


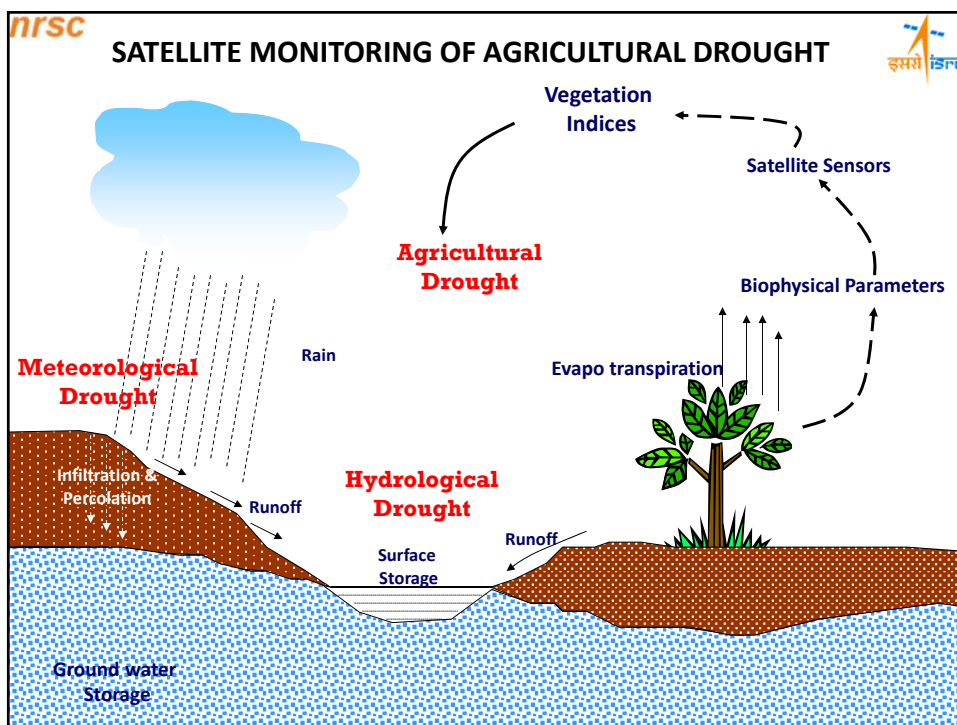
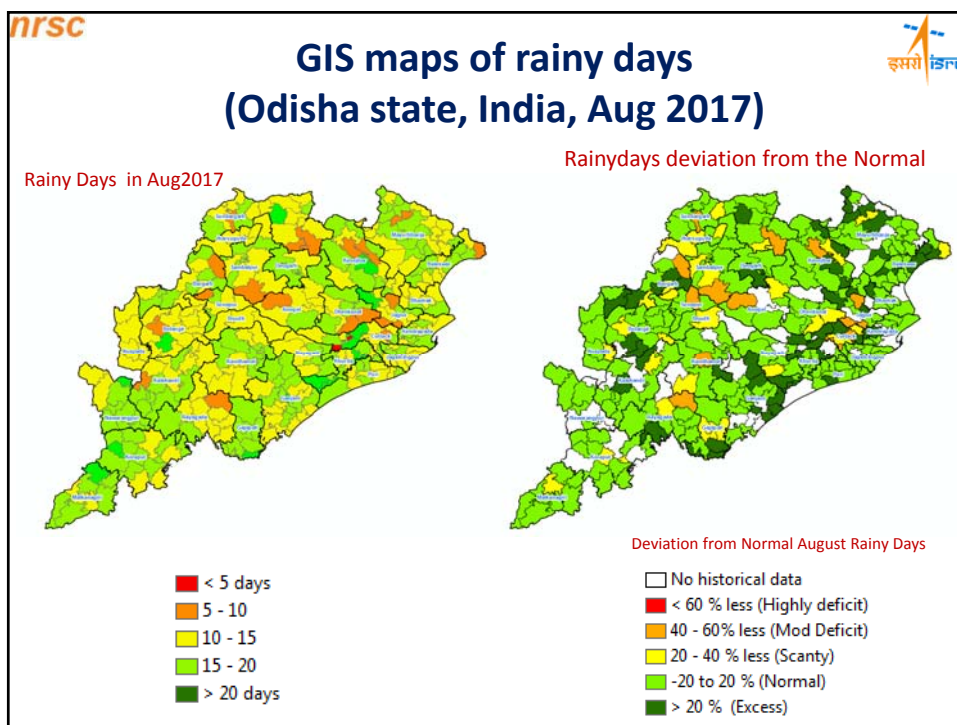
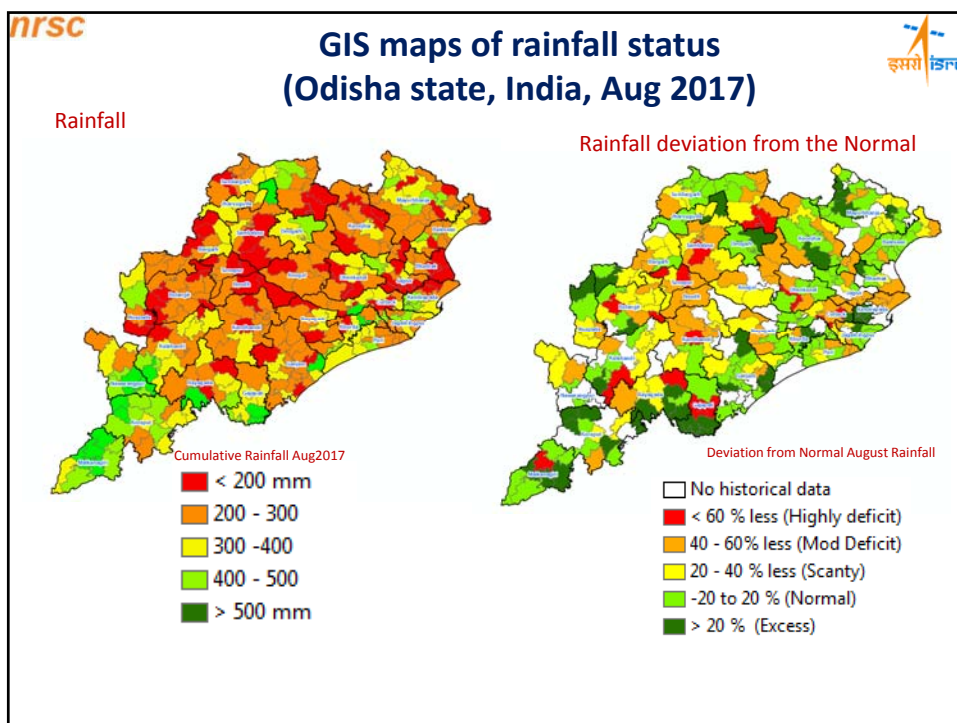


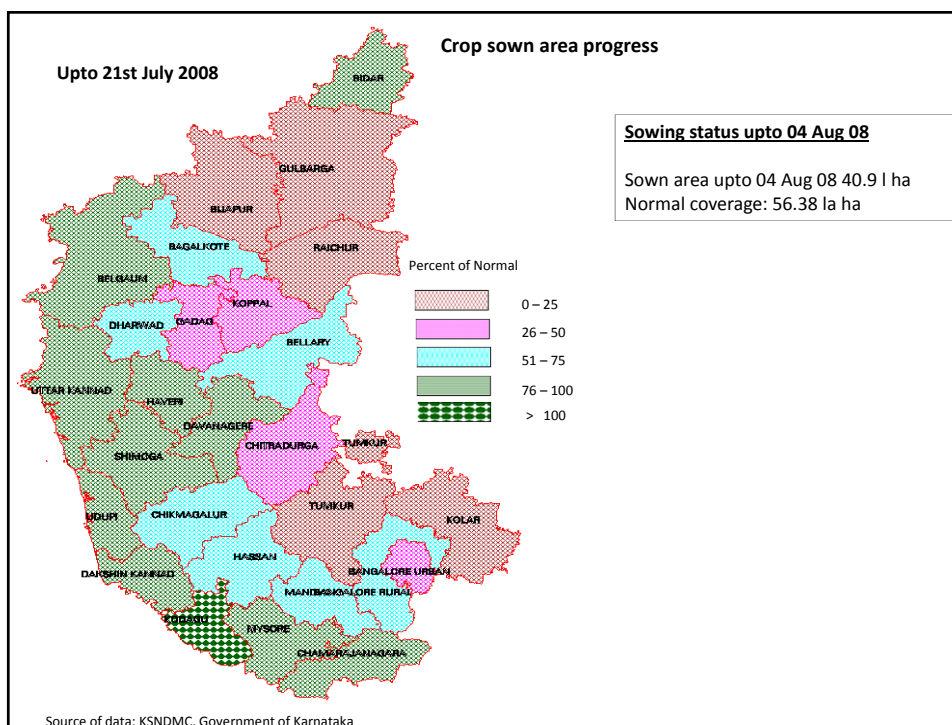
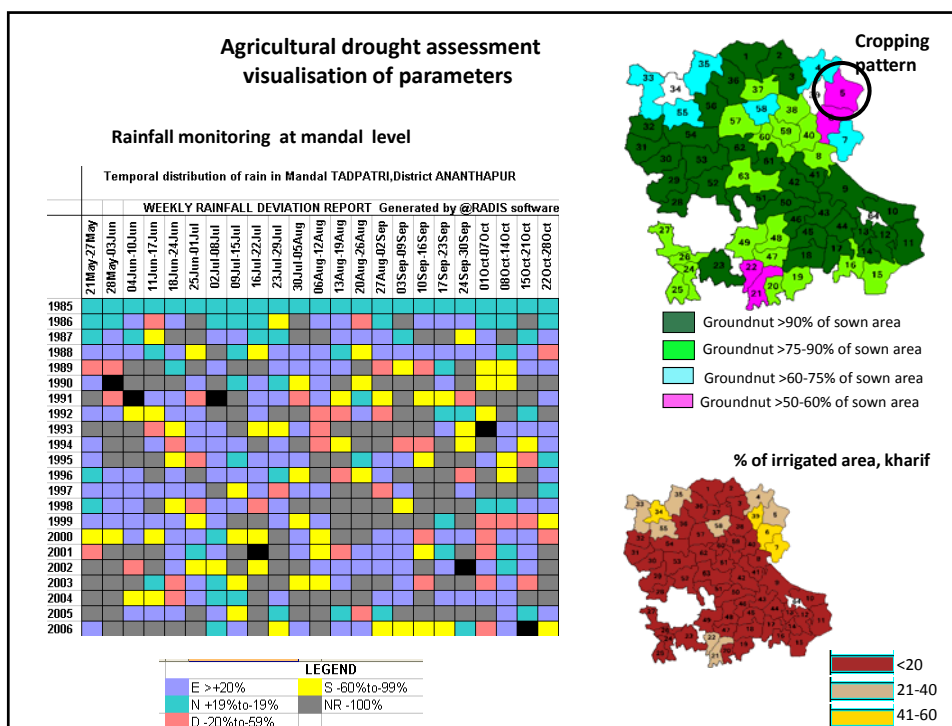
nrsc 

