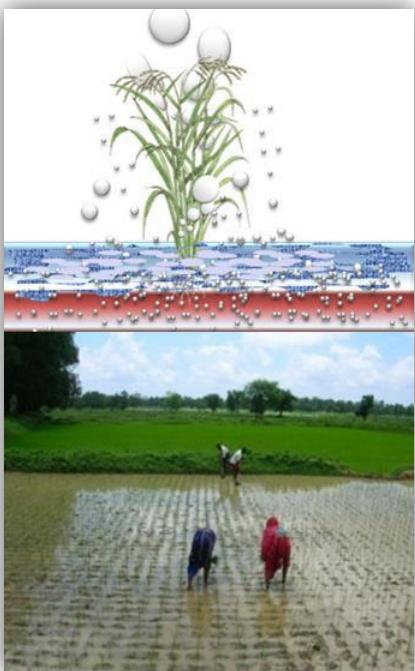
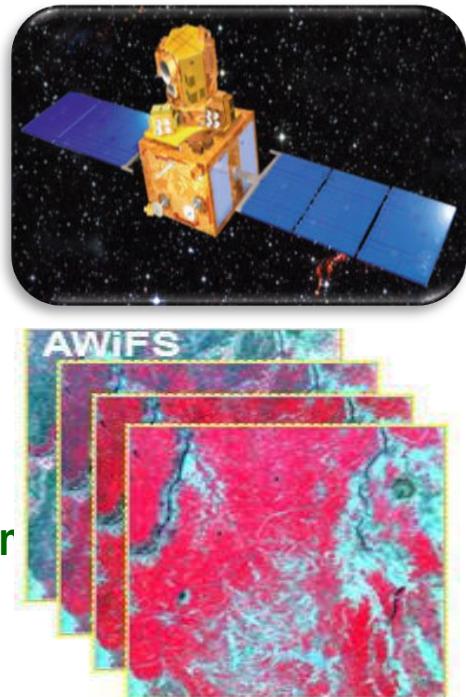


Agriculture Management using EO data in India



K R Manjunath
Indian Space Research Organisation
Bangalore, INDIA
krmanjunath@isro.gov.in



September 19, 2017

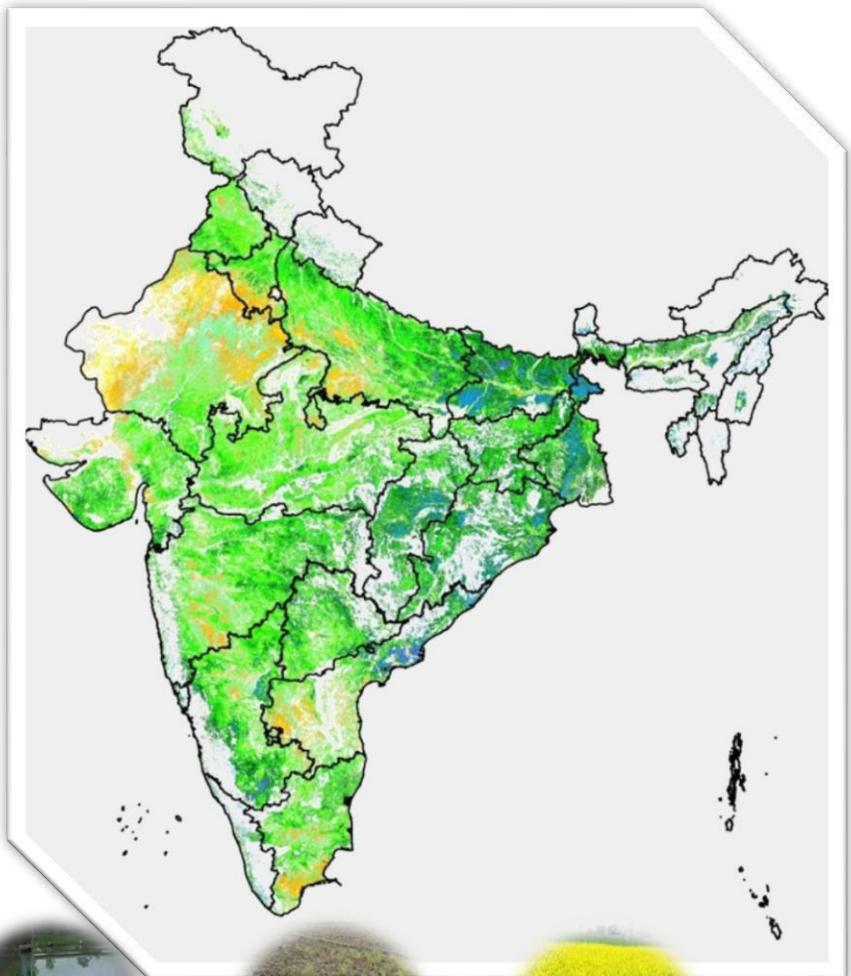
Presentation Structure

- The Indian agriculture – salient features
- Indian Earth Observation sensors – in support of Agriculture
- The EO Agriculture: The Operational programmes
- The R&D aspects of Agriculture addressed
- The techniques for other agriculture issues- few examples
- Linking with line departments
- Capacity building
- Wayforward and focus

- Production
- Resources
- Operationalisation
- R&Ds
- Systems analysis
- Advisories

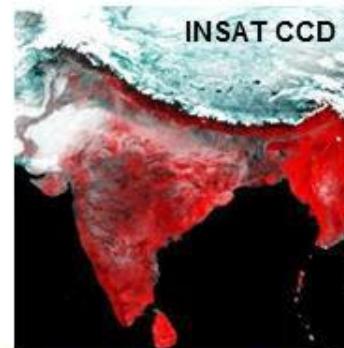
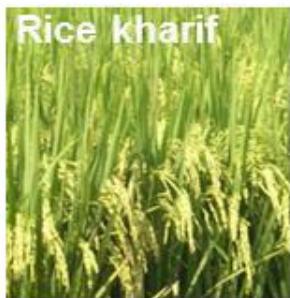
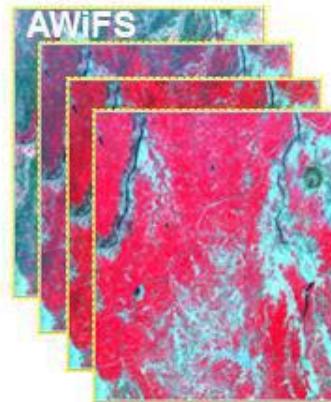
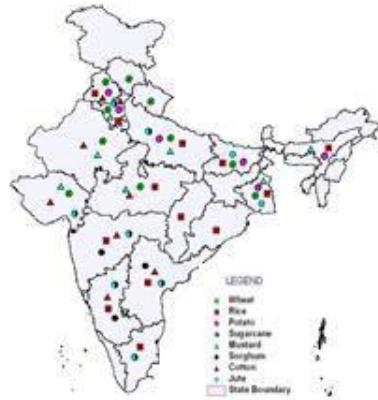
Indian Agriculture

DIVERSITY



The 10th GEOSS Asia-Pacific Symposium “Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region” Hanoi, Vietnam, 18-20 September 2017

Crop Monitoring using Remote Sensing



Indian Agriculture

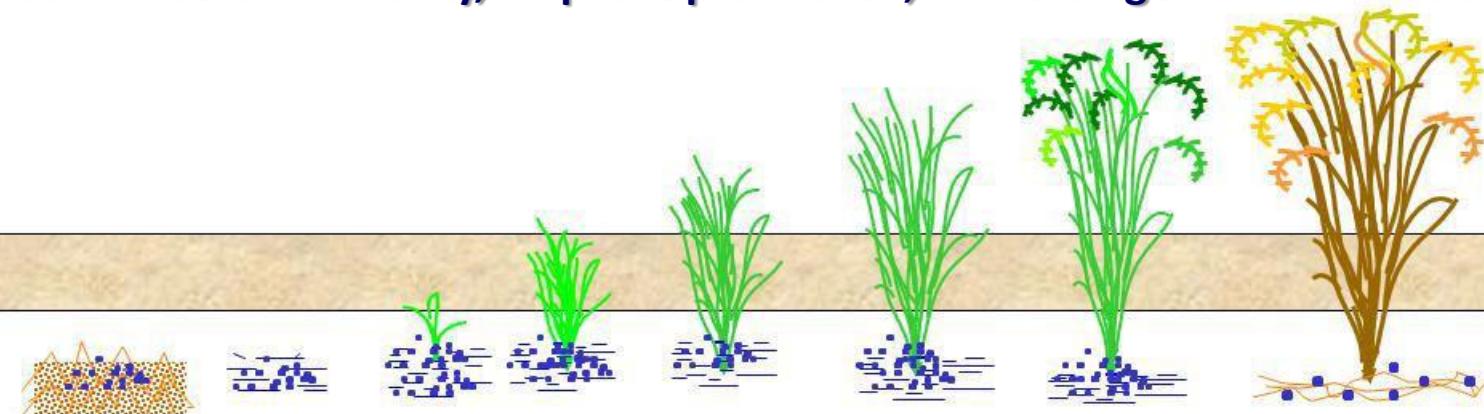
Information Need in Agriculture and Sources

(Crops, Horticulture, Fisheries, Agriculture, Dairy)

Information Need: Forecast, actual area sown, stage, production, condition, anomaly,

Weather Forecast	Initial Moisture	Actual Rainfall	Weather	Crop Vigour	Weather	Pest diseases	Infrastructure, Price	Residual Moisture
------------------	------------------	-----------------	---------	-------------	---------	---------------	-----------------------	-------------------

Goal: Assess availability, Improve production, Plan storage and distribution



Source: SAR, Optical, Sounders, Field, expert knowledge

IMD, AWS INSAT	SAR Passive MW	SAR	AWIFS/LISS SAR	AWIFS SAR	Multi-source	Multi-source	Multi-source	Integrated
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22-Sep-17

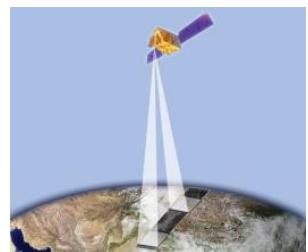


The 10th GEOSS Asia-Pacific Symposium "Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region" Hanoi, Vietnam, 18-20 September 2017

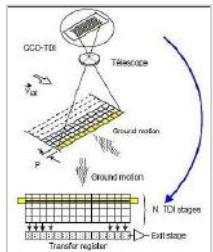


Earth Observation Sensors for Agriculture

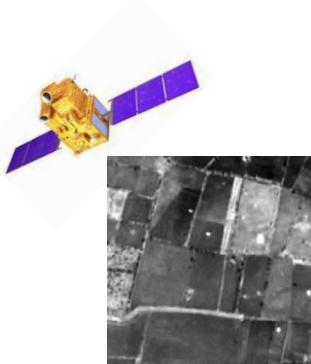
Indian EO Satellites: Evolution



Stereo imaging



TDI Imaging



TDI Imaging

Cartosat 2 Series (2016)
0.6 m, 11 bits

Altimeter
(2013)

Microwave
(2012)

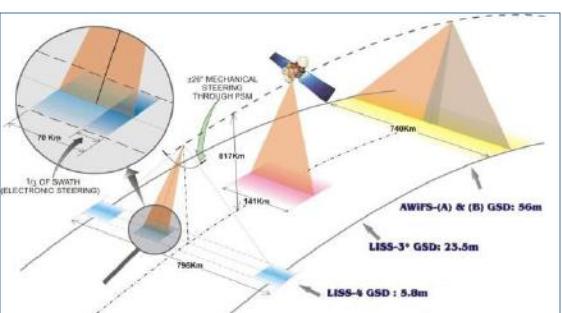
Scatterometer
(2009)

Stereo imaging

Cartosat 1 (2005)
2.5 m, 10 bits,

TES (2001)
~1 m, 10 bits

Step-and-Stare



3 tier imaging



3 tier imaging

Resourcesat 1/2/2A (2003/ 11/ 16)
6 to 56 m, 7-14 bits, 5 / 24 days

Spatial Resolution

1 Km → 0.6 m

Temporal Resolution

24 days → 2.5 days

Spectral Resolution

7 bits → 14 bits



IRS IC/ID (1995/ 1997)

6 to 188 m , 7 bits
5 / 24 days

Operational Satellites



2 tier imaging

IRS 1A/1B (1988/ 91)
36/72 m, 7 bits, 22 days



Bhaskara-1/2 (1979/ 81)

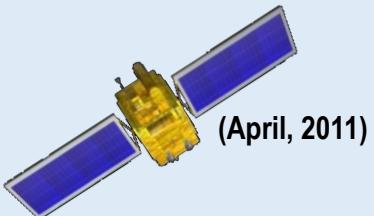
1 Km resolution OSS Asia-Pacific Symposium "Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region" Hanoi, Vietnam, 18-20 September 2017

Indian EO Programme: Current Satellites

LAND & WATER

RESOURCESAT-2

LISS-3, LISS-4, AWIFS



(April, 2011)

