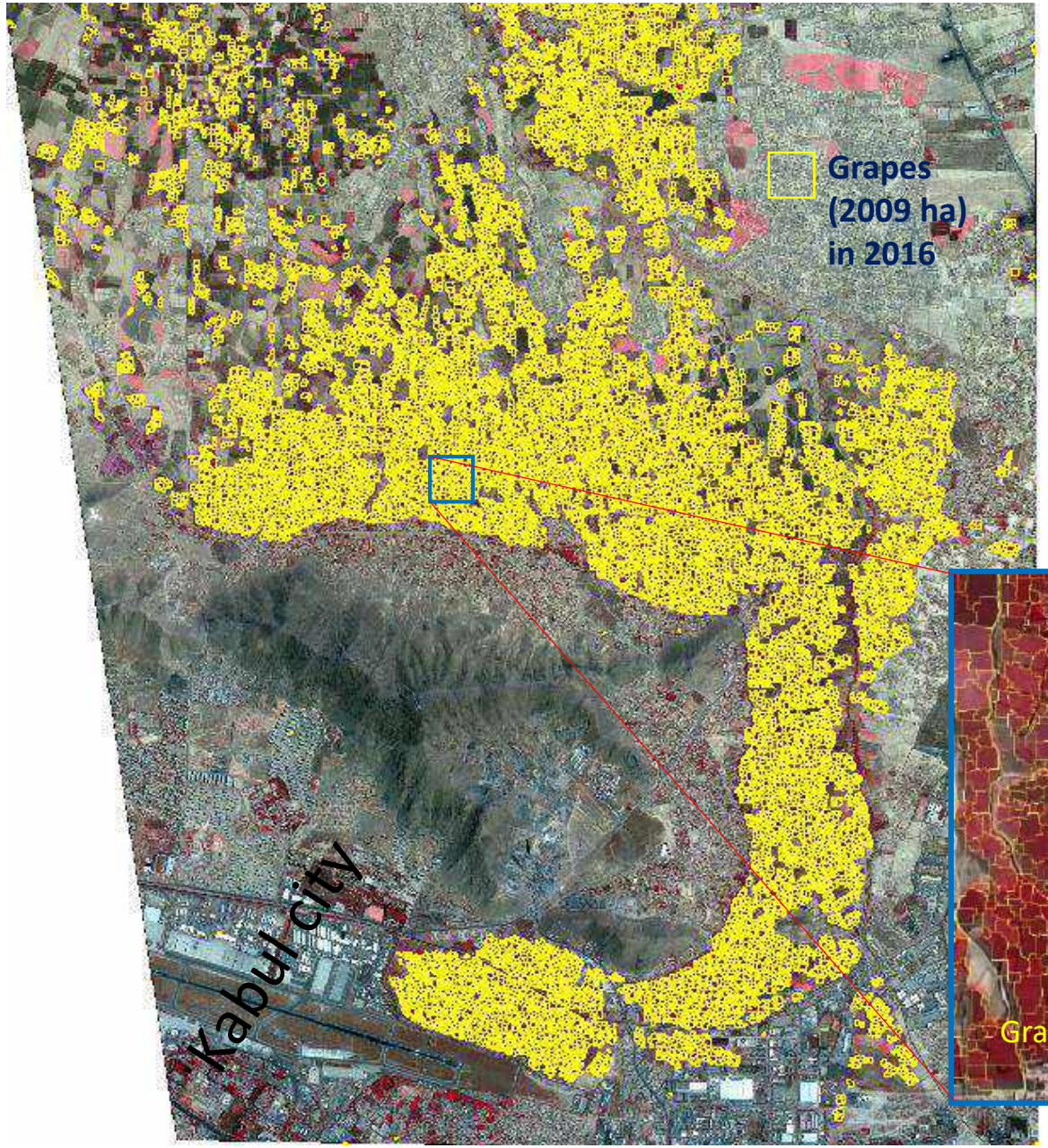
•Delineation of rice cropped area in 12 major rice growing districts of Sri Lanka using temporal Sentinel-1A data for the **2015-16 Maha season** under ISRO_UNESCAP initiative for drought.

• Verified with the statistics with the Department of Agriculture, Sri Lanka.