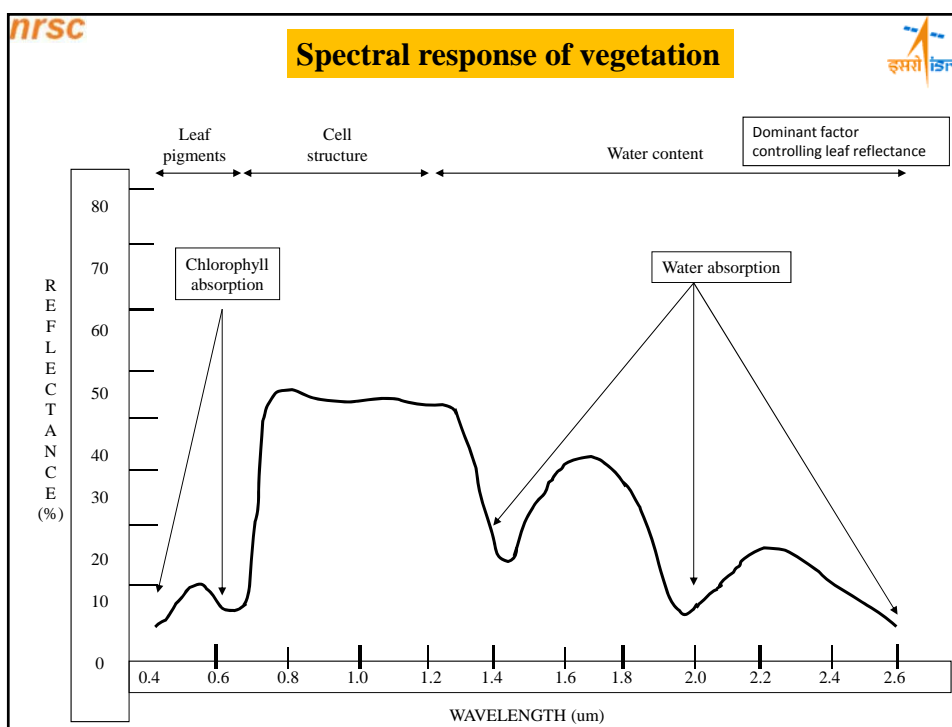
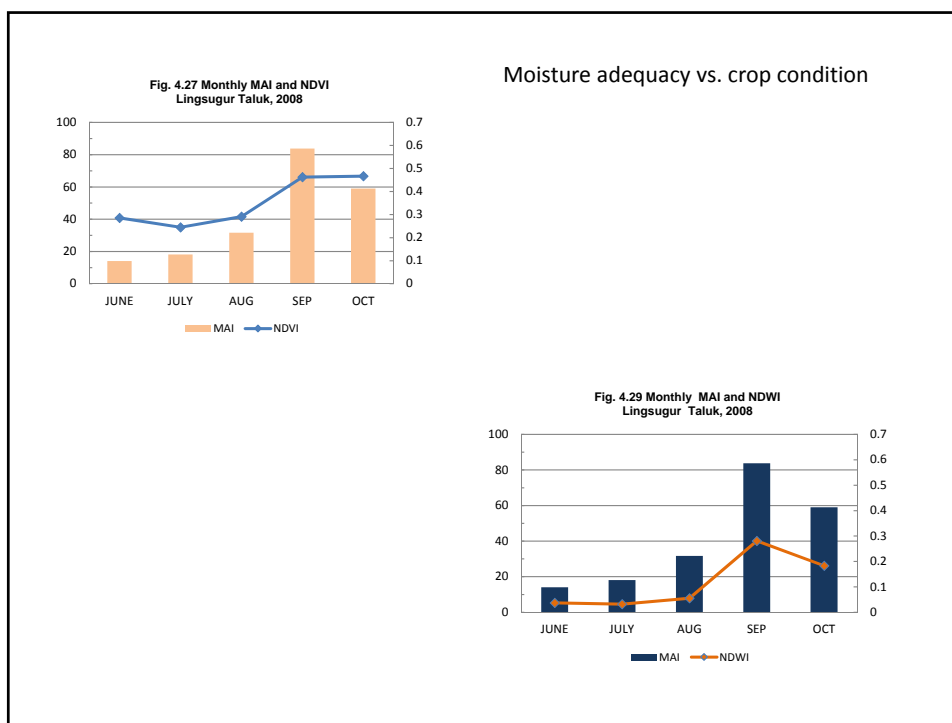
Computation and interpretation of different drought indicators

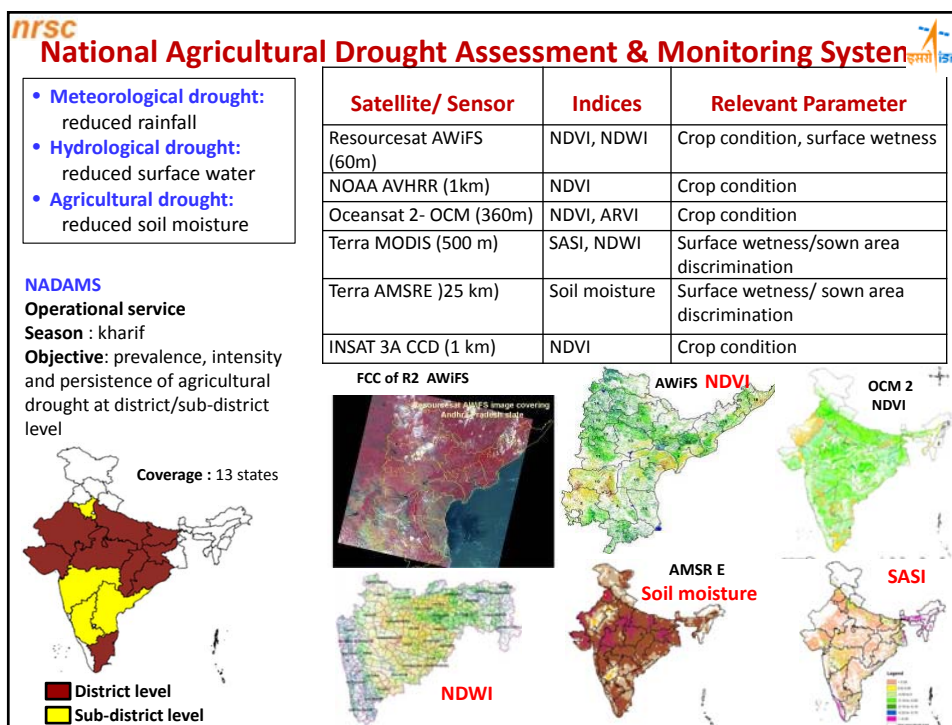
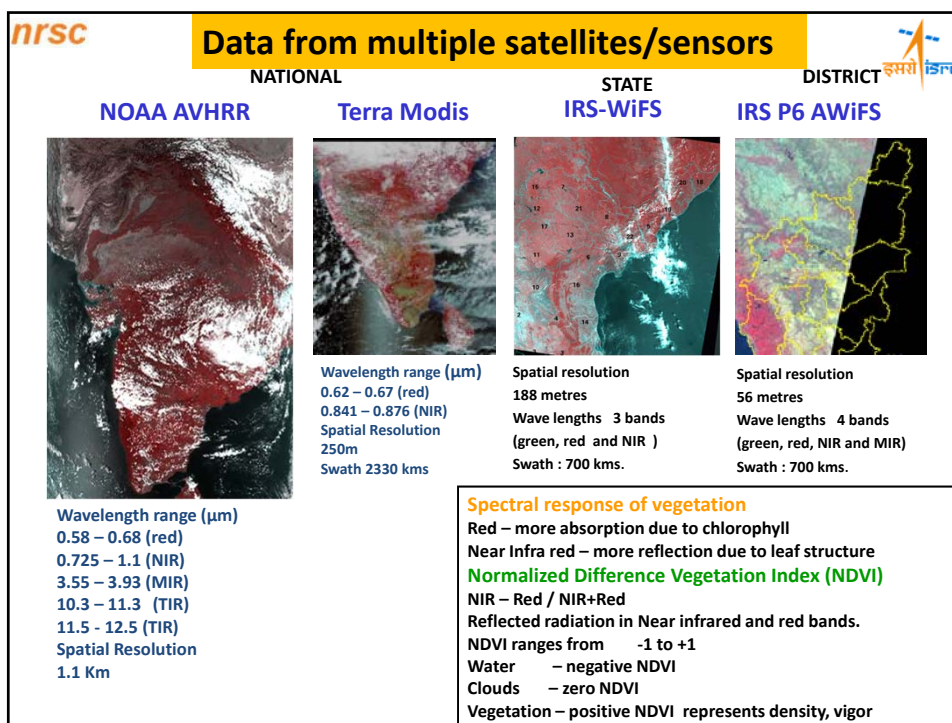
 **Dr. C.S. Murthy**
 Head, Agricultural Sciences and Applications
 National Remote Sensing Centre, Hyderabad
murthy_cs@nrsc.gov.in, csmurthy09@gmail.com 

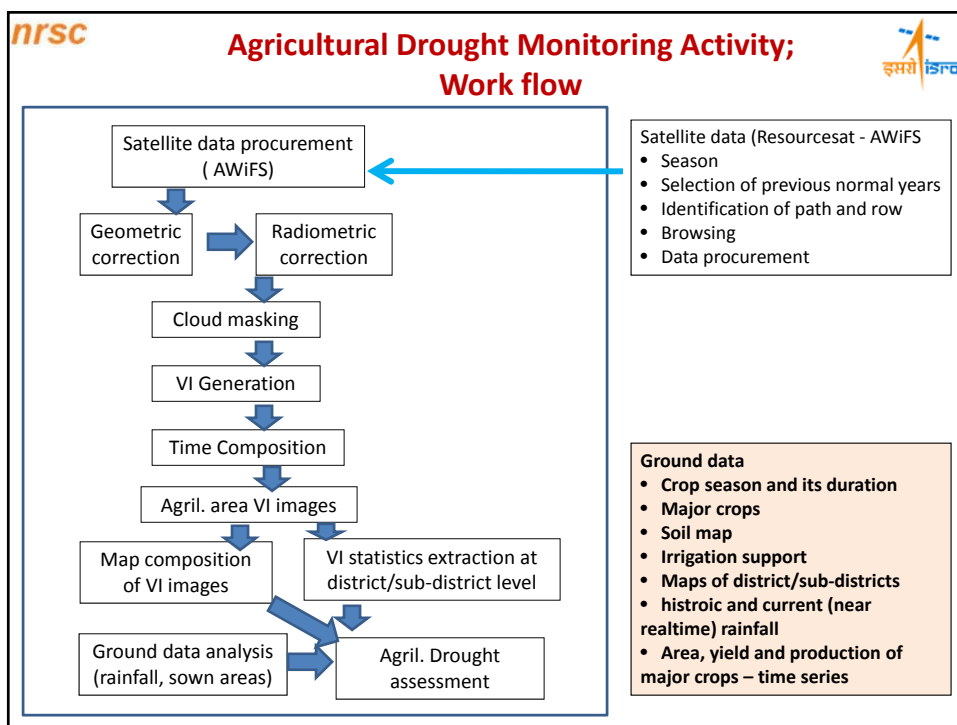
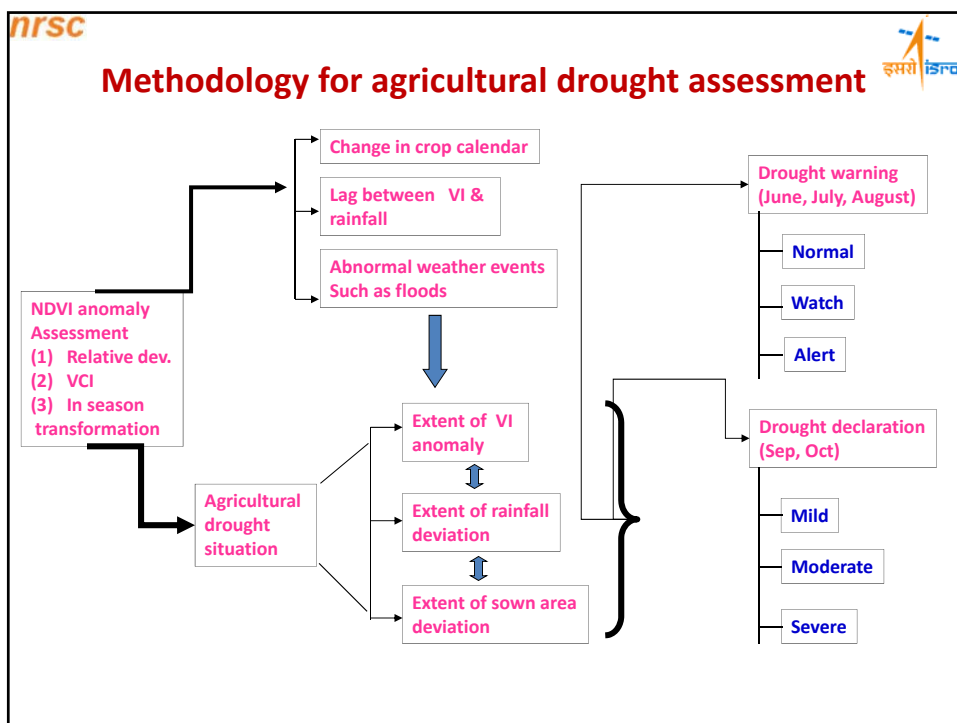