RISAT-1

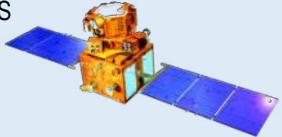
C-Band SAR



(April, 2012)

RESOURCESAT-2A

LISS-3, LISS-4,
AWIFS



(Dec., 2016)

HIGH RESOLUTION

CARTOSAT-1

2.5m PAN stereo



(May, 2005)

CARTOSAT-2

0.8 m PAN



(Jan, 2007)

OCEAN

OCEANSAT-2

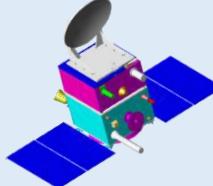
OCM, Scat, Rosa



(Sept, 2009)

SARAL

Ka-Altimeter



(Feb, 2013)

SCATSAT-1

Ku Scat

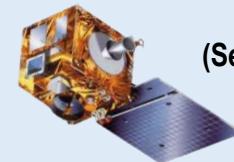


Sept, 2016

WEATHER; CLIMATE

KALPANA

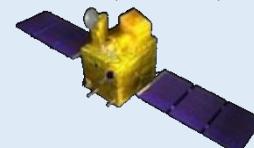
VHRR



(Sept, 2002)

MEGHA-TROPIQUES

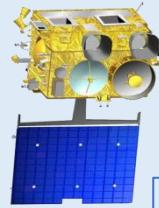
MADRAS, SCARAB, SAPHIR, ROSA



(Oct, 2011)

INSAT-3D

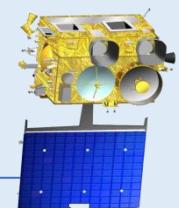
Imager, Sounder



(July, 2013)

INSAT-3DR

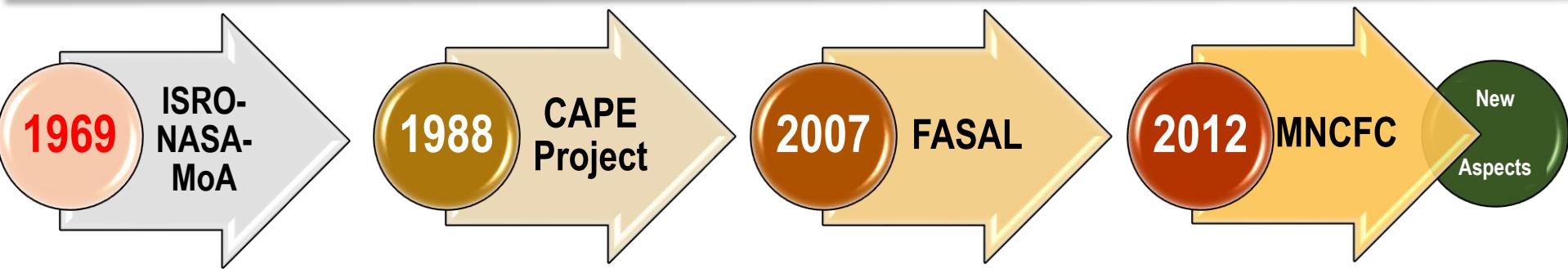
Imager, Sounder



8
(Sept, 2016)

Operational Programme of Agriculture

48 Years of use of Space Technology in Agriculture



FASAL – Forecasting Agricultural output using Space, Agro-meteorology and Land based observations

Coconut Root Wilt study in Kerala

Area & production Estimates of major crops at State level.

District-State-National forecasts using multiple approaches & satellites for multiple forecasts

Operationalisation of Space Technologies developed by ISRO

Pre-harvest Production Forecast

Rice, Wheat, Rapeseed/Mustard, Rabi Sorghum, Winter Potato, Sugarcane, Cotton, Jute

National level: Kharif rice, rabi rice, wheat, jute, potato, mustard

District level : Wheat, cotton, mustard, sorghum, sugarcane



22-Sep-17

First Estimate
Early stage

Satellite Images
Ground Data
Temp./ Rainfall



Second Estimate
Mid Season

Satellite Images
Meteorological data
Ground data



Third Estimate
Before harvest

Integrated Models
Remote Sensing &
Agro-meteorology

FASAL

- Crop Forecasting
- 8 Major Crops
- District/State/National Level
- SAR & Optical Data

NADAMS

- Drought Assessment
- District/Sub-District Level
- Multiple Satellite Data
- Weather, Crop, Soil Moisture Inputs

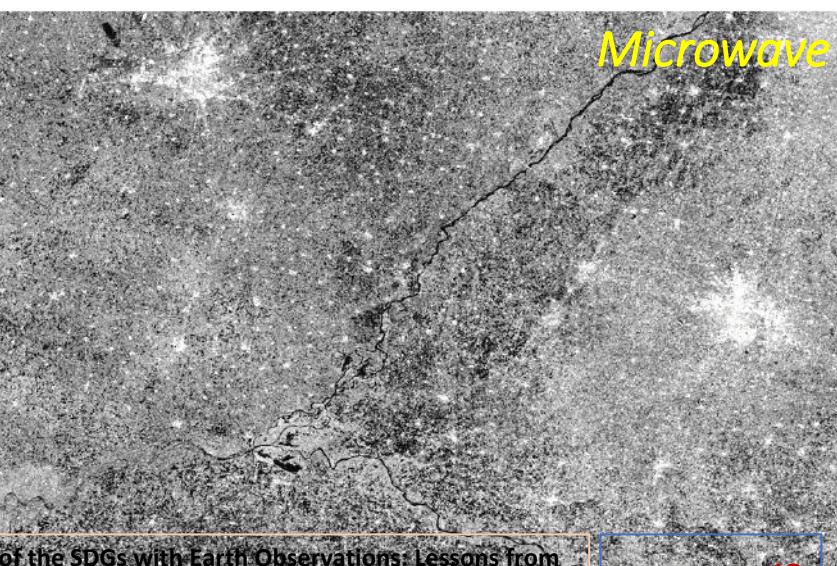
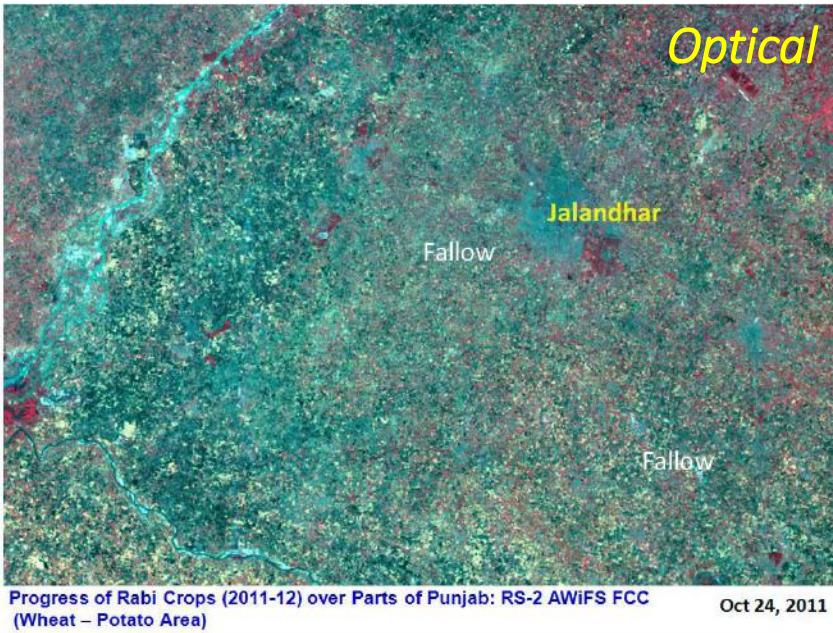
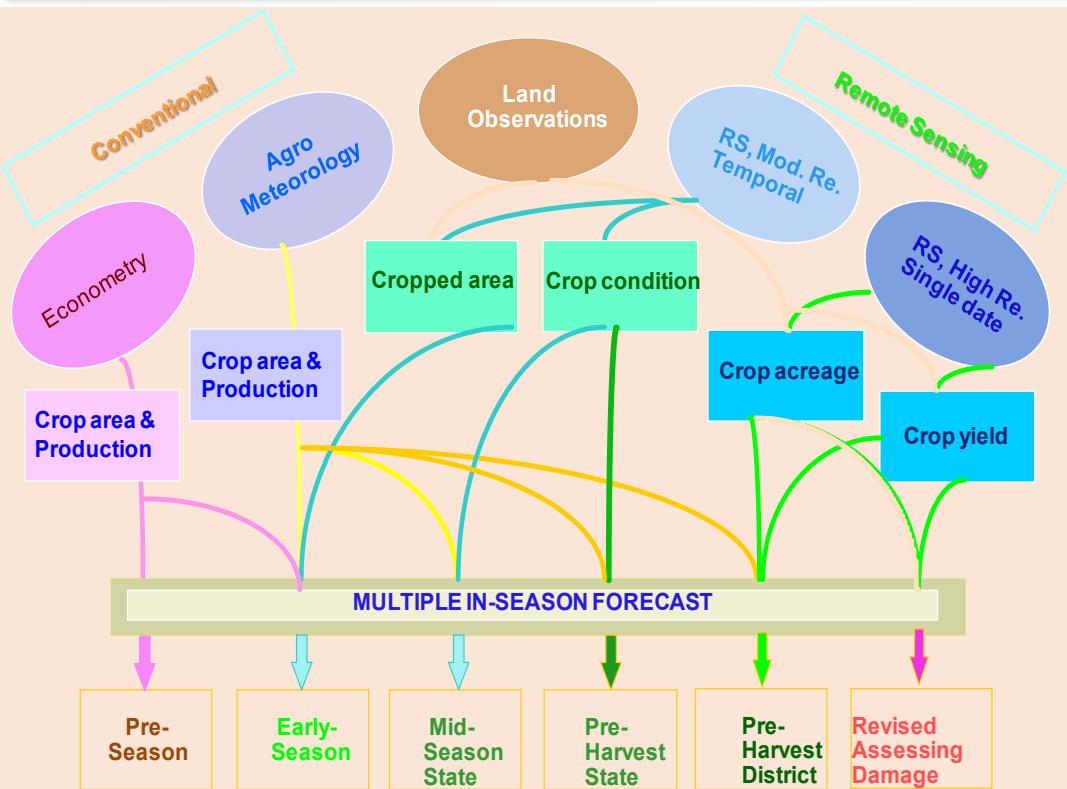
CHAMAN

- Horticultural Crops
- 7 Crops in 185 Districts
- Horticultural Developmental Plans
- Precision Farming

KISAN

- Technology for Crop Insurance
- High Resolution Data
- CCE Planning and optimization
- UAVs for Loss Assessment

Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL)



Multiple Pre-harvest production forecasts of 8 major crops

Both optical (R2 AWIFS & LISS III; L8 OLI; S2 MSI) and Microwave (RISAT-1 SAR/Sentinel 1) Data

Spectral Yield Model (Empirical/Semi-physical)

18 forecasts in a year at National/ state/ district level

>90 partner organisations (DACFW, 3 ISRO centres, 19 SDAs, 18 SRSACs, 46 AMEUs, IEG, IMD, MNC, NCPOR, DOSS Asia-Pacific Symposium "Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region" Hanoi, Vietnam, 18-20 September 2017

Aims at providing multiple pre-harvest production forecasts of crops at National/State/ District level

National/State forecasts:

- Kharif Rice (3 Forecasts, 13 states)
- Rabi Rice (1, 4)
- Wheat (3,6)
- Winter potato (2, 4)
- Rapeseed & Mustard (3,5)
- Jute (1,3)

State/District forecasts:

- Cotton (1,7)
- Sugarcane (1,3)
- Rabi Sorghum (1,2)



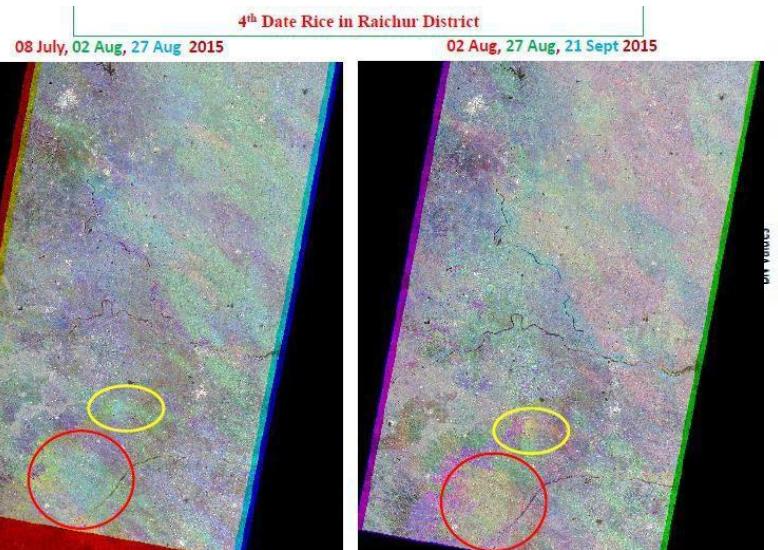
What is New?