Mapping and inventory of Grapes cultivation in Afghanistan

nrsc



- Grapes cultivation –priority crop in the country
- Study area – part of Kabul province
- Data - LISS-IV and PAN covering early and peak vegetative phase of grapes (Feb and Sep 2016)
- Segmentation approach on merged product

Jute crop identification and mapping in Bangladesh

nrsc

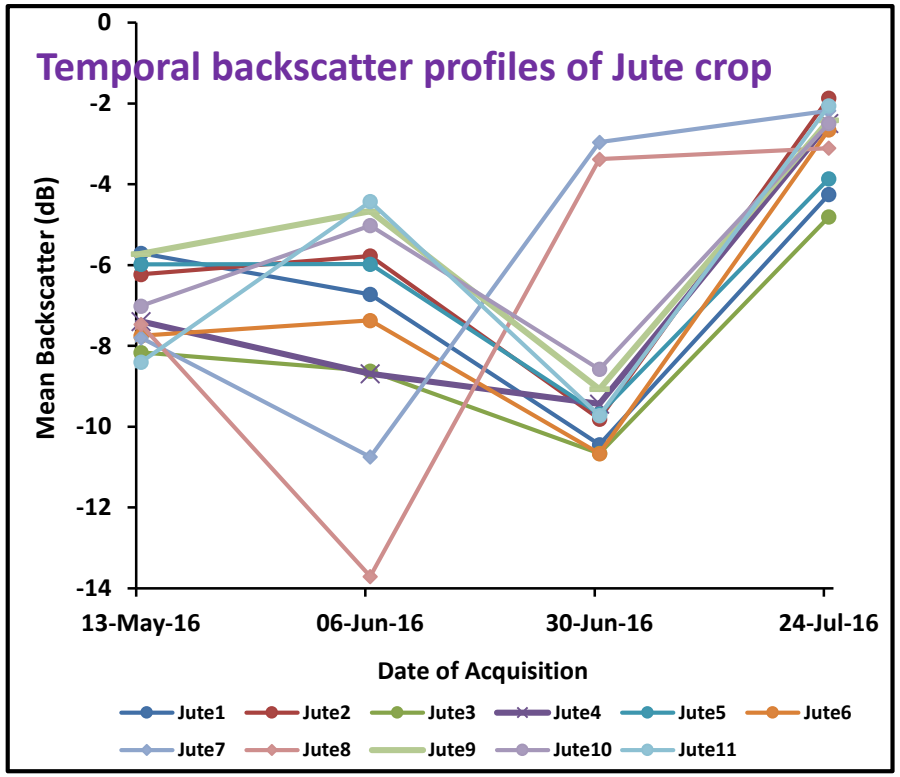
2016

Jute is an important natural fibre cash crop just like cotton crop and grows well in hot and moist climate. India and Bangladesh are biggest jute producer in the world

Estimates of Total Area of Jute crop *(Bangladesh Bureau of Statistics)*

2014-15	2015-16	% Change over previous year
6,72,615	6,77,678	(+) 0.75

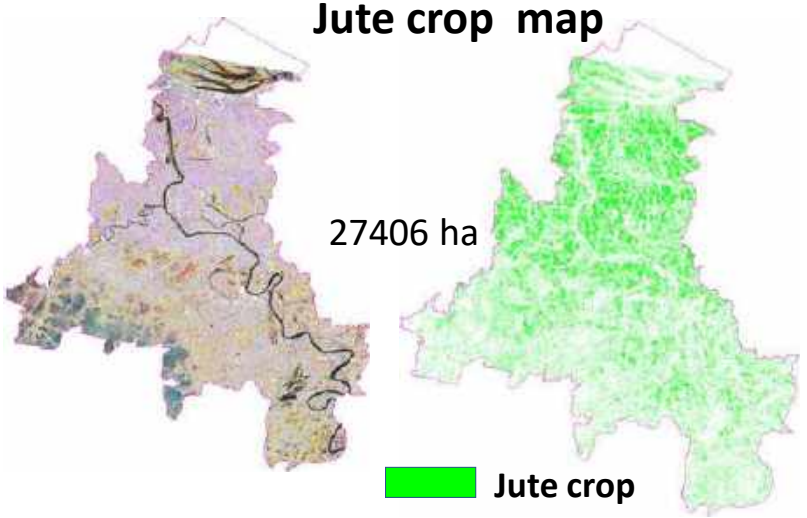
Area in hectares



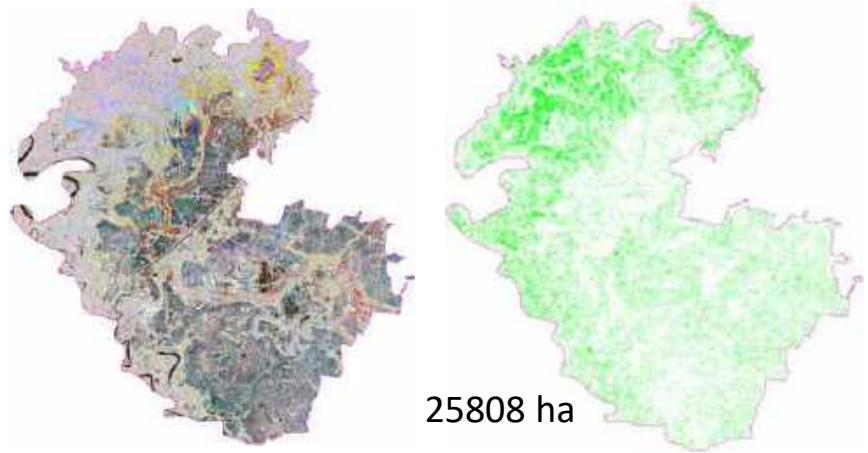
Sentinel-1A, RGB combination 06Jun30Jun24Jul 2016 data