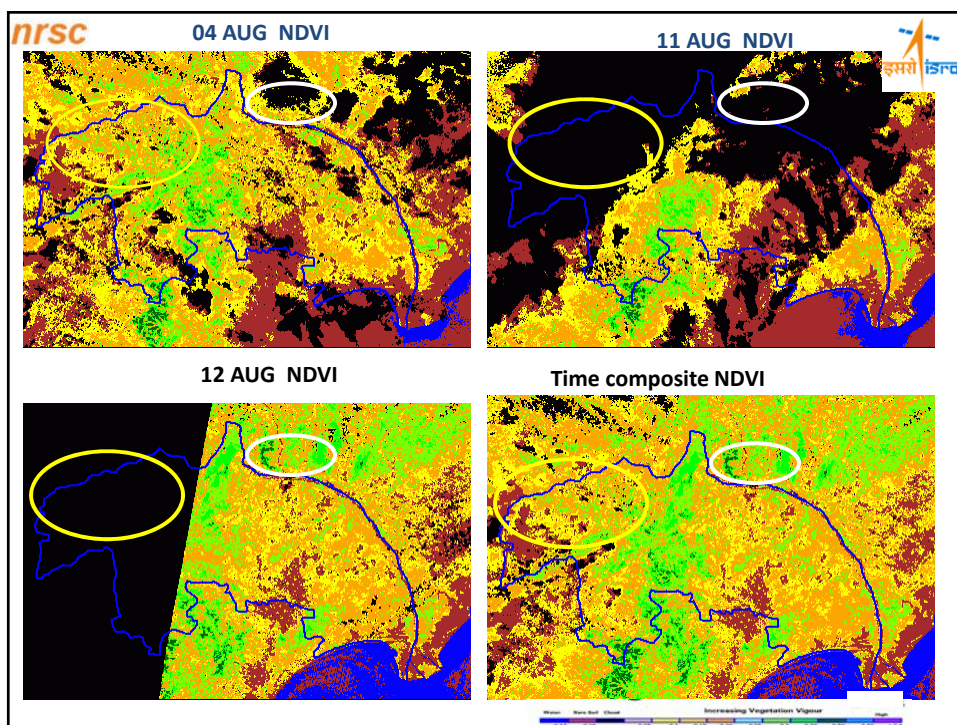
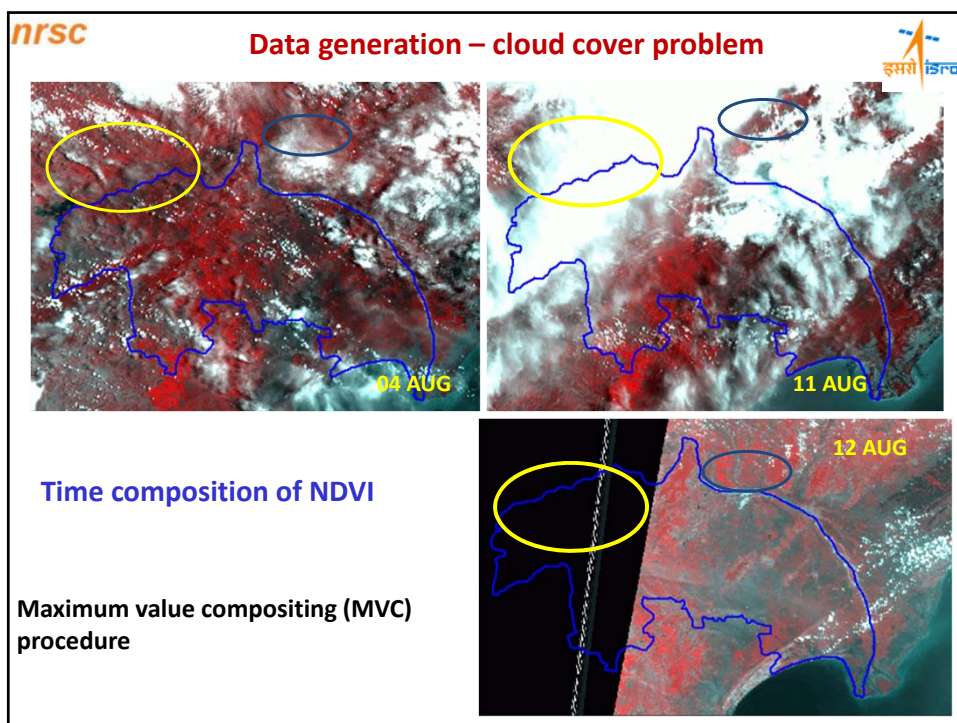


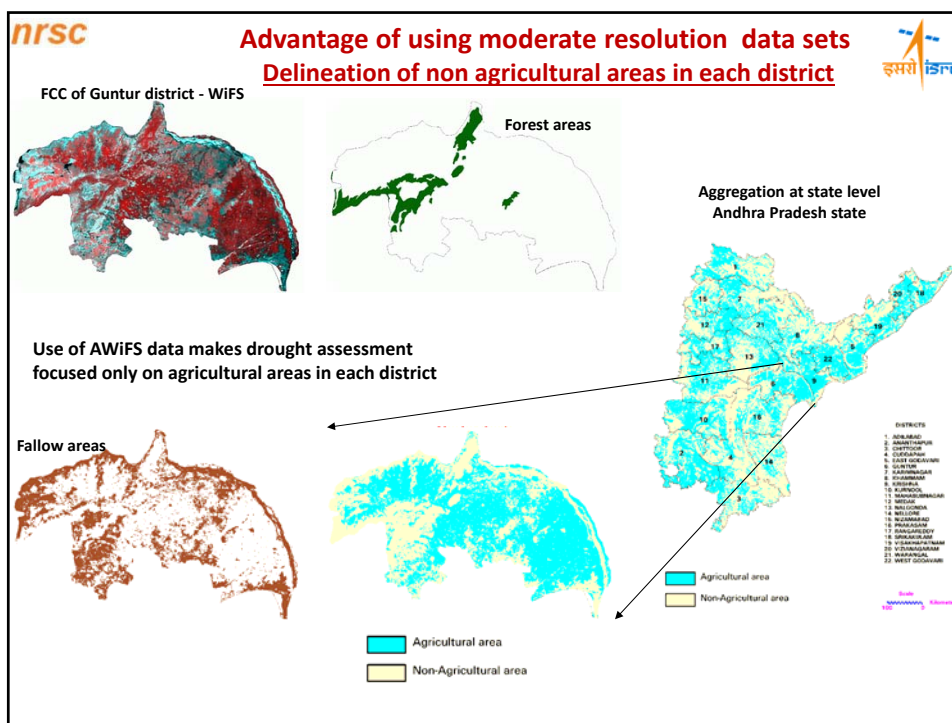












nrsc **NDVI** **इसरो ISRO**

Ratio of difference and sum of surface reflectance in NIR and red spectral bands

NIR can see roughly 8 layers
Red – one layer

Most successful indicator for describing vegetation

- ✓ Normalisation - reduces the effect of sensor degradation
- ✓ sensitive to changes in vegetation
- ✓ easy to compute and interpret
- ✓ available from most of the sensor systems

Limitations 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

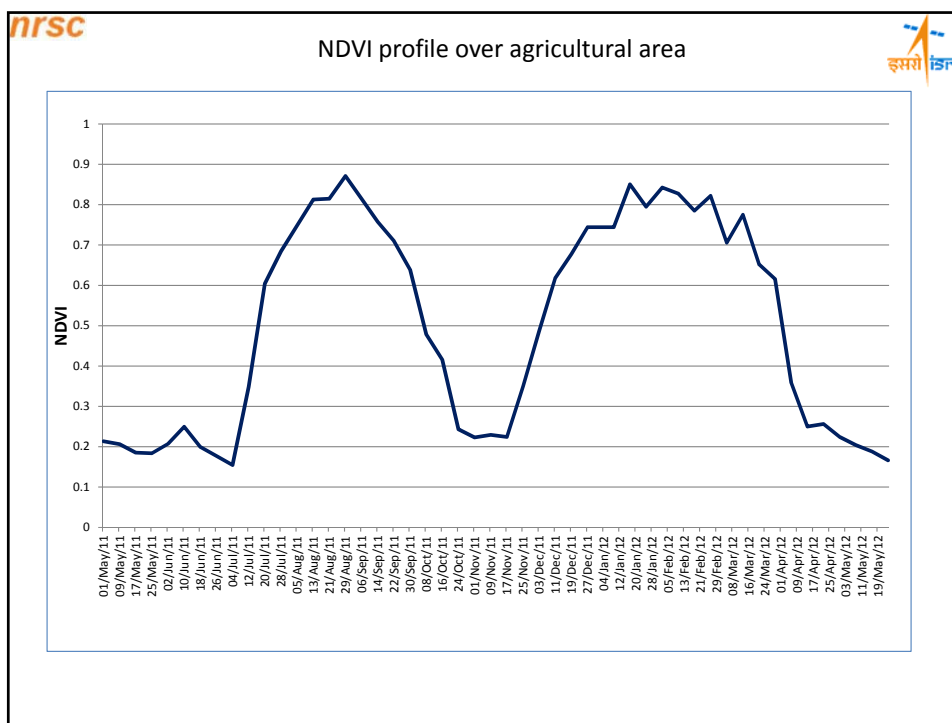
Spectral response of vegetation...

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



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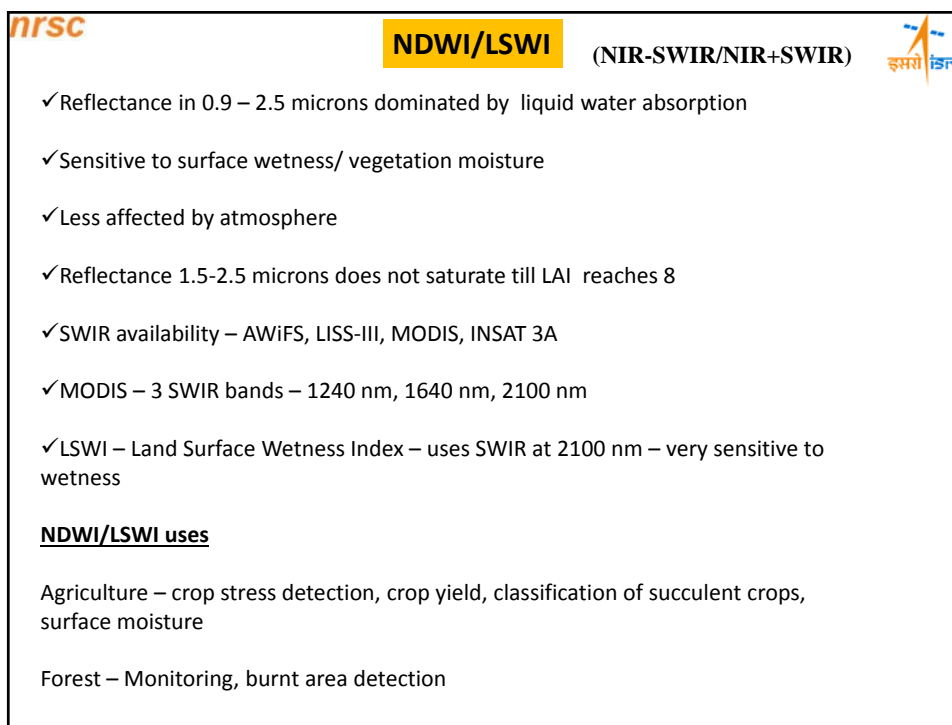
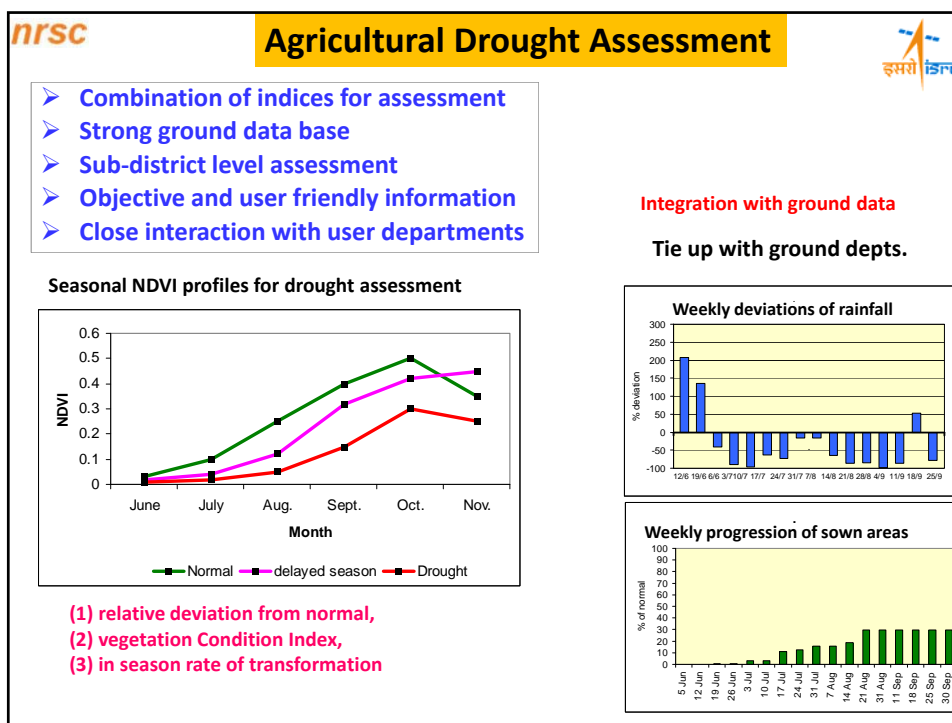
Some important VI data sets


Moderate resolution data

Satellites	Sensor	Spatial resolution	Temporal resolution	Swath
Resourcesat 1 & 2	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

Coarse resolution data

Satellite/ Sensor	Indices	Relevant Parameter
NOAA AVHRR (1km)	NDVI	Crop condition
Oceansat 2- OCM (360m)	NDVI, ARVI	Crop condition
Terra MODIS (500 m)	SASI, NDWI	Surface wetness/ sown area discrimination
Terra AMSRE (25 km)	Soil moisture	Surface wetness/ sown area discrimination
INSAT 3A CCD (1 km)	NDVI	Crop condition



nrsc **Commonly used indices for drought assessment** 

Most commonly adopted index – NDVI

- a) chlorophyll based index
- b) plant vigour and density
- c) easy to compute and interpret
- d) robust index
- e) Limitations – soil back ground, saturation, time lag etc.