- Real-time Ground-truth by State Agriculture Departments
- Complete Indian Data (RISAT & Resourcesat)
- FASALSoft Implementation
- Operational integration of district-level yield modeling by IMD
- Feedback from State Agriculture Departments
- New Sampling Plan for Jute, Cotton, Sugarcane, Rabi Sorghum....
- Spectral Modeling for Final forecast of Rice (K) and Wheat, with help from ISRO

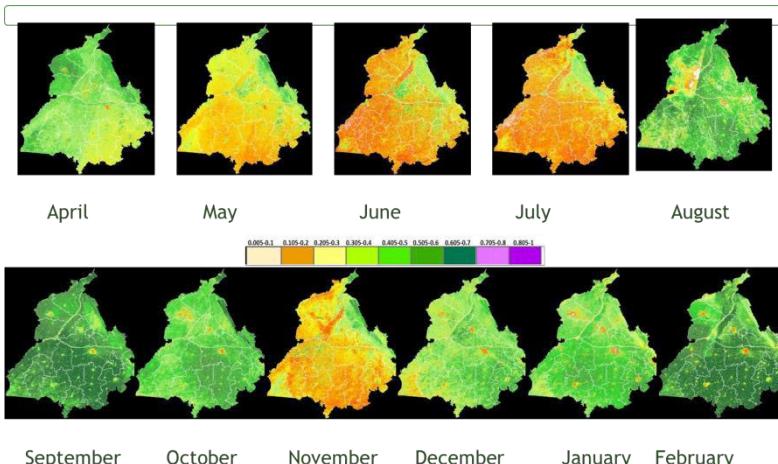


Satellite Data use in FASAL Project

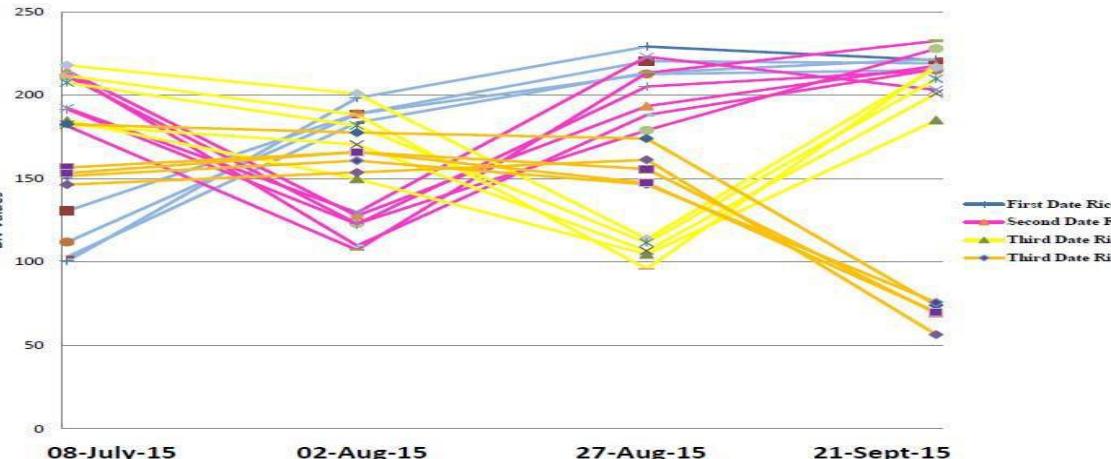
RISAT 1/Sentinel SAR Data for Rice & Jute



Multidate AWIFS NDVI Product for State level Estimation

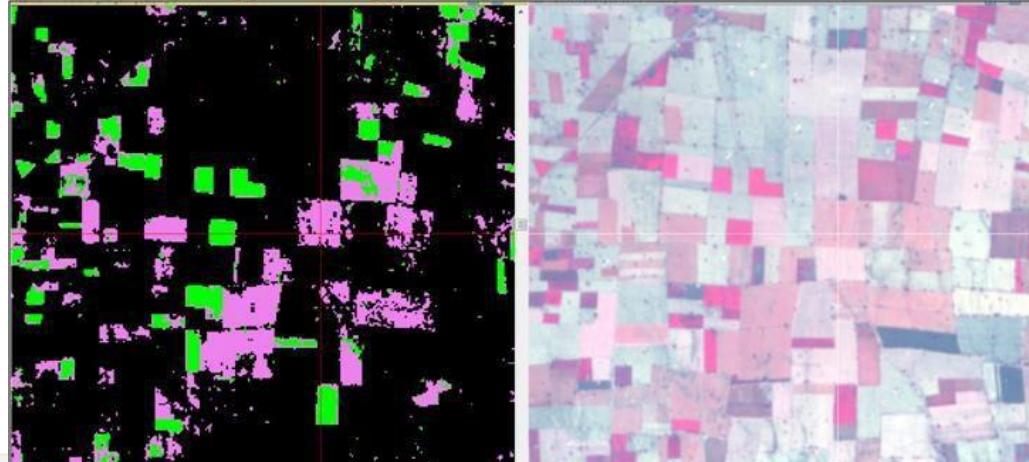


4-Date Rice Profiles

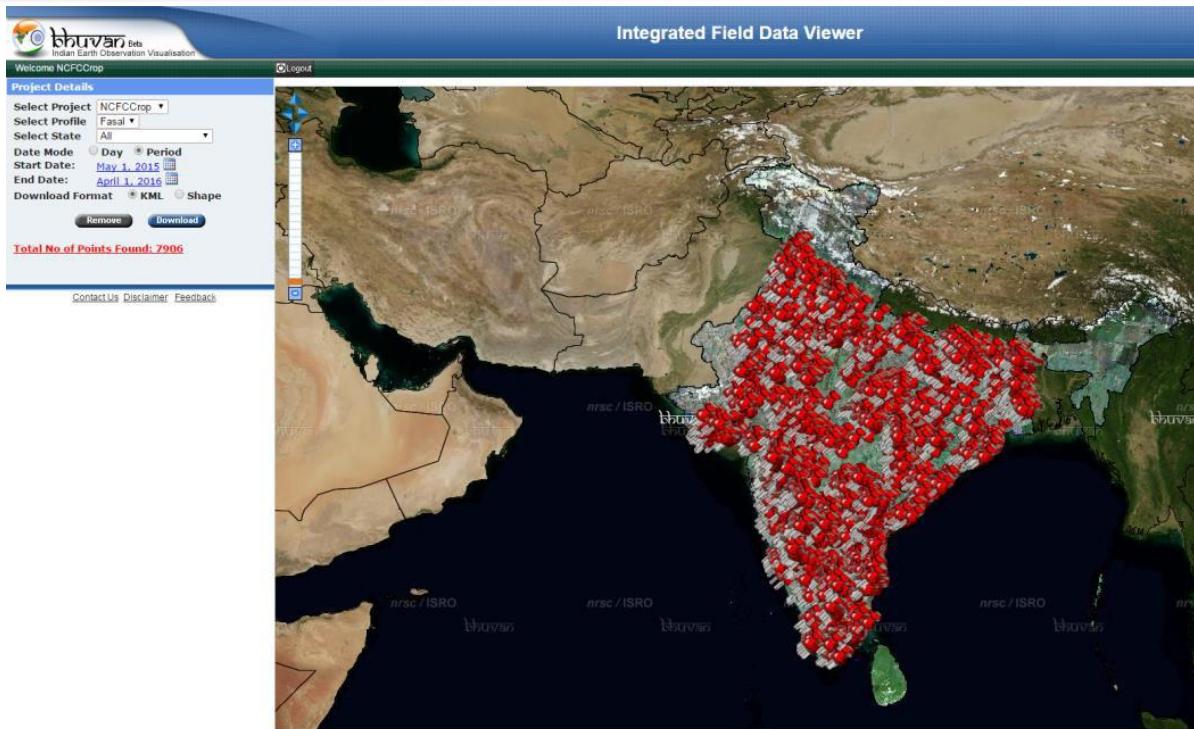


LISS III/ Landsat/Sentinel Data for District Level Assessment

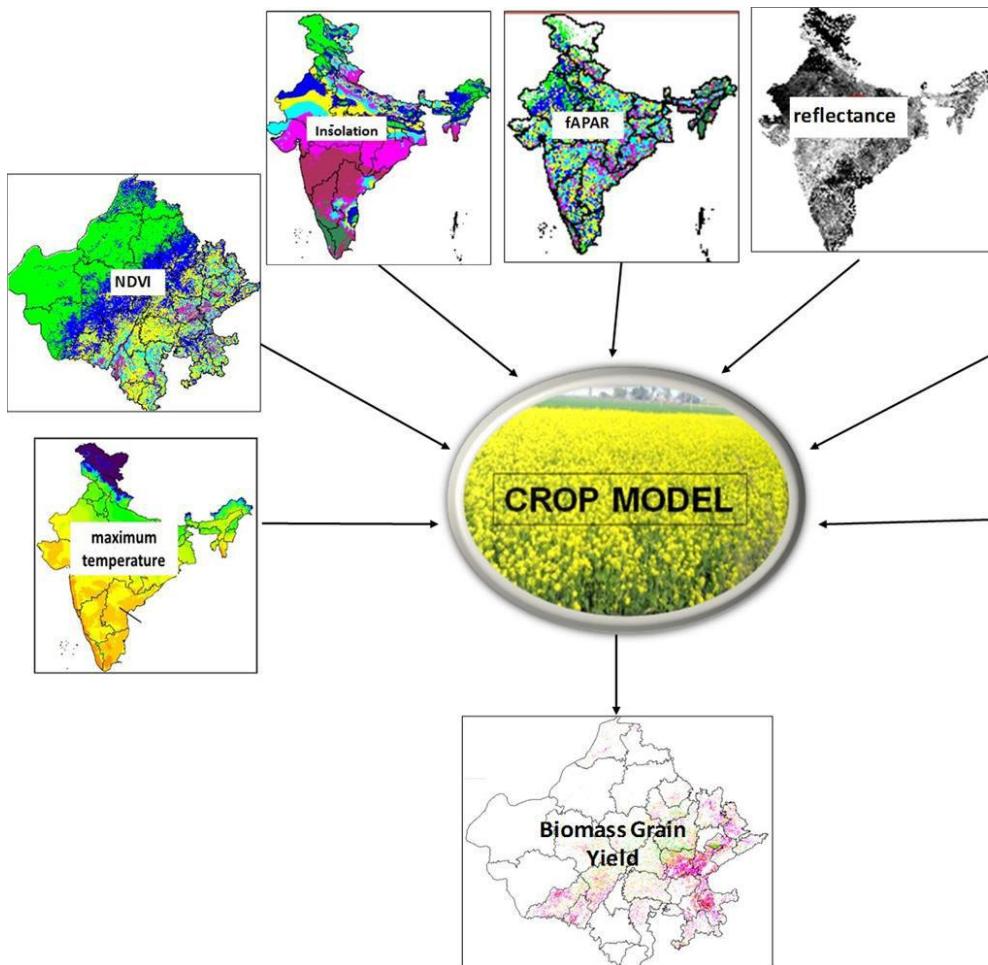
Classified Image showing the Rabi Sorghum and Tur Crop



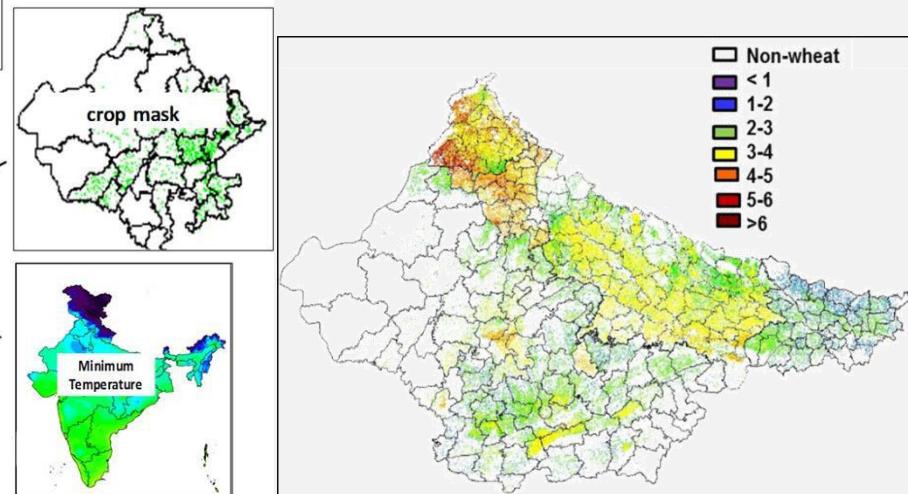
Smartphone for Field Data Collection



Modelling framework



Yield Map



Rice Yield Models

(14 rice states in Kharif and 4 in Rabi)