Madaripur district

Jute crop map



Gopalgonj district



Agriculture Group – RSA - NRSC

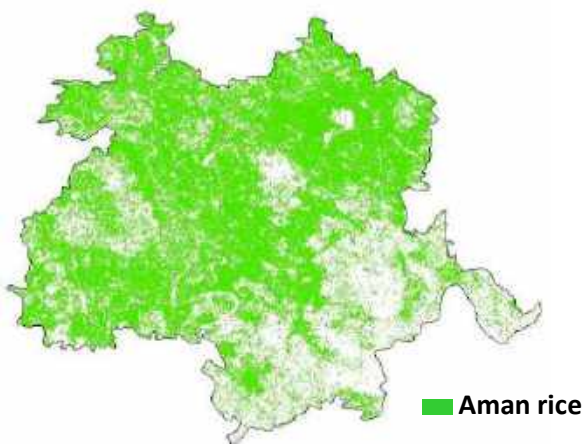
Mapping rice-fallow cropland areas, Bangladesh

nrsc

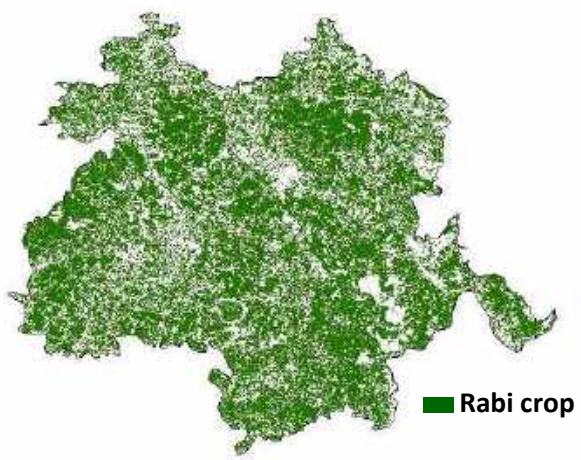
Delineation of Transp. Aman rice-rabi fallow lands using satellite derived images for crop intensification

- Study area: Jessore district, Bangladesh (2606.94 Km^2)
- Satellite data (microwave and optical): Sentinel-1 and Landsat-8 OLI
- Season/Year of study: kharif and rabi season, 2016-17

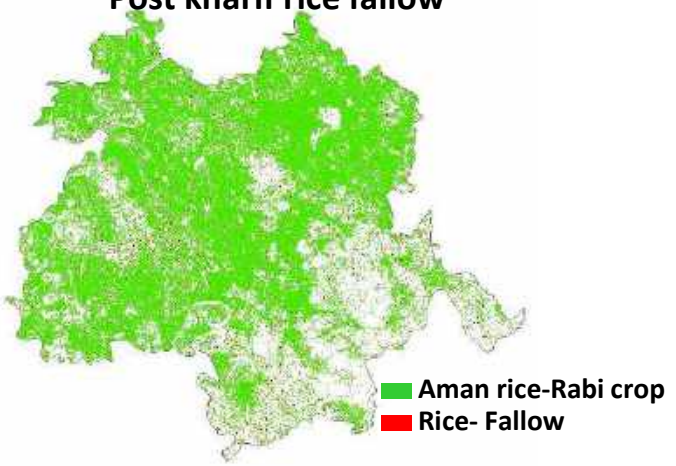
Kharif Rice (Aman)



Rabi crop



Post kharif rice fallow



Kharif rice	Rabi crop area	Cropping intensity	Remark
1.41 lakh ha	1.53 lakh ha	192%	Very less area under rice fallows and hence less scope for intensification. Since both the seasons are under rice crop, there is scope for crop diversification

Challenges and way forward

- Utilisation of space data for drought monitoring, has enhanced in recent years
- Scope exists for using more data sets and more indicators
- SAR data is yet to be exploited
- Synergistic use of data-centric technologies
- Quantitative algorithms/ Improved retrieval methods
- Objective monitoring / Crop specific assessments
- Local scale assessments

Thank you