Recently popularized index – NDWI

- a) Plant moisture based index
- b) NIR and SWIR based
- c) No saturation issues
- d) Immediate response
- e) Sensitive to surface wetness during sowing period

Combination of NDVI and NDWI

- a) Overcomes limitations of either one
- b) amplifies anomalies and
- c) more responsive to ground situation

Interpretation of NDVI changes to assess Agricultural drought

NDVI anomaly

% dev. from normal

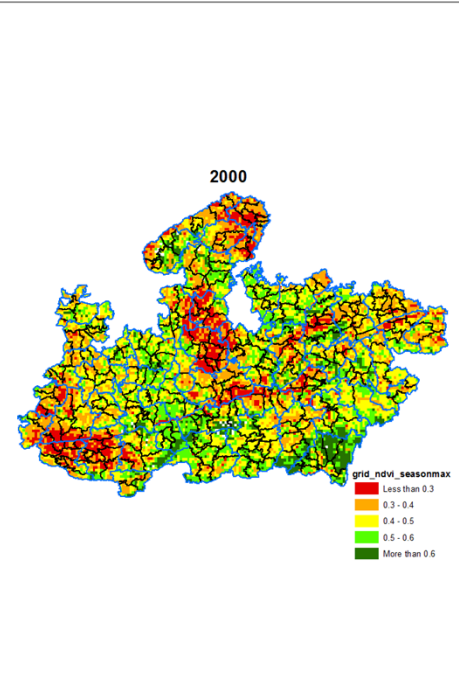
$$\frac{(\text{actual NDVI} - \text{normal NDVI})}{\text{normal NDVI}} \times 100$$

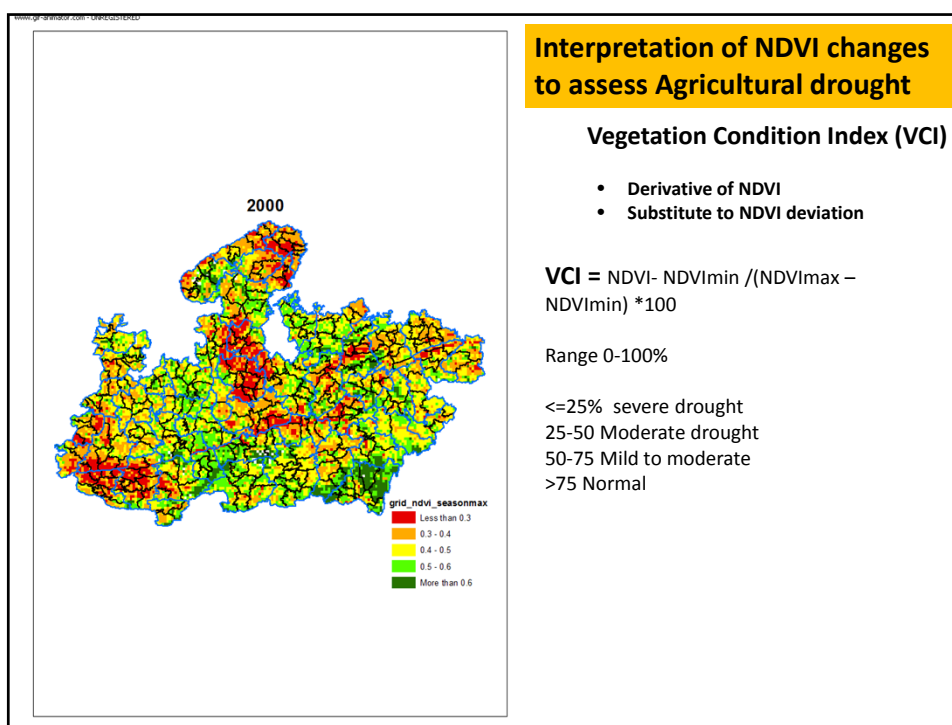
Selection of normal year – average of recent past normal years

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





Vegetation Condition Index (VCI)

Computation

VCI = $\text{NDVI} - \text{NDVI}_{\min} / (\text{NDVI}_{\max} - \text{NDVI}_{\min}) * 100$

September year	NDVI	VCI
2000	0.5	8
2001	0.55	50
2002	0.6	92
2004	0.52	25
2005	0.55	50
2006	0.51	17
2007	0.49	0
2008	0.59	83
2009	0.61	100
2010	0.54	42
2011	0.51	17
Mean	0.54	
Min	0.49	
Max	0.61	
diff	0.12	

Some critical issues

Time series data base
(at least 10-12 years)

Differences due to cropping pattern, crop calendar to be normalised

Interpretation of NDVI changes

Reduction in NDVI is caused by;

Crop moisture stress
Flooding/excess rainfall

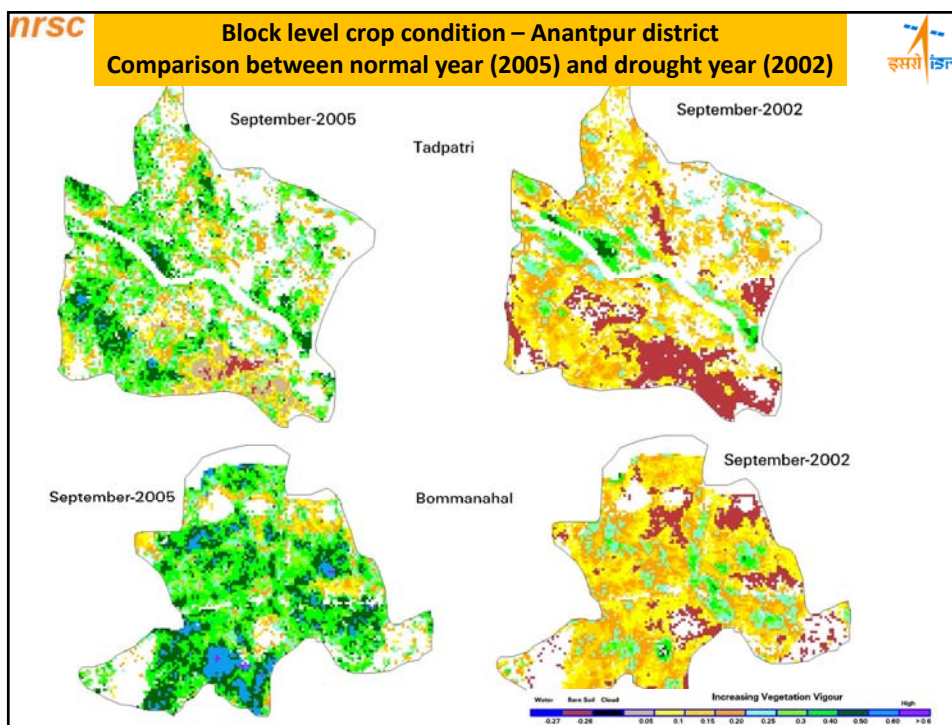
Crop and crop stage differences between
the two years under comparison

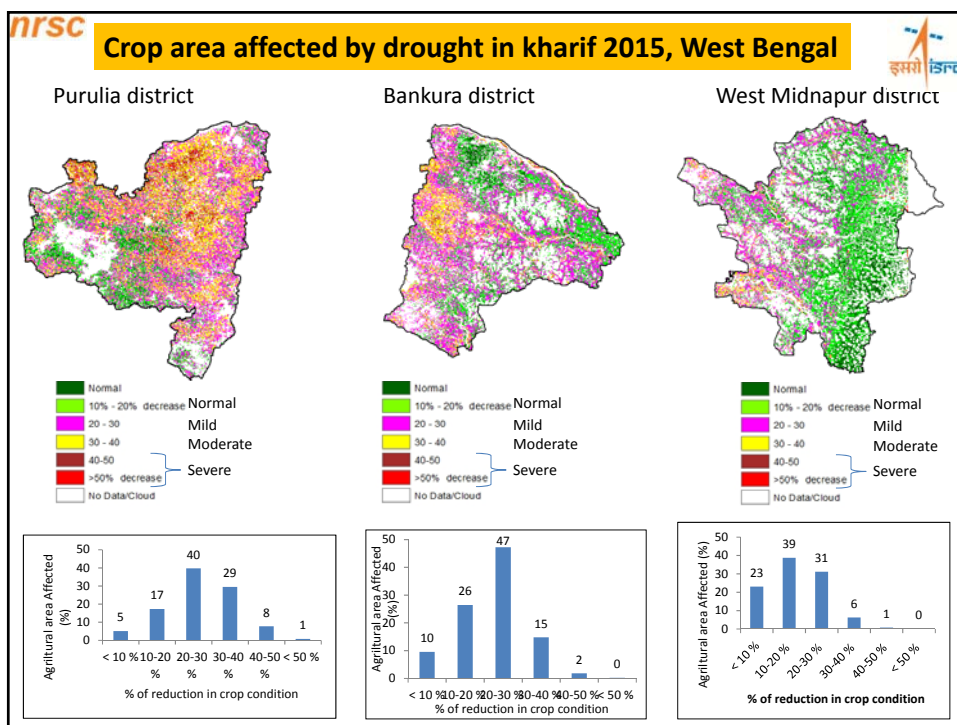
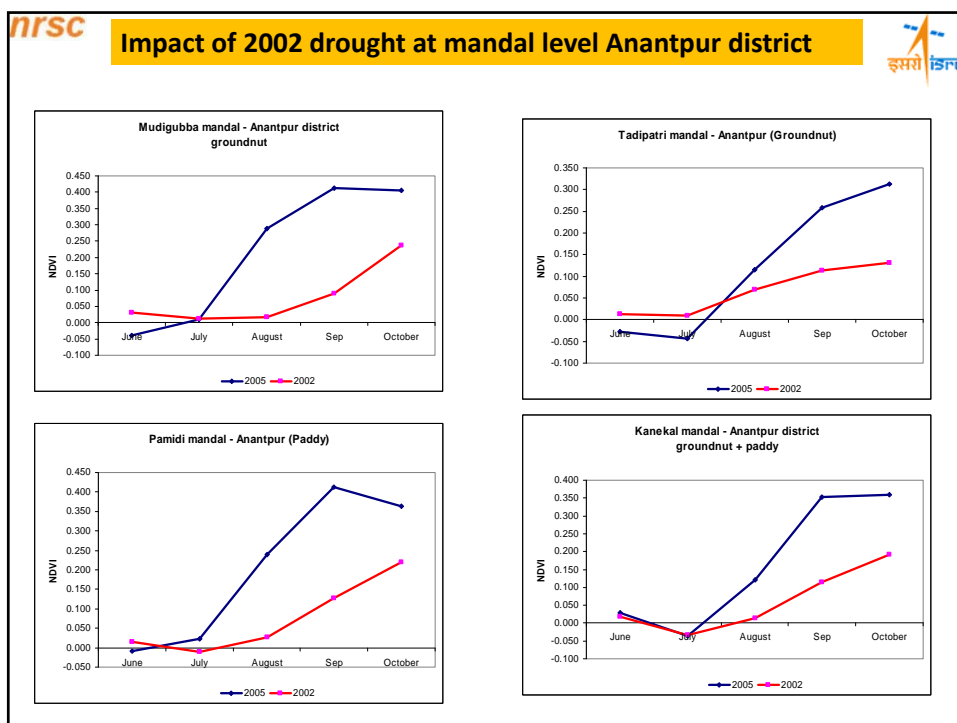
Limitations of NDVI based interpretation