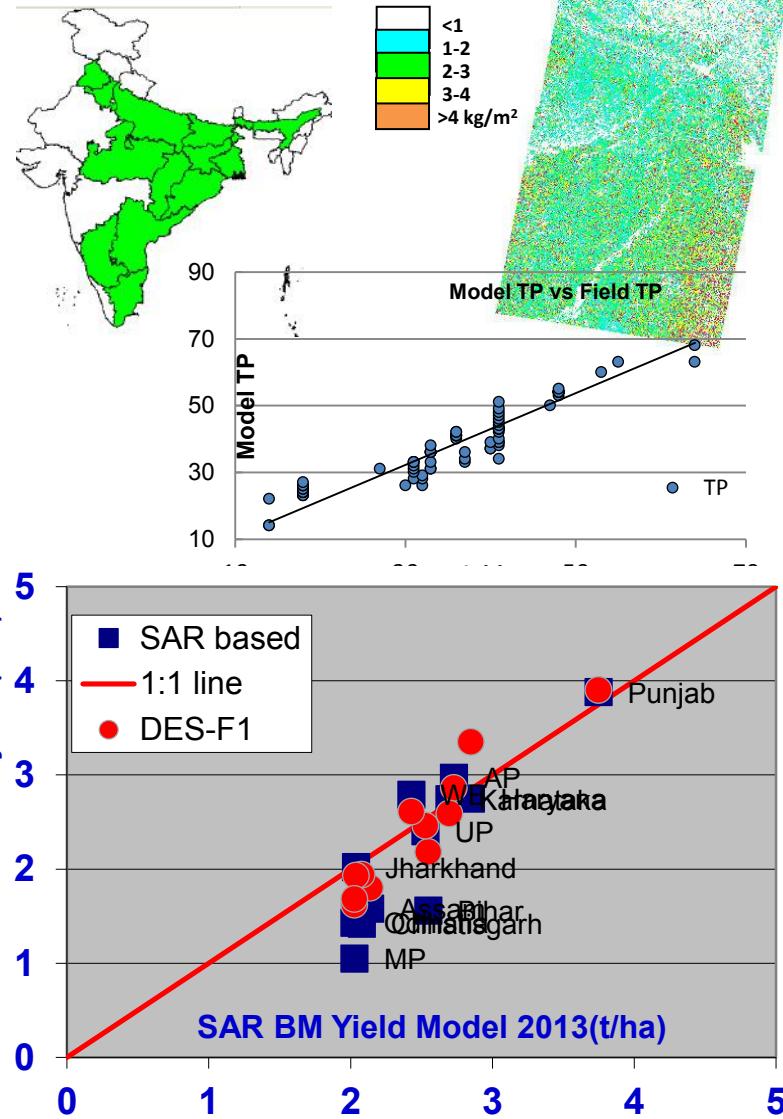


- Rice biomass and transplantation date retrieval from multitemporal SAR data.
- Current season analysis completed for all 14 states during November with MNCFC.

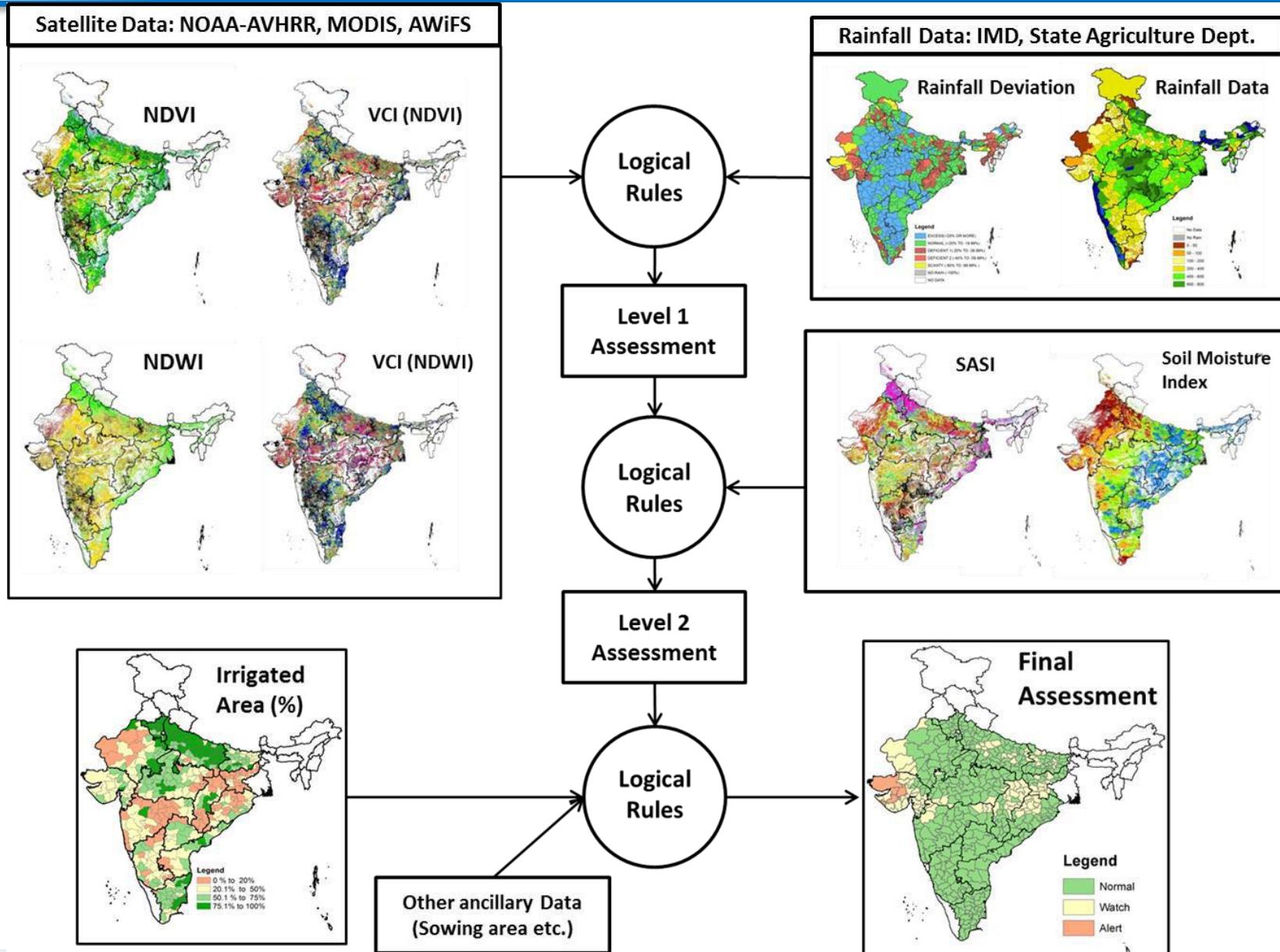
State	Biomass (kg/m ²)	HI	Grain yield 2013-14	RS&Met (2013-14)
AP	3.41	0.4	2.73	2.882
Assam	3.56	0.3	2.14	1.934
Bihar	3.54	0.36	2.55	2.22
Chhattisgarh	3.47	0.3	2.08	1.669
Haryana	3.56	0.4	2.85	2.843
Punjab	3.75	0.5	3.75	3.786
Jharkhand	3.39	0.3	2.04	2.024
MP	3.39	0.3	2.03	1.371
UP	3.61	0.35	2.53	2.371
WB	3.37	0.36	2.43	2.459
Odisha	3.38	0.3	2.03	1.774
Tamil Nadu	3.45	0.4	2.76	3.115
Karnataka	3.37	0.4	2.70	2.744

Rabi Rice-2014 Yield Estimation			
State	Biomass	Harvest Index	Yield(t/ha)
AP	3.67	0.42	3.08
Karnataka	3.37	0.42	2.83
Odisha	3.51	0.40	2.81
West Bengal	3.67	0.40	2.94

Biomass map for part northern Punjab 2014 (right)using RISAT systematic MRS data.

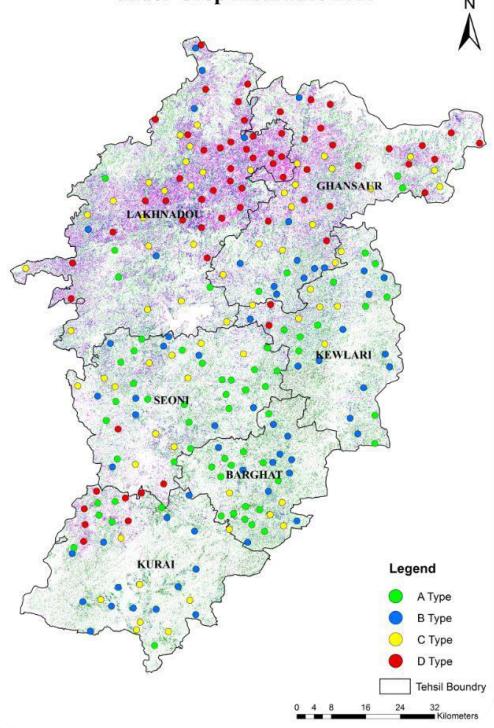


NADAMS: Drought Assessment

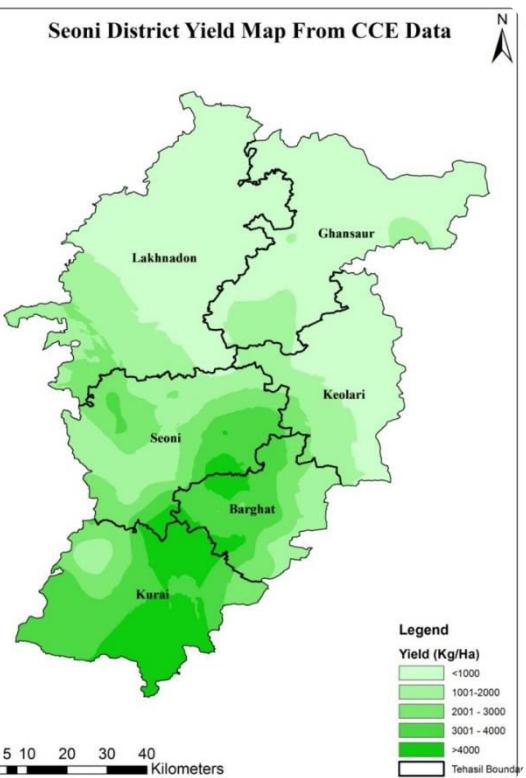


Improving Quality of Crop Cutting Experiment

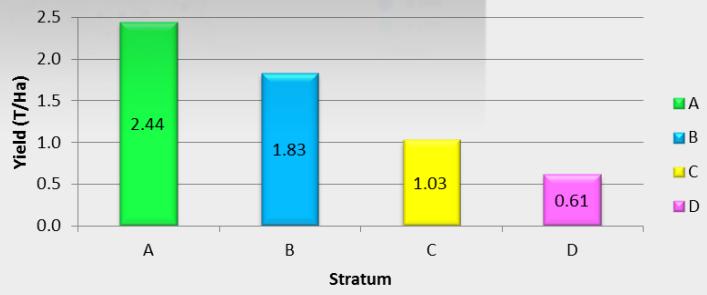
CCE Points for Seoni district of Madhya Pradesh under Crop Insurance 2015



Seoni District Yield Map From CCE Data

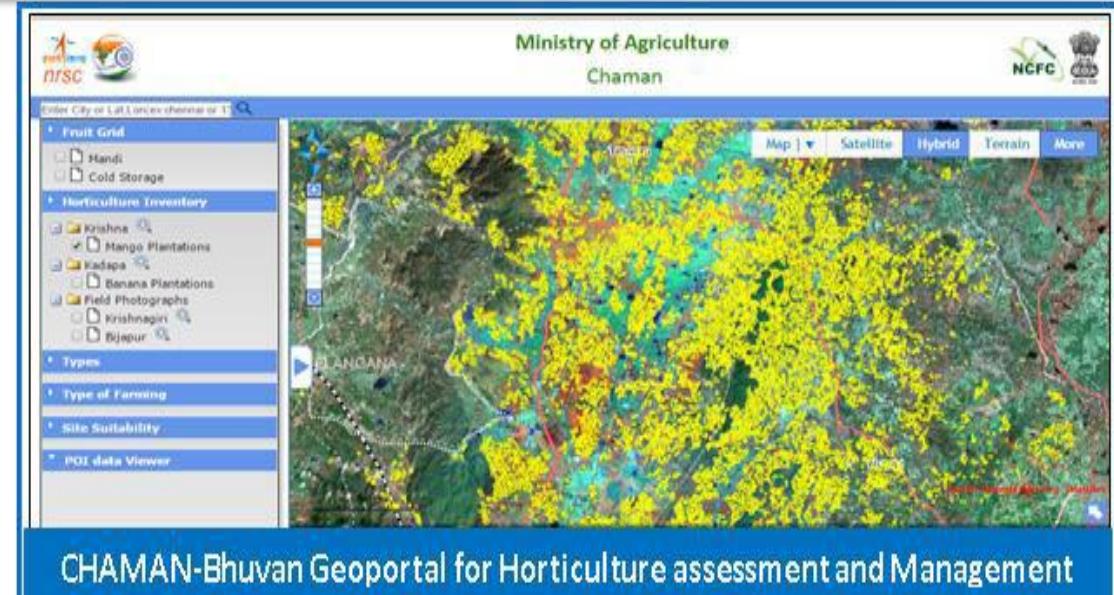


Stratumwise Average Yield in Seoni District (MP)

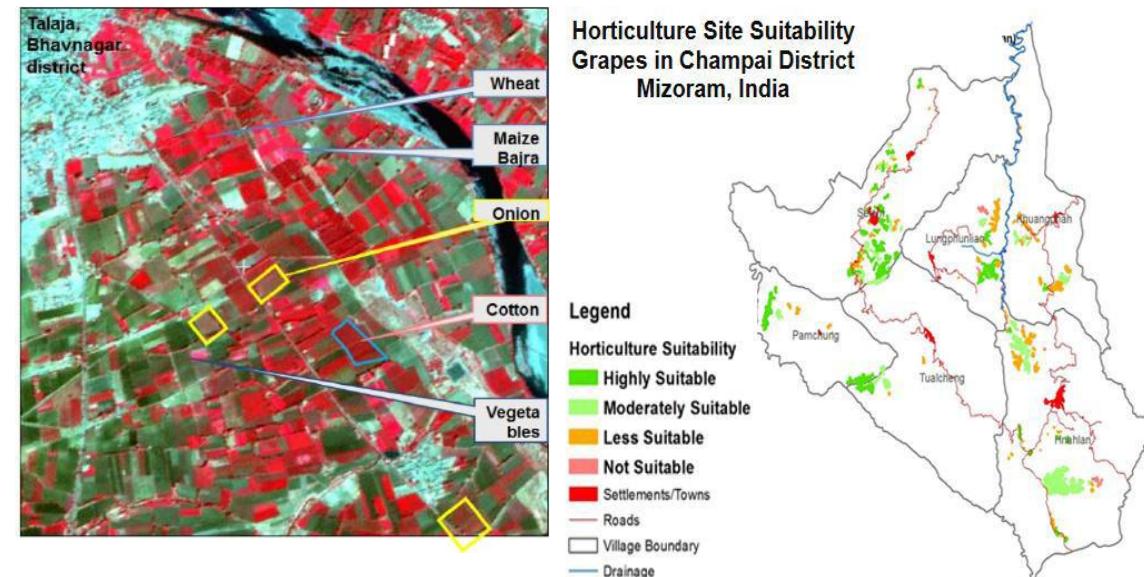


HORTICULTURAL CROP INVENTORY & SITE SUITABILITY

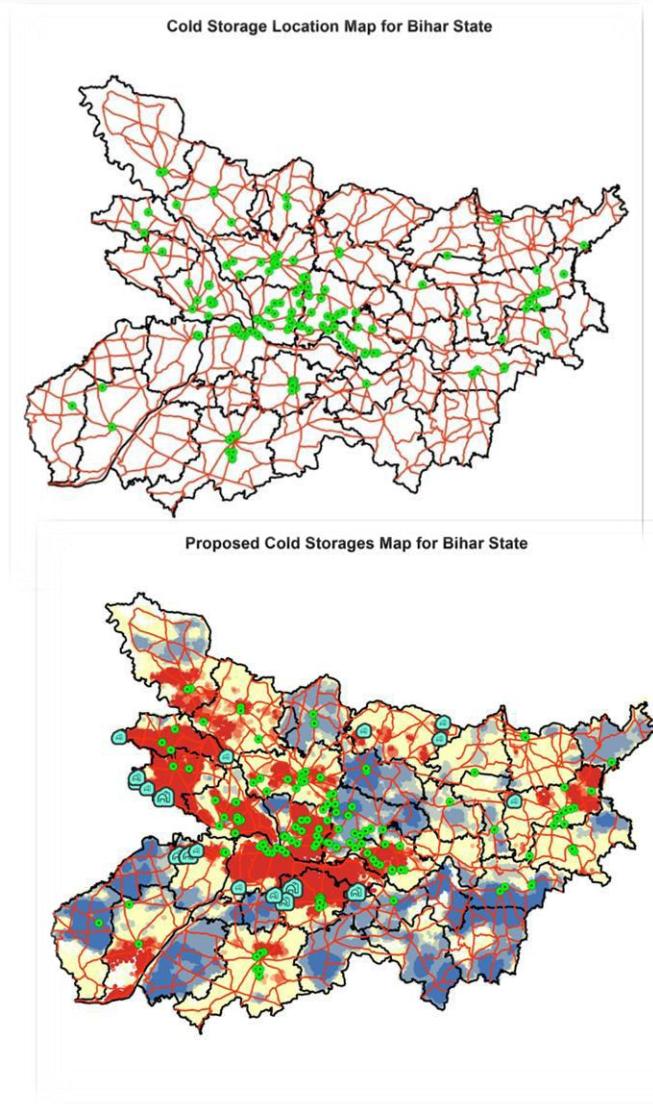
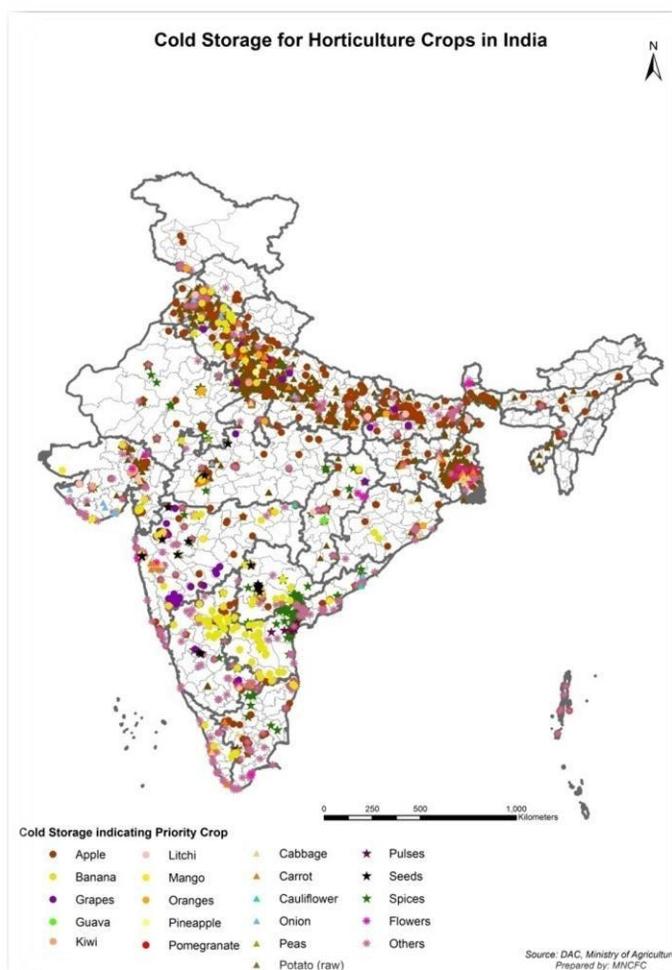
- Area assessment & production forecasting of 7 major horticultural crops in 188 districts
 - Mango, Citrus, Banana, Onion, Potato, Chilli, Tomato
- Geospatial applications for horticultural development & management planning
 - Site suitability analysis
 - Optimum locations of post-harvest infrastructure
 - Areas for intensification & rejuvenation
- Scientific studies: crop identification, yield modelling and disease assessment
- Geoportal for horticulture inventory
- Input for large Govt programme



CHAMAN-Bhuvan Geoportal for Horticulture assessment and Management



Agricultural Infrastructure Planning



Existing

Proposed

Support to Flagship Programme of Governmental Programmes of Agriculture

Pradhan Mantri Fasal Bima Yojana

- Area Discrepancy
- Loss Assessment
- Yield Assessment
- Mid Season Adversity

Pradhan Mantri Krishi Sinchai Yojana

- Waterbody Mapping
- Watershed Development
- Irrigation Scheduling (per drop more crop)

Soil Health Card

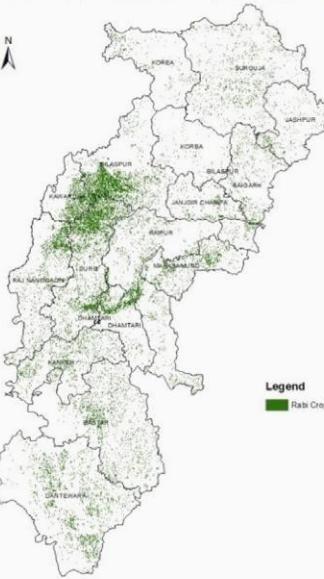
- Targeted Soil Sampling
- Geospatial Database

Crop Intensification: Rice-Fallow Area

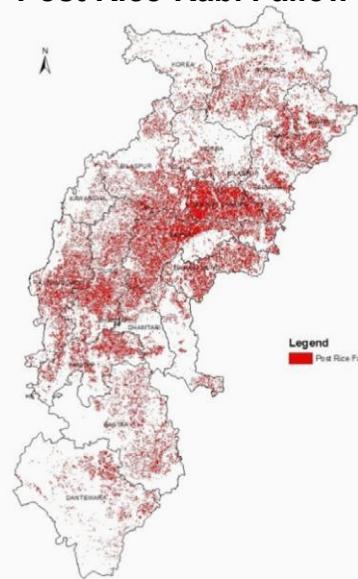
Paddy Crop Area (2015-16): Chhattisgarh



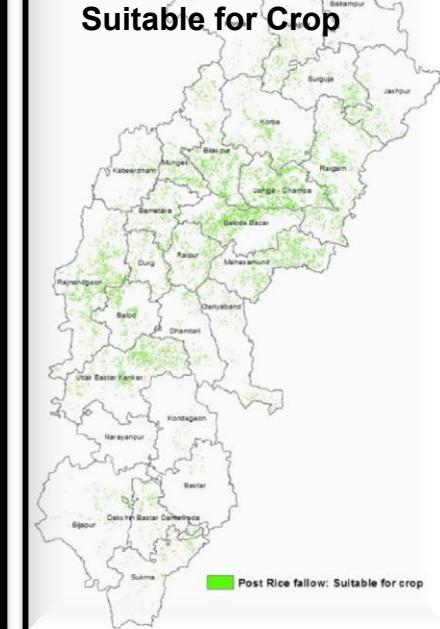
Rabi Crop Area (2015-16): Chhattisgarh



Post Rice-Rabi Fallow



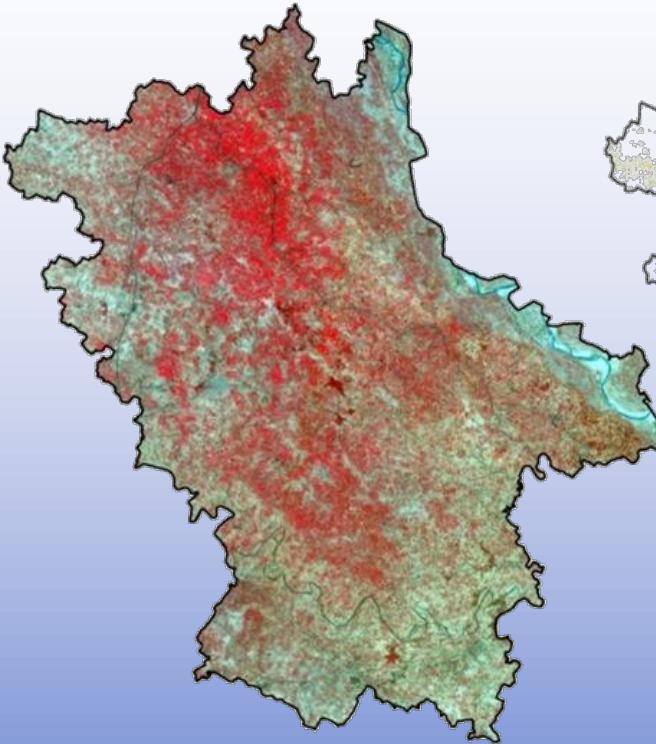
Post Rice-Rabi Fallow,
Suitable for Crop



HIGH VALUE CROPS: MAPPING AND ASSESSMENT OF MINT CROP

R2 LISS-III data 22-May-2016

Spices Board, Ministry of Commerce



Mint crop distribution

Mint Area=85,386 ha

Crop status	Mean Biomass ($t\ ha^{-1}$)
Poor	9.6
Medium	17.4
Good	21.0
Very good	26.1

Study area: Barabanki, UP

Season: Summer 2016

Expansion to other regions of UP and Bihar is being carried out using conducive parameters

- Vertical expansion / Crop intensification through second/ third crop
- Rural job expansion/ family employment through out the year
- Value of employment: Rs. 128 Crores (for district)
- Simple local oil extraction scheme- links product and produce to industry
- Net Return to farmer: Rs. 52,000 / ha, Benefit-cost ratio: 2.05
- Value of menthol oil per Cu.M of water: Rs. 168 – 224