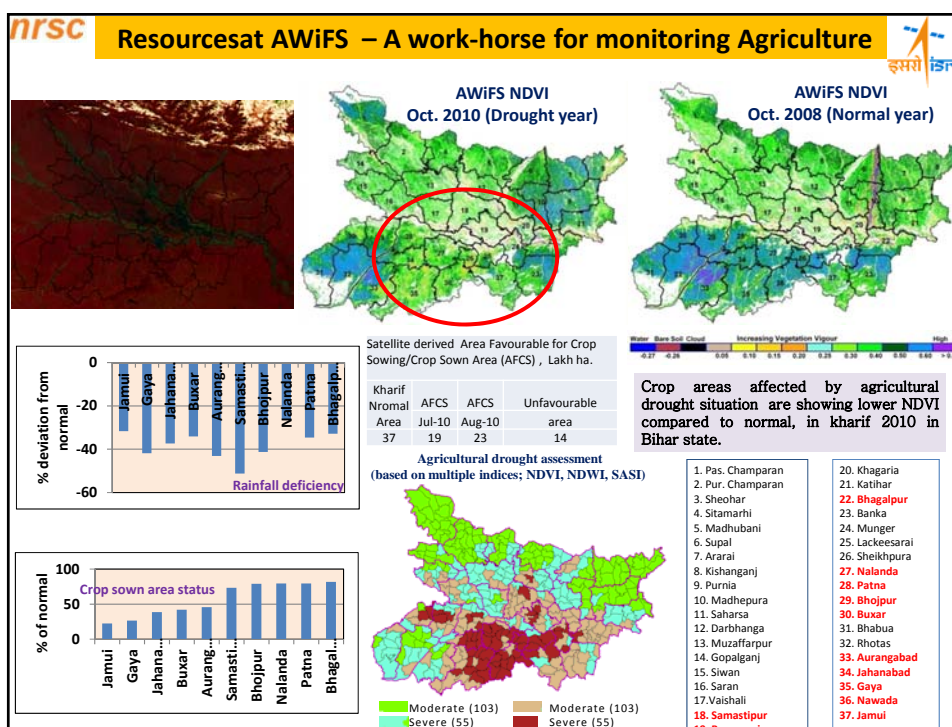
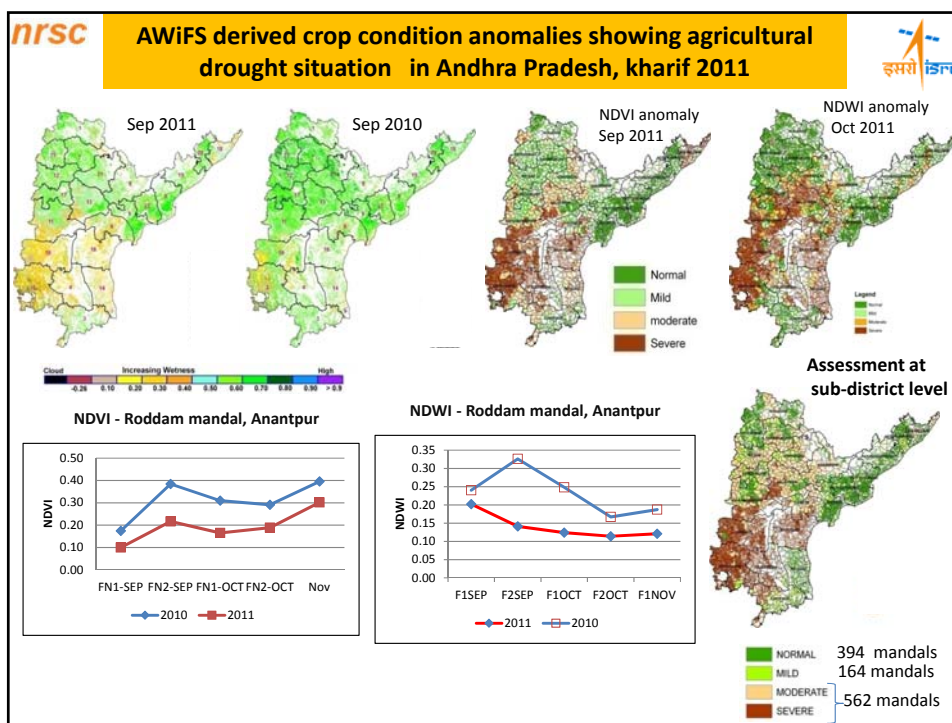
Time lag between rainfall and NDVI
manifestation

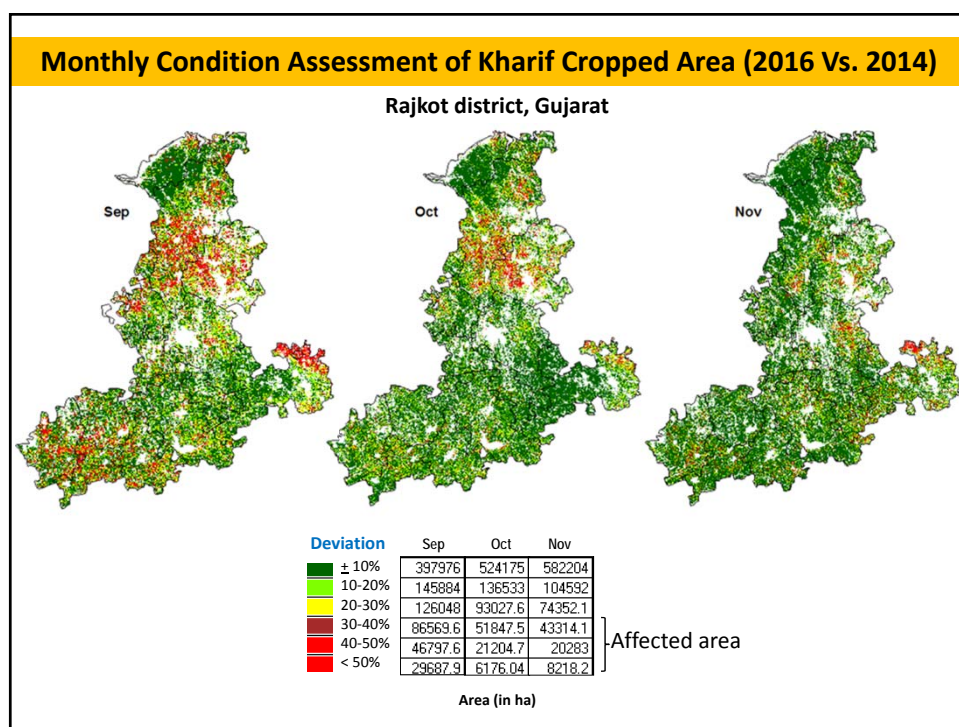
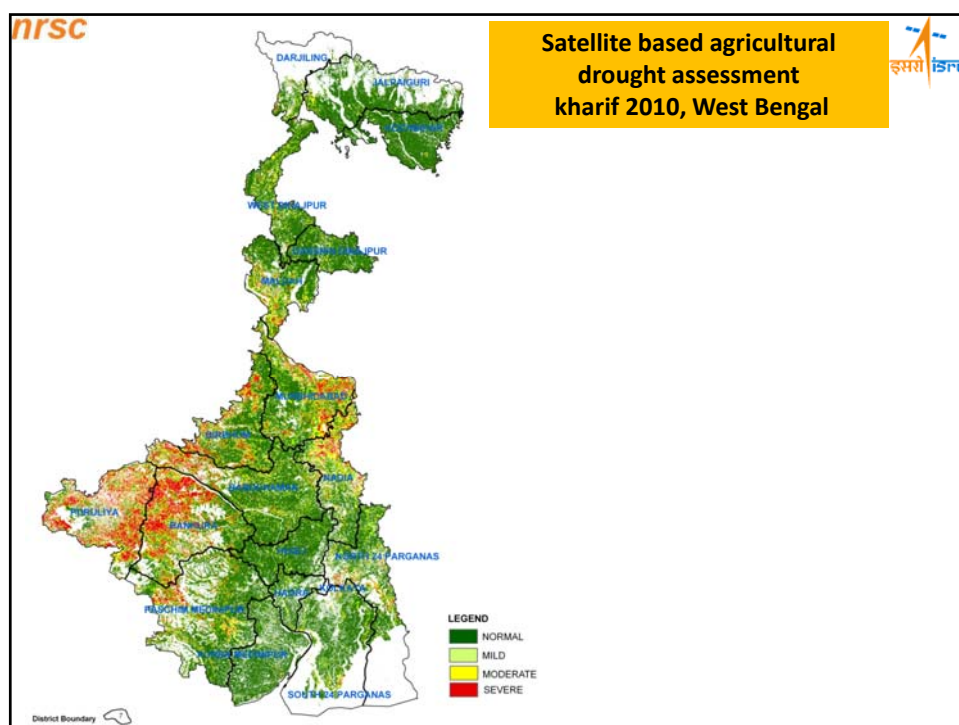
Saturation with crop growth

Despite its limitations, NDVI is a successful indicator for agricultural drought assessment

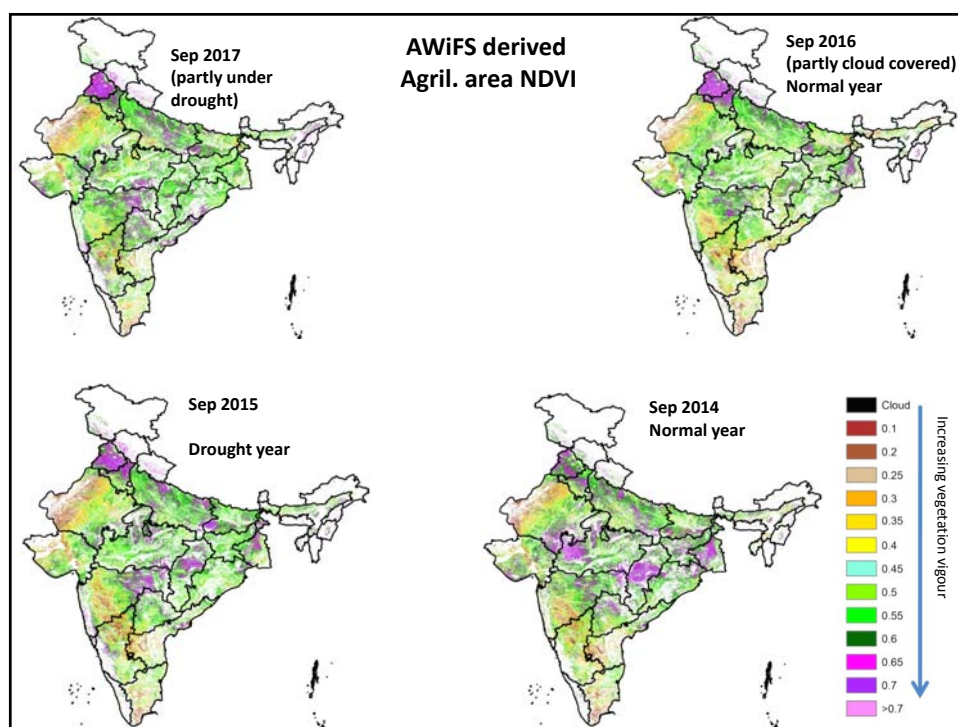
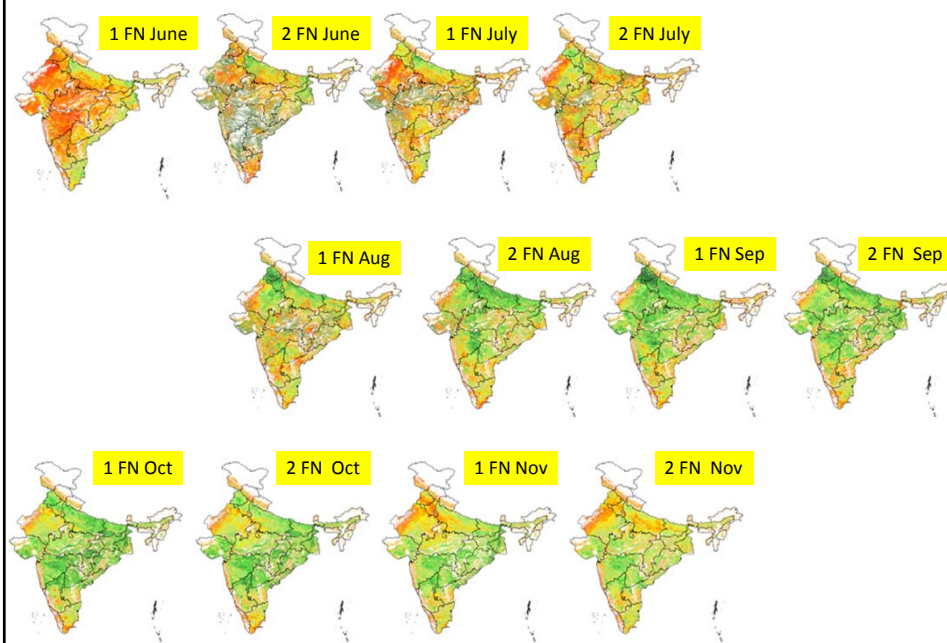