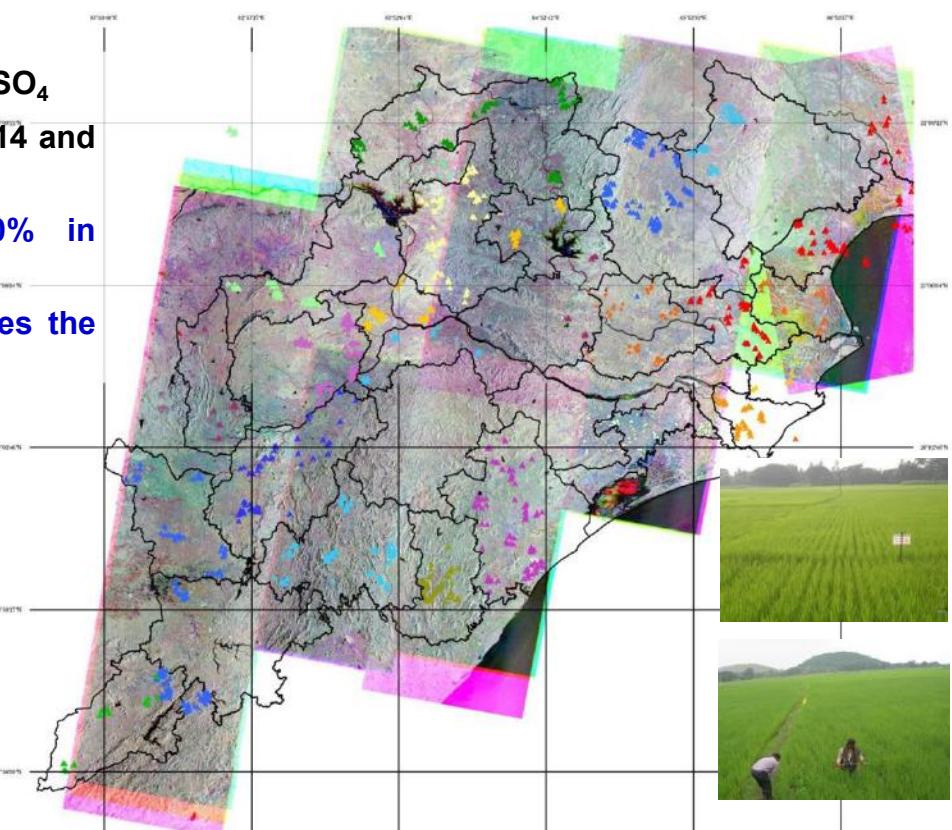
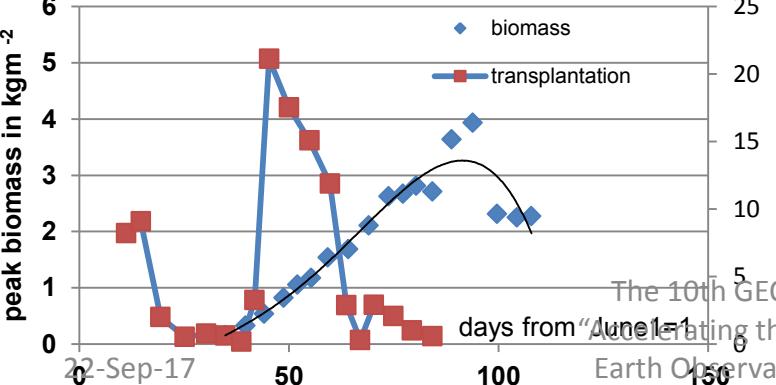
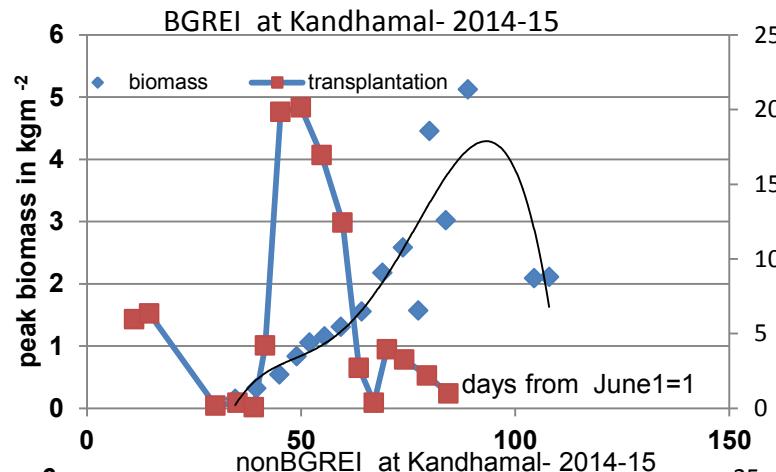
RKVY: Bringing Green Revolution in Eastern India (BGREI)

Inputs: seeds, irrigation inputs, nutrients including $ZnSO_4$

Kandhamal and Anugul shows highest increase in 2014 and 2013 respectively- 30% in biomass

NW-central Orissa show marginal increase 5-10% in biomass.

CV is lower due to uniformity of the practice, reduces the patchiness .

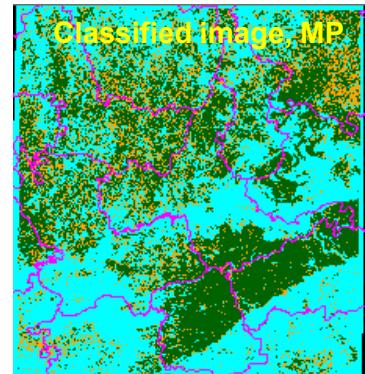
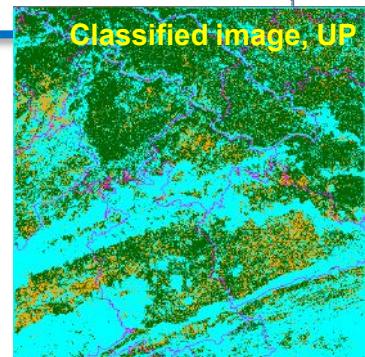
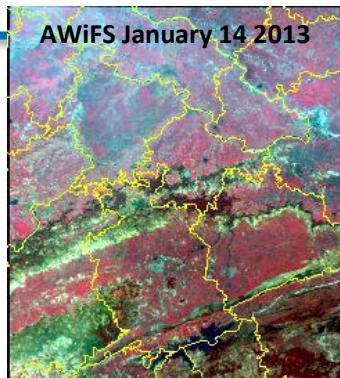
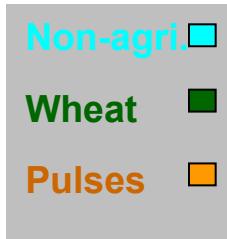


Physiographic zones	Gross percentage change in peak biomass of BGREI over non-BGREI	
	2012-13	2013-14
Coastal Odisha	12%	7%
Central Odisha Plateau	16%	13%
North-western irrigated belt	7%	3%
Southern highlands	21%	28
		8%

National Food Security Mission - Pulse Intensification Programme-



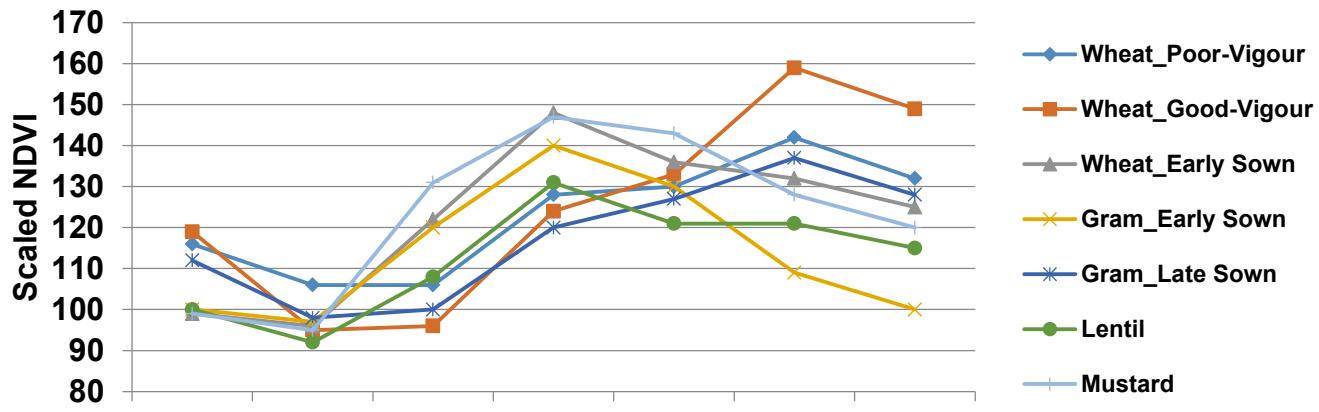
- Pulses crop discrimination using multi-date AWiFS data LISS III for detailed study.
- Optimum data set determination for pulses crop discrimination.
- Multiple area estimates of pulses crop.
- Multi-date AWiFS data of Oct.2013-Mar. 2014



Pulses area estimates for study area for Rabi season

Year	MP (20 dists)	MP (20 dists)	UP (10 dists)	UP (10 dists)	Karnatak a	Karnatak a
	F1 ('000 ha)	F2 ('000 ha)	F1 ('000 ha)	F2 ('000 ha)	F1 ('000 ha)	F2 ('000 ha)
2012-13	2125.35	2311.18	636.54	989.43	-	-
2013-14	1627.90	2007.40	875.60	1362.90	-	1699.68

Spectral-temporal profiles of pulse and major Rabi crops



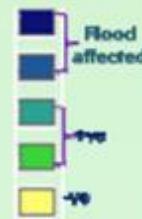
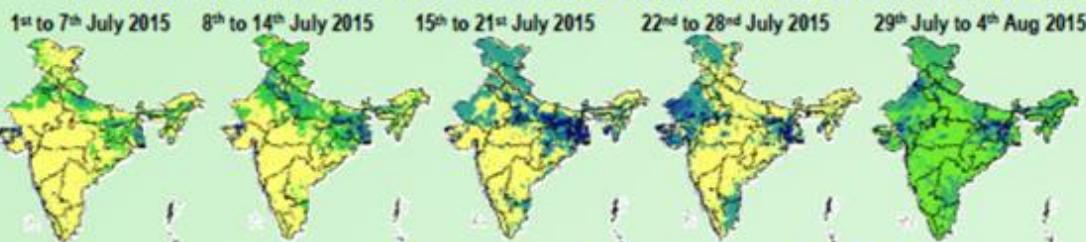
Additional EO R&D Components to Agriculture

Weekly Agricultural Outlook of India from Space-based Observations during July-August 2015



Change in soil moisture status from long term mean

Status of Surface Soil Moisture from Passive Microwave Radiometer, AMSR-2

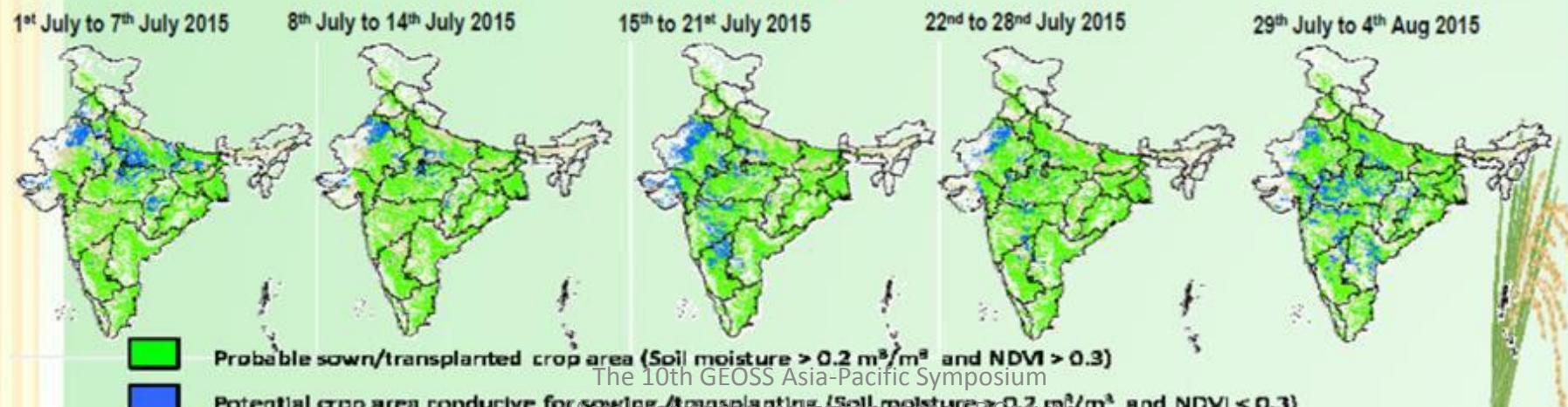


Change in agricultural vigour from long-term mean

Status of Agricultural Vigour from INSAT 3A



Analysis of INSAT 3A CCD NDVI and AMSR-2 Soil moisture for July for early agricultural situation over India



Probable sown/transplanted crop area (Soil moisture > 0.2 m³/m³ and NDVI > 0.3)



Potential crop area conducive for sowing/transplanting (Soil moisture > 0.2 m³/m³ and NDVI < 0.3)

Permanent agricultural area

The 10th GEOSS Asia-Pacific Symposium

Accelerating the realization of the SDGs with

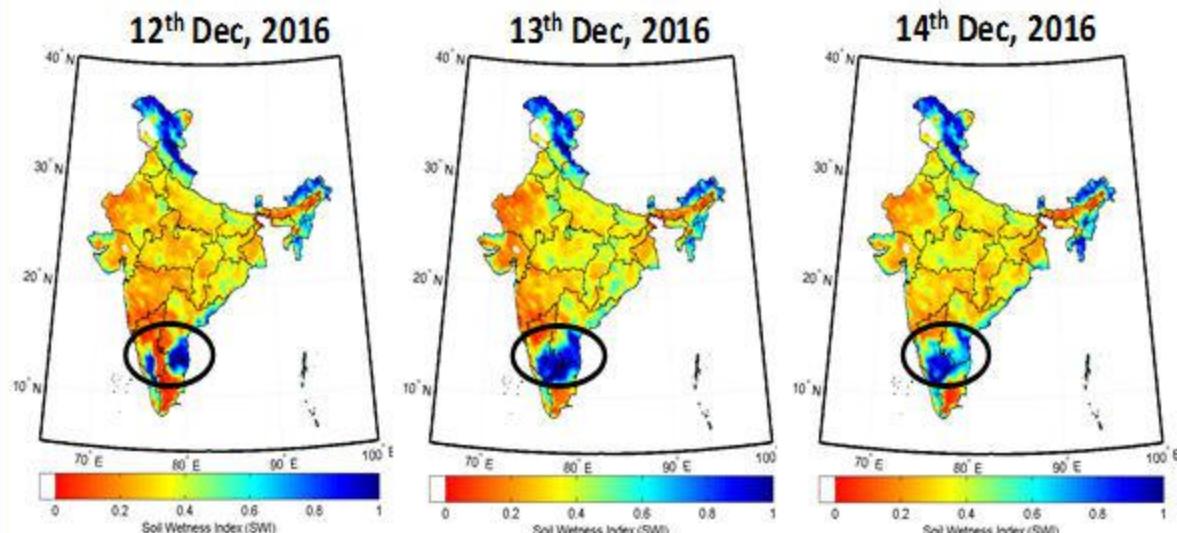
Earth Observations: Lessons from the Asia-Oceania Region" Hanoi, Vietnam, 18-20

Large-scale Soil Moisture estimation over India

Achievements:

- Large-scale Soil Wetness Index (SWI) and Soil Moisture (SM) using SMAP L-band radiometer data.
- Operational daily data product is available over MOSDAC and VEDAS web portal
- Captured major climatic and unseasonal events like Mumbai & Chennai flood, Hailstorms, very heavy rainfall due to cyclone

Observed the impact of Vardha cyclone on soil wetness over Southern states



Way forward:

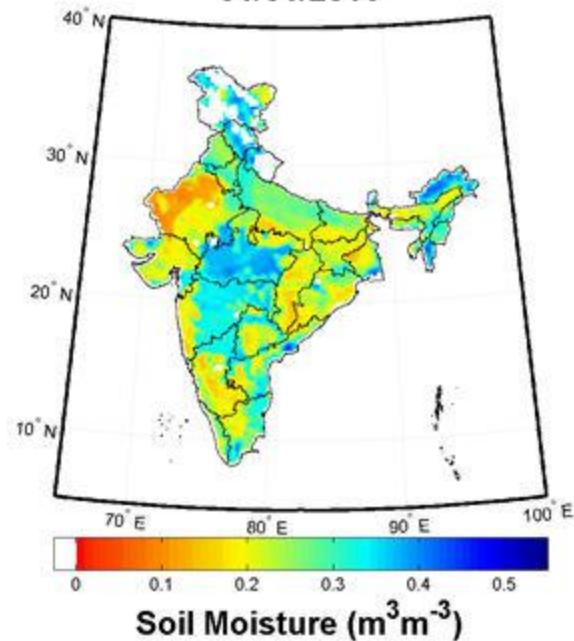
High Spatio-temporal soil moisture products

Benefits to stake holders:

The 10th GEOSS Asia-Pacific Symposium
“Accelerating the realization of the SDGs with
Earth Observations: Lessons from the Asia-Oceania Region” Hanoi, Vietnam, 18-20

Temporal dynamics over India
(Jan, 2016 to Oct, 2016)

01/01/2016

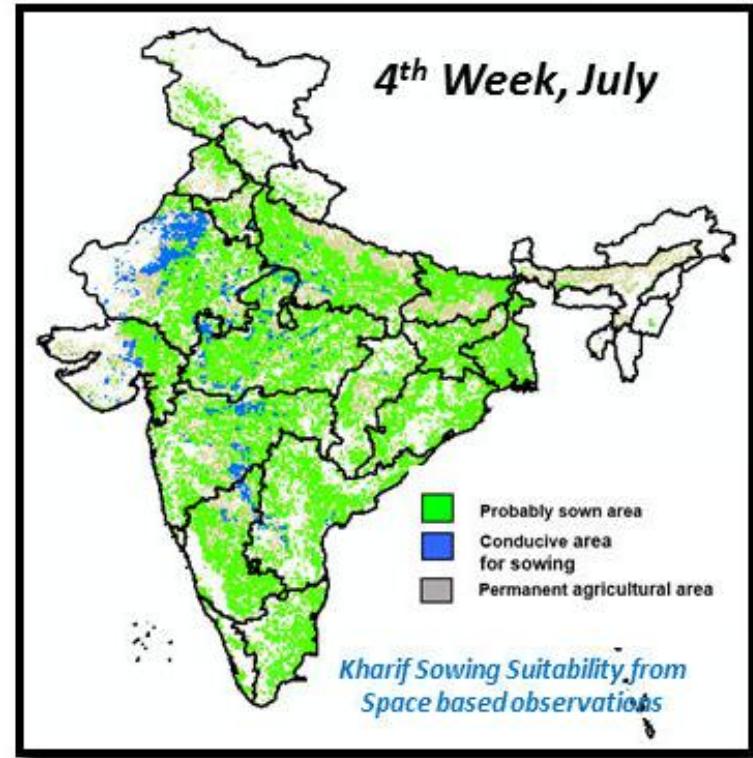
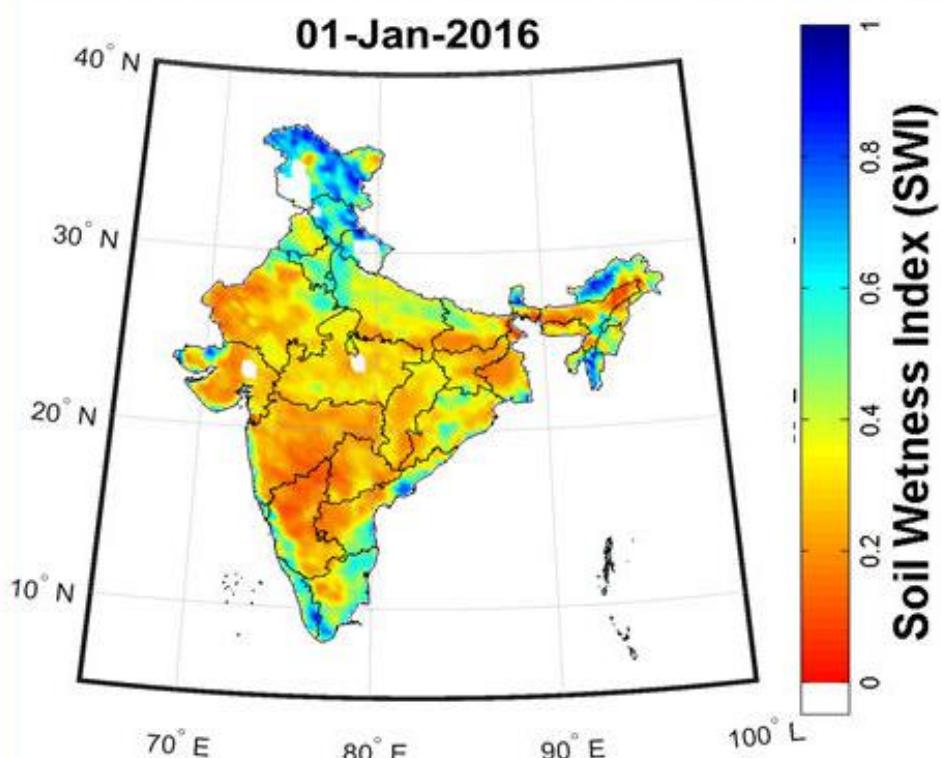


[\(vedas.sac.gov.in\)](http://vedas.sac.gov.in)

Satellite-based Value-added Agro-met Products

Achievements

- Development and operationalization of surface soil moisture product through VEDAS & MOSDAC
- Kharif Sowing suitability based on crop vigour and available soil moisture
- Early warning advisory for major pests-diseases : Aphid for mustard



Way Forward

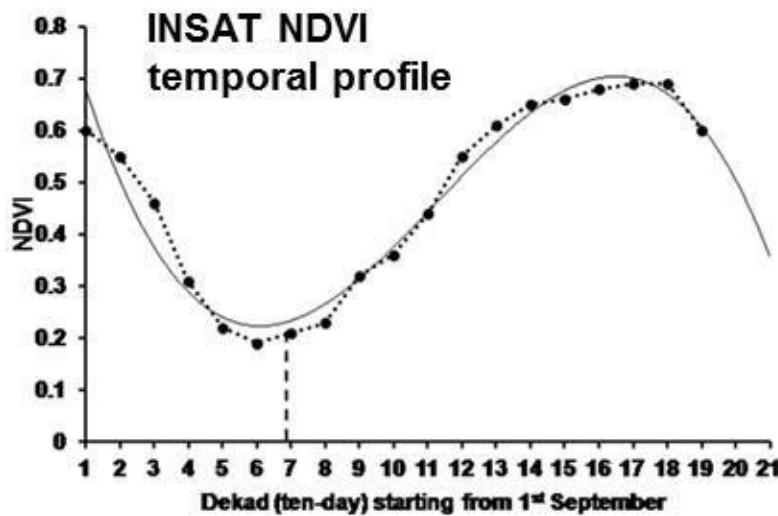
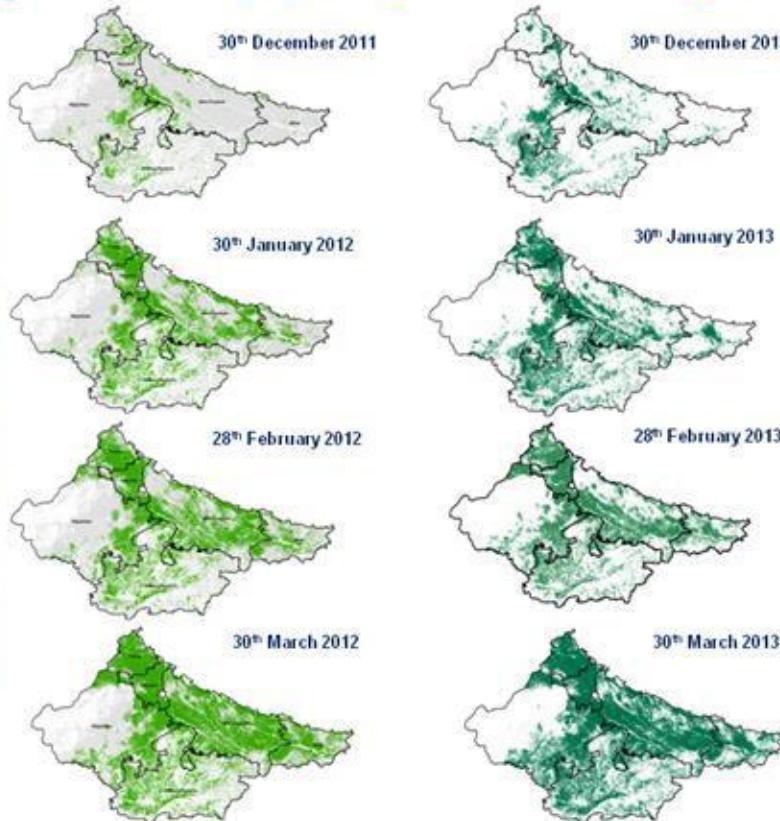
- 'Irrigation advisory' through crop water requirement

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Earth Observations: Lessons from the Asia
Oceania Region" Hanoi, Vietnam, 18-20