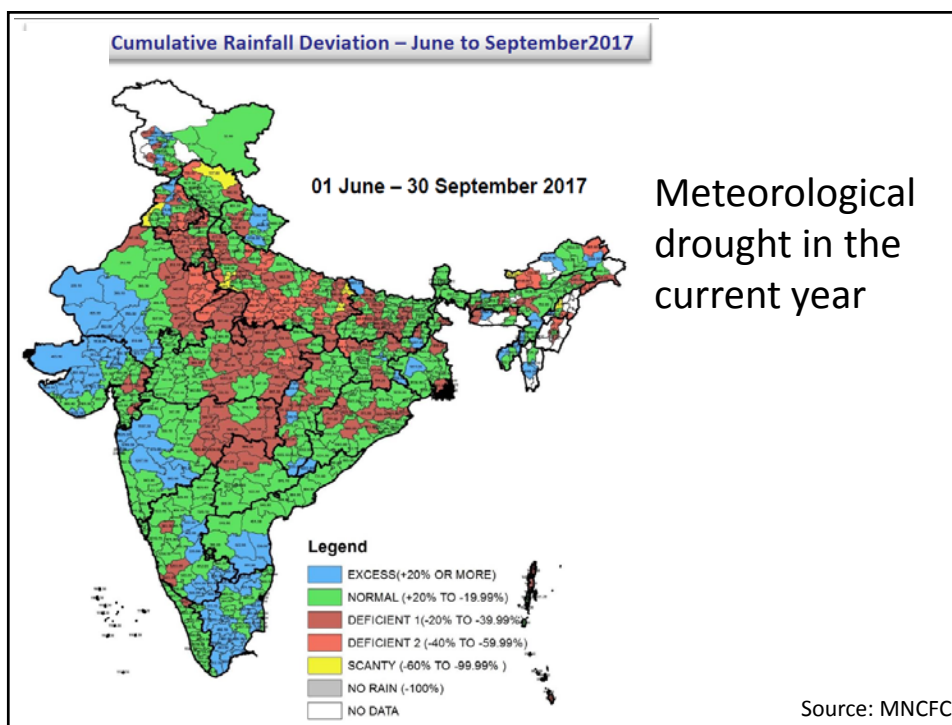
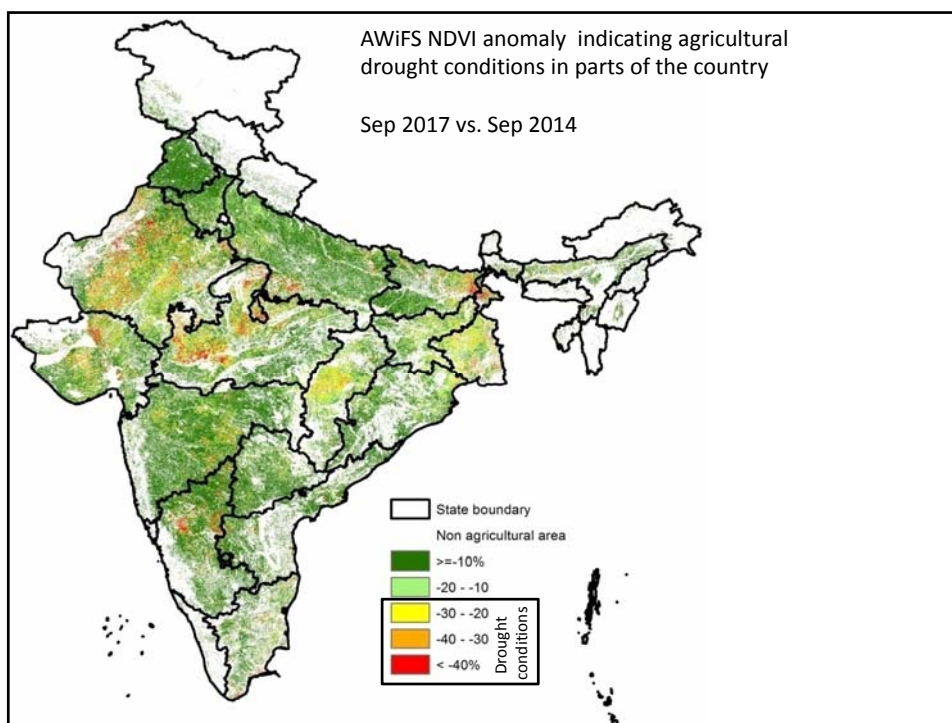




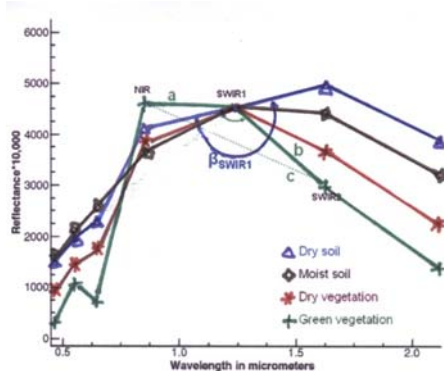


Fortnightly NDVI Composite of Resourcesat-2 AWiFS – 2016





Shortwave Angle Slope Index (SASI)



$$\beta_{\text{SWIR1}} = \cos^{-1} \left[\frac{(a^2 + b^2 - c^2)}{(2 \cdot a \cdot b)} \right]$$

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

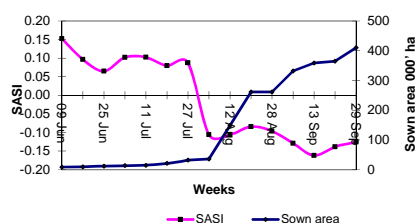
$$\text{SASI} = \beta_{\text{SWIR1}} \cdot \text{Slope (radians)}$$

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

Features	SASI value
Dry soil	highly positive
Wet soil	low positive

Features	SASI value
Dry vegetation	low negative
Moist veg.	high negative

Response of SASI to crop sown area



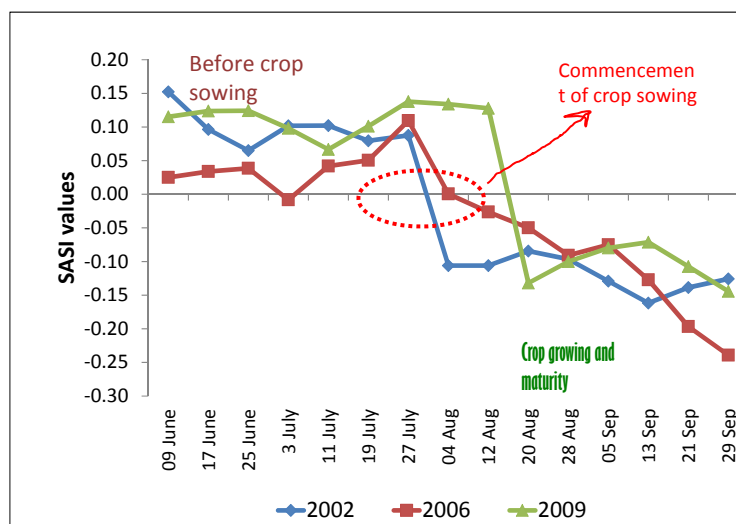
Chronological synchronization between

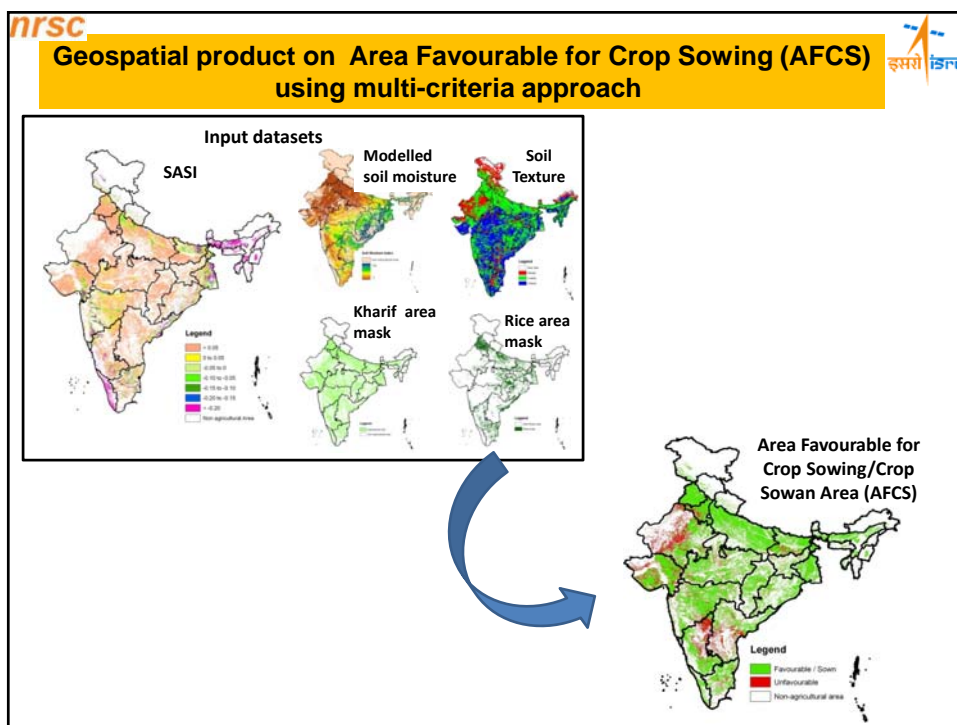
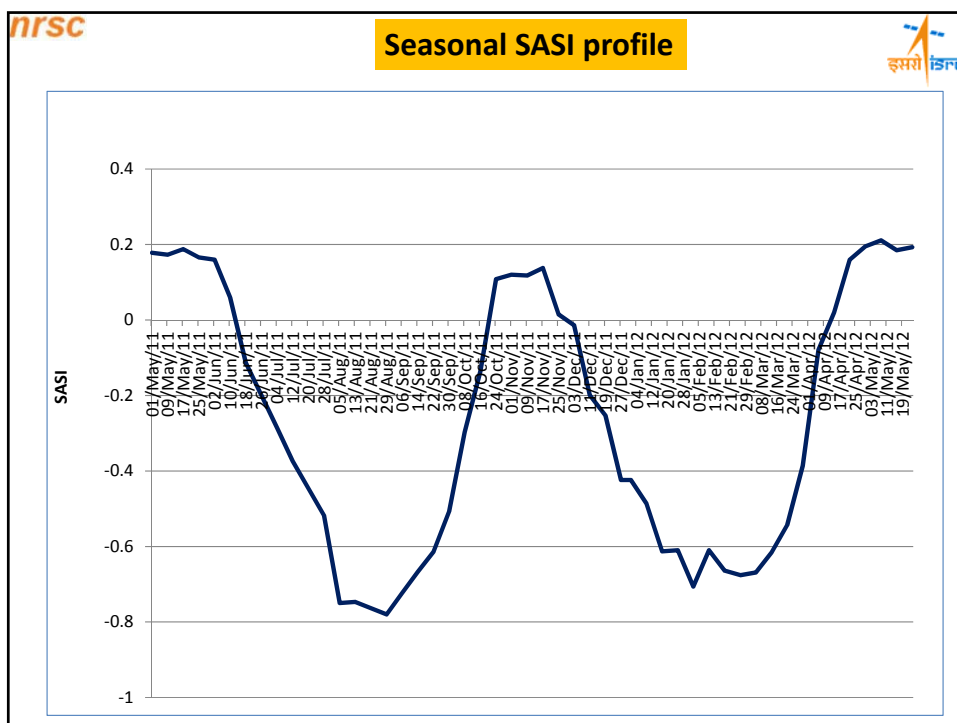
- (a) Decrease in SASI
- (b) Increase in rainfall
- (c) Increase in sown area

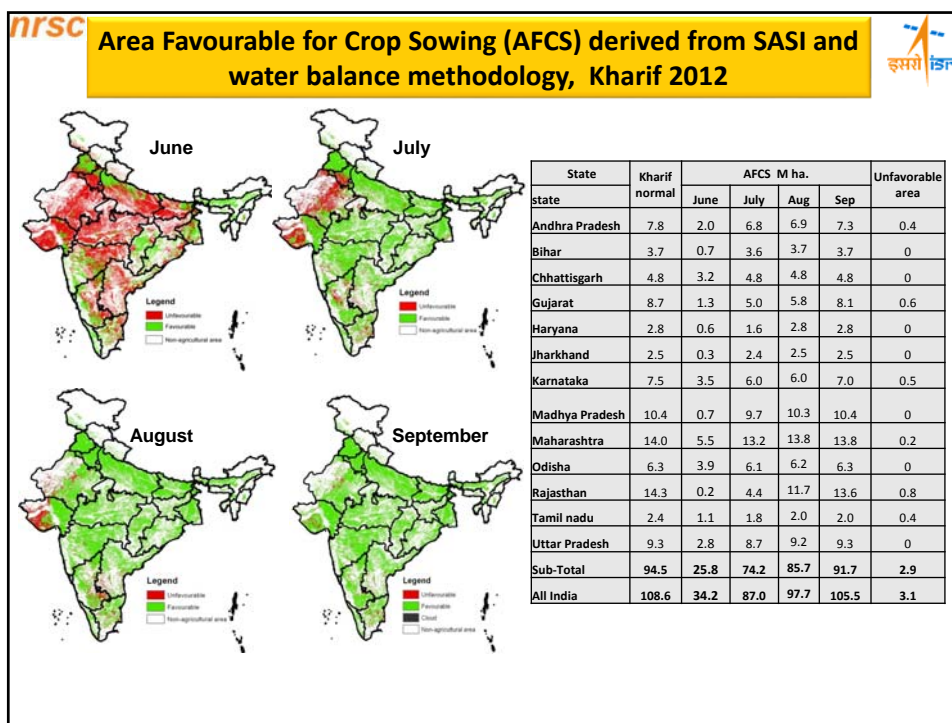
NADAMS project

Conceptually and computationally simple procedures to discriminate the crop sowing favorable areas at state level

Seasonal dynamics of SASI







nrsc **Soil moisture**

Soil moisture important data for hydrology, agriculture, environment, climate system etc.

Sources of soil moisture data

Non-spatial data

I. Insitu measurements
non-spatial data

Manual

- accurate
- inadequate coverage

Automatic systems

- calibration related issues
- large area coverage is expensive

Spatial data

Hydrological models

- Mass balance approach
- Profile level moisture
- Parameterisation of models – challenge

Satellite based

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

Several microwave sensors

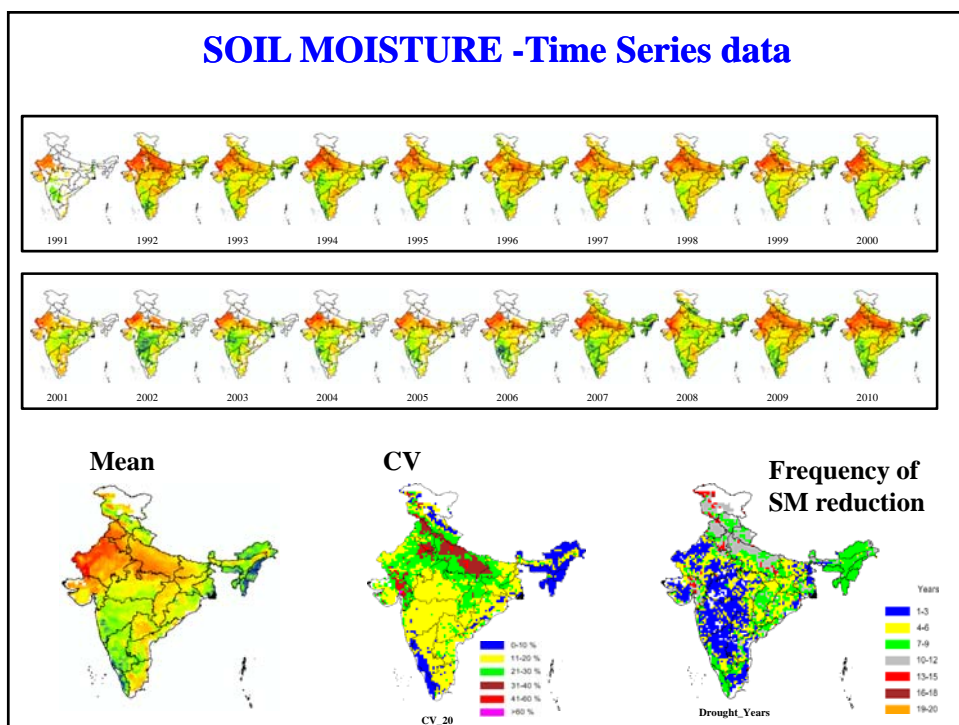
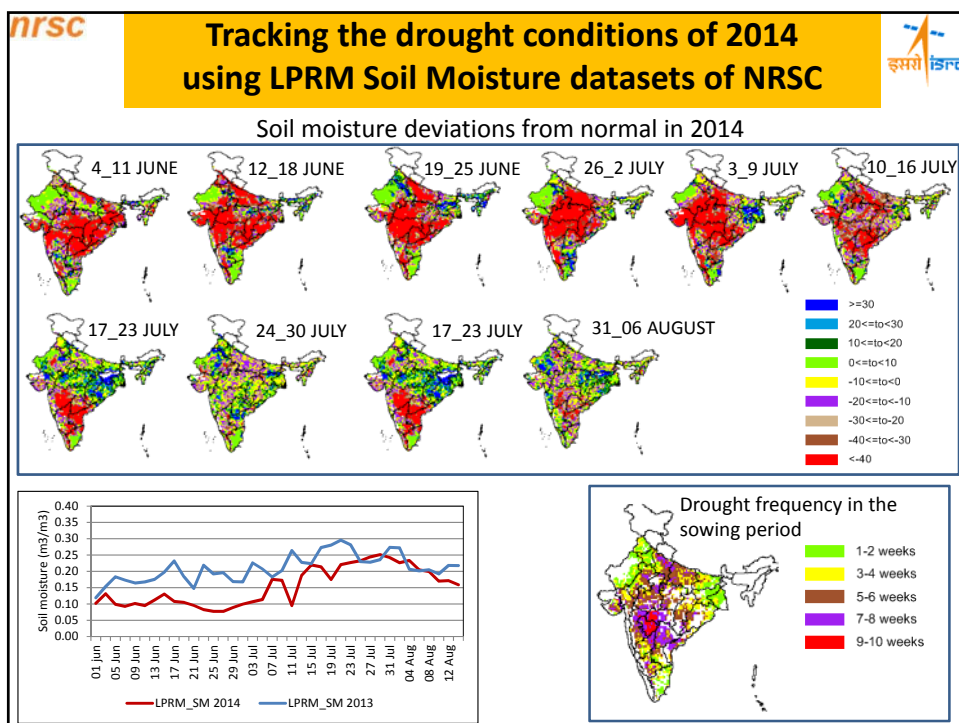
- SMRR – 1978-1987
- TRMM – TMI since 1997
- Scatterometer – ERS 1 & 2
- ASCAT – MetopA
- AMSR – 2002-2011
- SMOS – 2009
- SMAP - 2015


Retrieval algorithms from passive systems

- NASA
- LPRM
- PRI


Soil moisture products from NRSC

- VIC hydrological models – daily soil moisture images
- AMSR 2 LPRM soil moisture 25 km, 2 day frequency





Weather and hydrology indicators




Weather based indices


- Rainfall deviation
- Standardised Precipitation Index
- Moisture Adequacy Index

Hydrological indicators

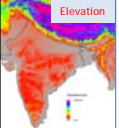
- Reservoir Storage Index
- Ground water index



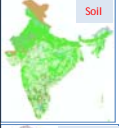
Operational Web-based National Hydrological Modeling System




Input dataset



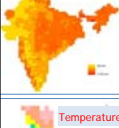
Elevation




Soil



Land use



Rainfall



Temperature

Hydrological Modeling Framework

Variable Infiltration Capacity Hydrological Model

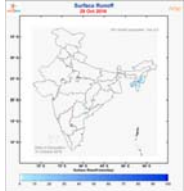
- Open source; Grid-wise water and energy balance
- Sub-grid heterogeneity of Land cover
- Soil depth-wise hydrological response
- Vegetation phenological changes
- Daily / sub-daily time step

9 min (~16.5km), 3 min (~ 5.5km) Grid-wise data base


Geo-spatial data

- Terrain - Topographic, Soil (NBSSLUP), LULC (NRC-250k), LAI, Albedo
- Meteorological - Rainfall, Temperature, ... (IMD & CPC)
- Hydrological - River discharge, Reservoir Storage/Releases, GW levels, ...

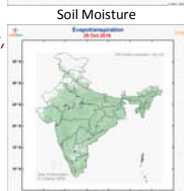
Output Products



Runoff

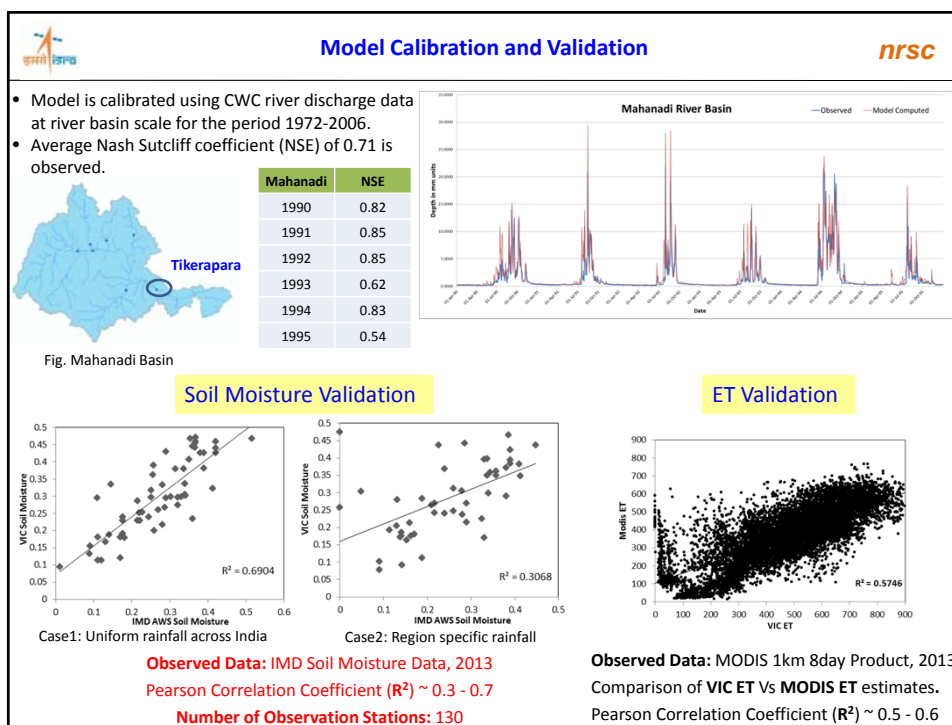


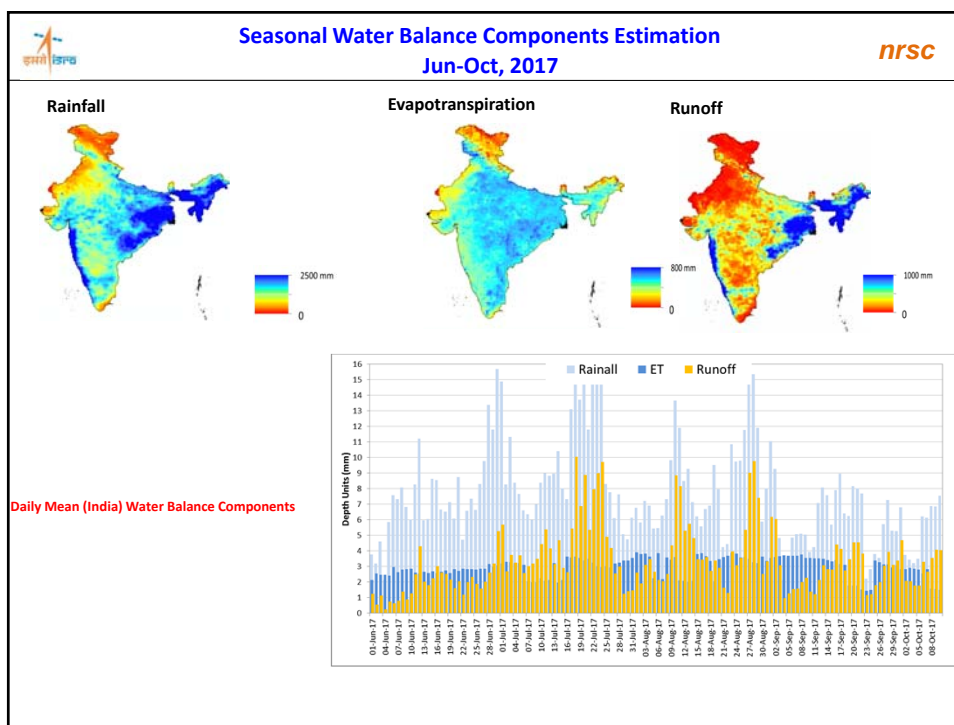
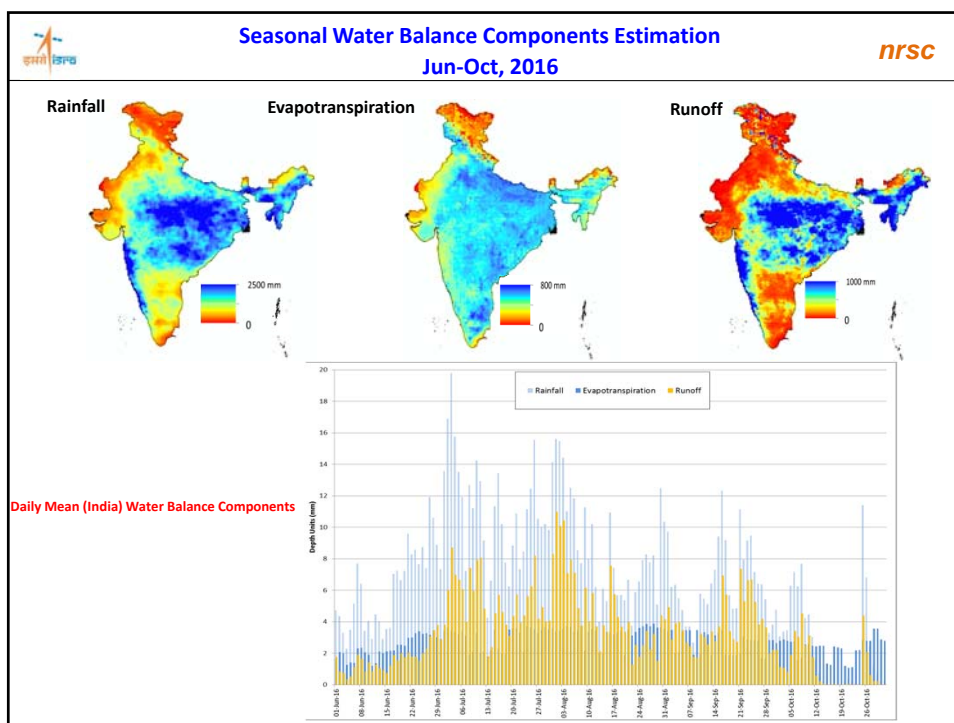
Soil Moisture




Evapotranspiration

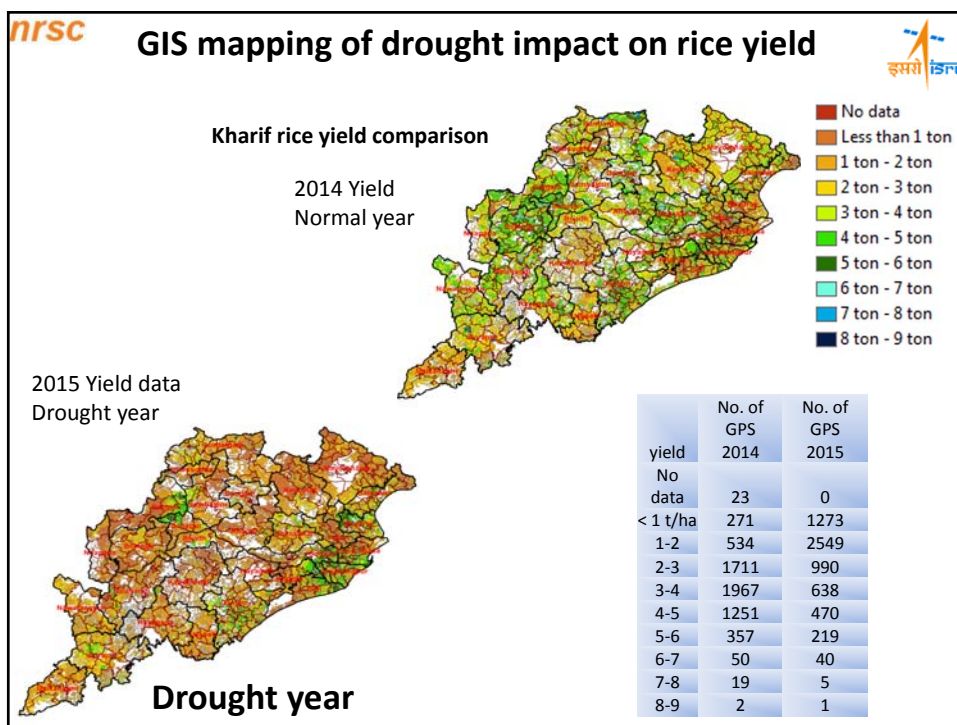
XYZ				nrsc		
Data Sources and related info.				Web Published VIC Model Derived Products		
Meteorological Data Source	Parameter	Resolution	Latency	Product	Resolution	Frequency
IMD Gridded data	Rainfall, Min, Max Temperature	0.5 degree	1 day	Water Balance Components for entire India	3min (~5.5km), 9min (~16.5km)	Daily
IMD AWS data	Rainfall, Min, Max Temperature	Point data (interpolated to 9min/3min)	1 day	Forecast Surface Runoff (d*+3)	9min (~16.5km)	Daily
IMD high density data (Godavari & Mahanadi)	Rainfall	Point data (interpolated to 3min)	1 day	Accumulated Surface Runoff	9min (~16.5km)	Daily
CPC	Rainfall	0.1 degree	2 days	Climate Indices – SPI, SRI (1, 3, 6, 12 Months)	9min (~16.5km)	Daily
GEFS	Rainfall, Min, Max Temperature	0.5 degree (interpolated to 9min/3min)	Daily forecast data	River Basin Wise Statistics	-	Weekly
APSDPS AWS data	Rainfall, Min, Max Temperature	Point data (interpolated to 3min)	1 day	WBC's for Godavari, Mahanadi River	3min (~5.5km)	Daily



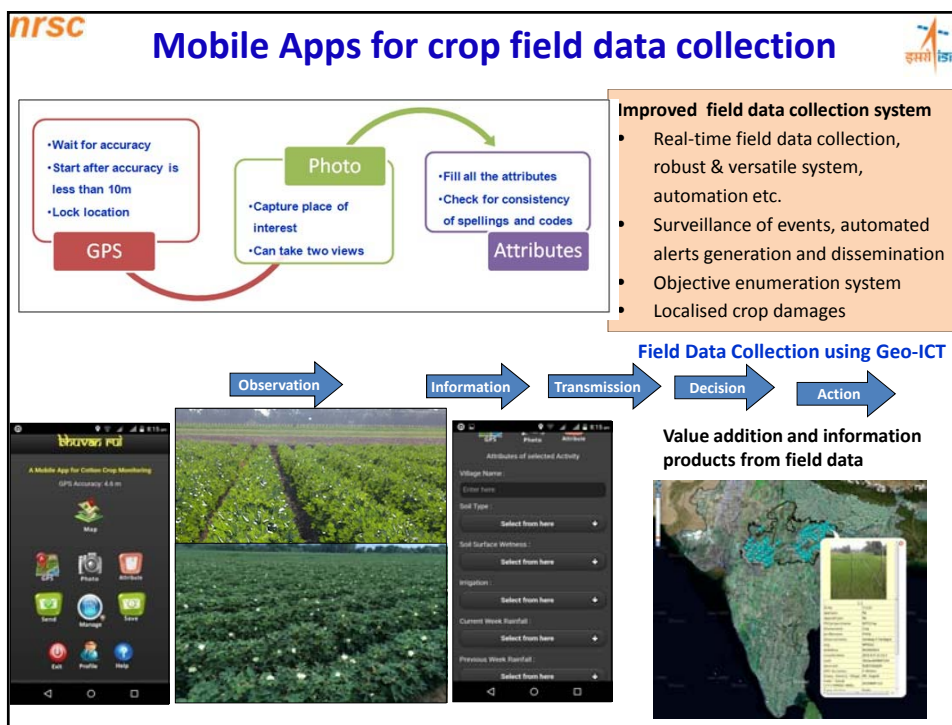
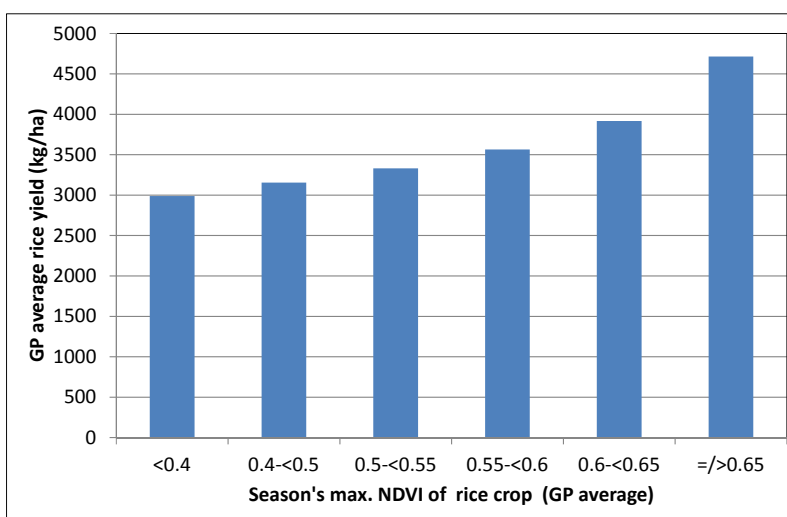



nrsc **Field enumeration for relief management** 

- Drought declaration
- Notification of affected areas
- Field enumeration
- Relief assessment and distribution




Paddy yield Vs. NDVI – kharif 2016, Odisha



nrsc **Analytics on the Mobile app based field data and generation of value added information products** 

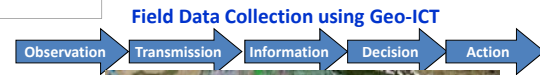
- Crop-sowing variability information - crucial input for (1) Crop management plans, (2) crop growth modelling based crop yield estimation
- Crop prospects information products – act as proxies for expected yield for crop insurance and drought impact assessment
- Information on Midseason adversaries – Pest/Disease incidence for crop management and crop insurance applications
- Evidence based verification final CCE yield data for crop yield assessment and indemnity computation in insurance
- Integration of mobile data with satellite data


nrsc **Mobile Apps** 

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

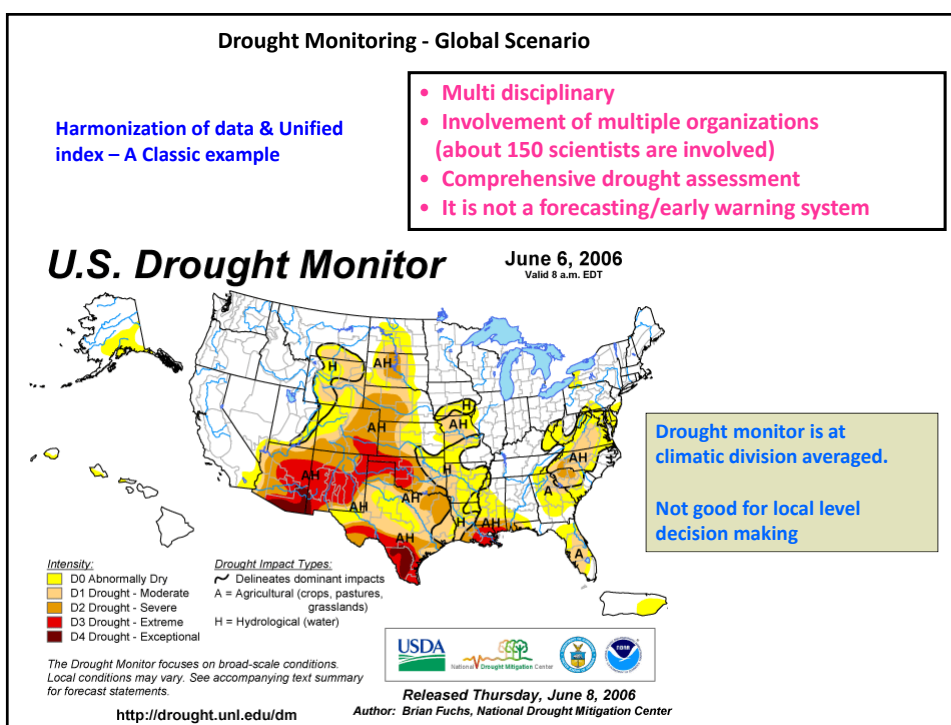
Field Data Collection using Geo-ICT





Value addition and information products from field data

nrsc	Global Scenario	
Details of International Systems for drought monitoring		
US Drought Monitor	Five Parameters <ul style="list-style-type: none"> Palmer drought index CPC Soil Moisture Model Standardized Precipitation Index (SPI) Satellite Vegetation Health Index VEG DRI – Drought response modelling with data mining techniques	
FEWS NET	<ul style="list-style-type: none"> NOAA NDVI Meteosat Rainfall 	
IWMI Drought Monitor	<ul style="list-style-type: none"> MODIS NDVI differences 	
FAO Drought Monitoring ARTEMIS/GIEWS	<ul style="list-style-type: none"> NDVI Difference between Current Decade and Average (SPOT 4) Cold Cloud Duration 	
China Drought Monitoring	NDVI deviation from coarse resolution data, LST	



Criteria in US Drought monitor

Category	Palmer drought index	CPC soil moisture model	Stream flows	SPI	Satellite Vegetation health index
Normal	-1 to -1.9	21-30	21-30	-.5 to -.7	36-45
Moderate drought	-2 to -2.9	11-20	11-20	-.8 to -1.2	26-35
Severe drought	-3 to -3.9	6-10	6-10	-1.3 to -1.5	16-25
Extreme drought	-4 to -4.9	3-5	3-5	-1.6 to -1.9	6-15
Exceptional drought	-5 or less	0-2	0-2	-2 or less	1-5