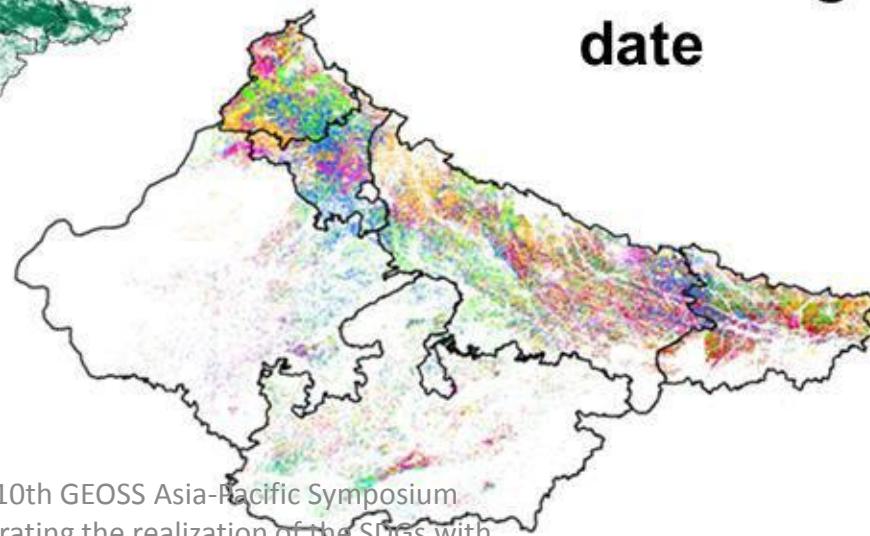
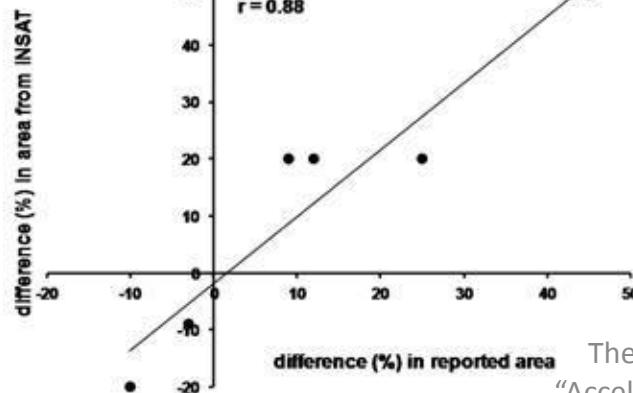


(vedas.sac.gov.in)

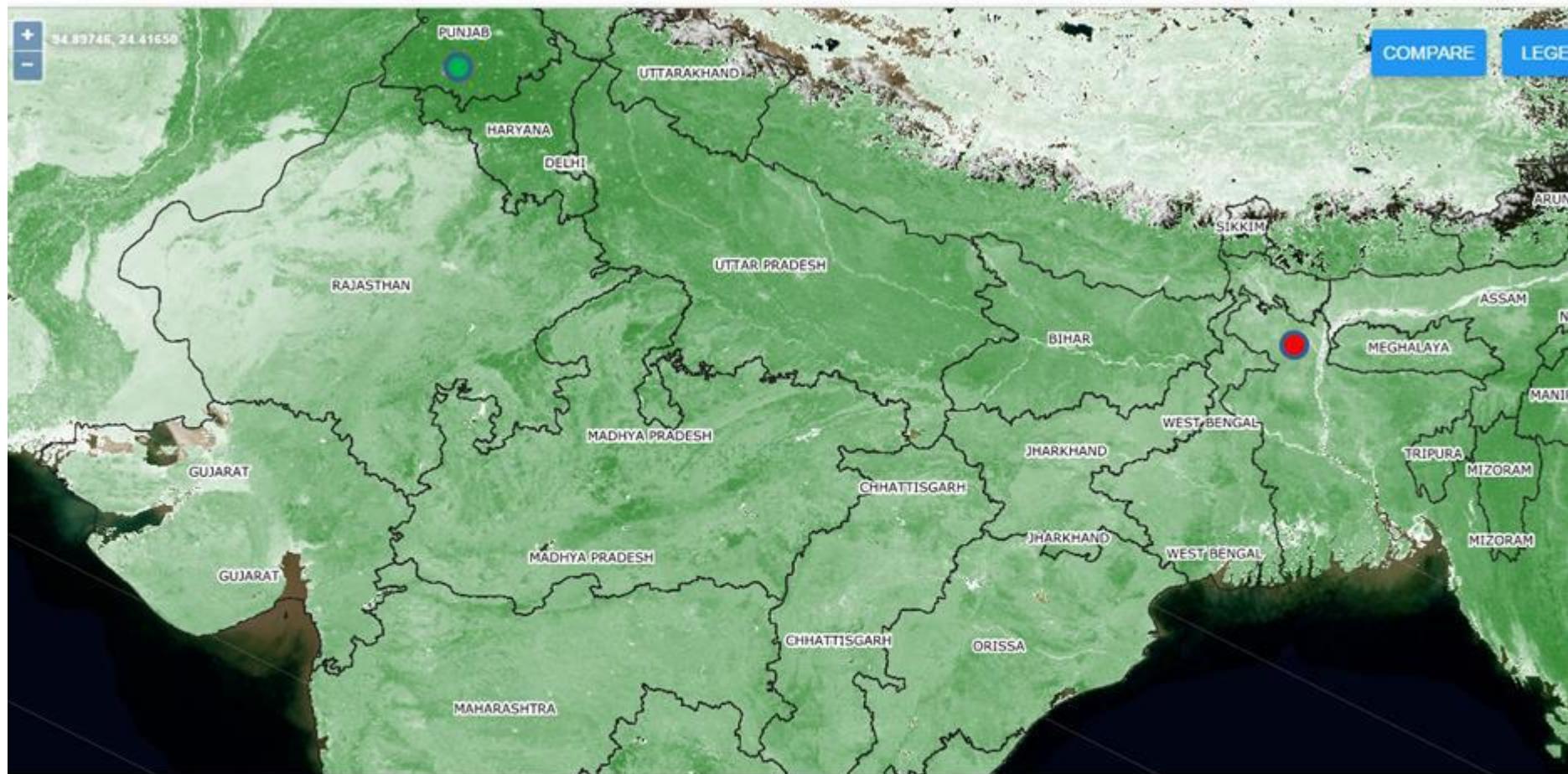
Rabi progress for 2011-12 & 2012-13



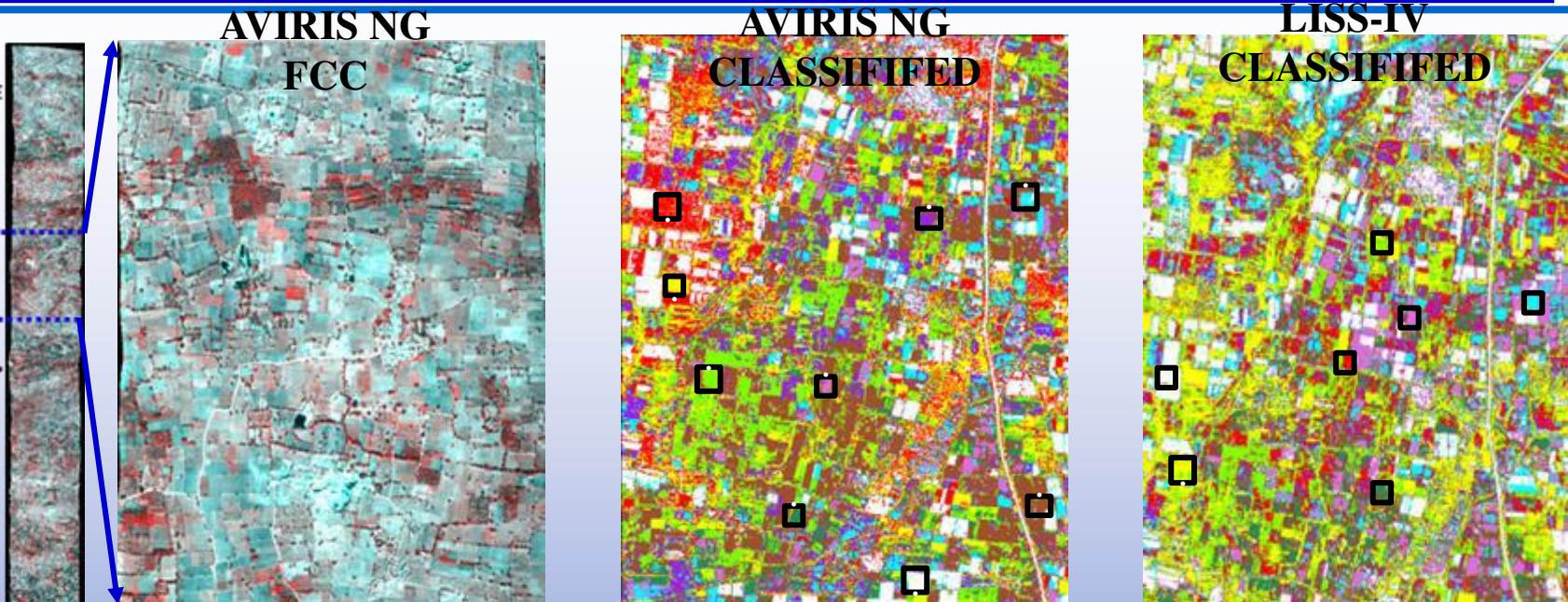
Wheat sowing date



Fortnightly NDVI composite using OCM data

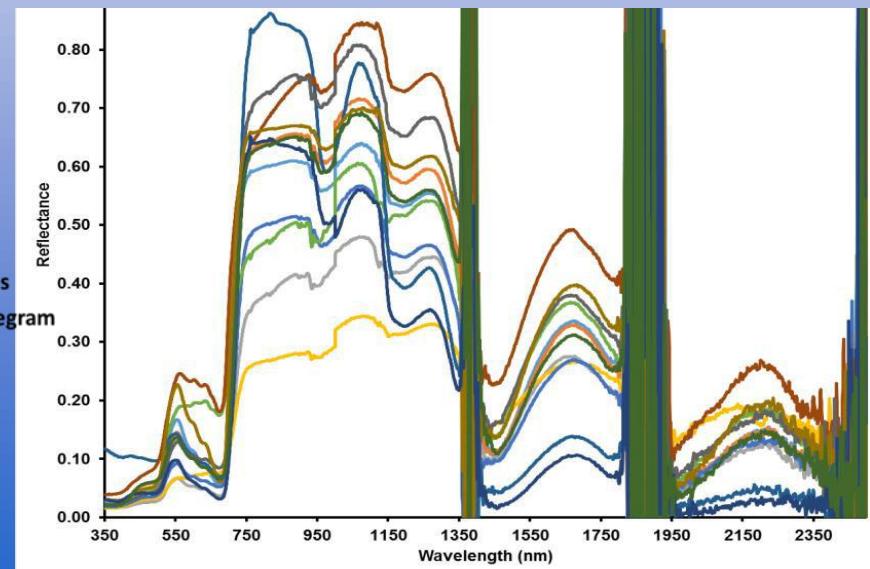


Crop Classification using AVIRIS-NG Data

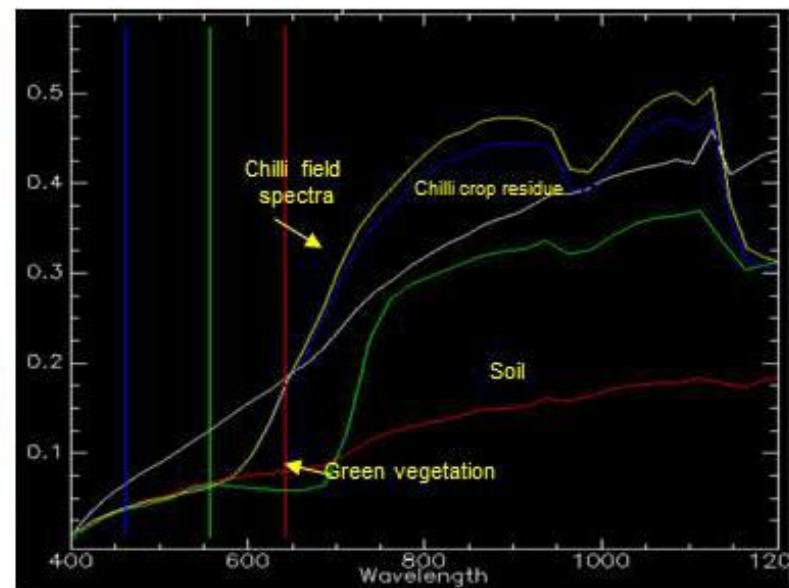


Data	Accuracy	Kappa Coefficient	Bare Soil
AVIRIS-NG	77.7%	0.75	Turmeric
LISS-IV	42.8%	0.34	Tomato

Turmeric
 Tomato
 Cotton
 Fieldbeans
 Horsegra
 Pulses
 Pulses and Beans
 Pulses and Horsegram



Red fields of Chilli Crop in Kurnool, Andhra Pradesh

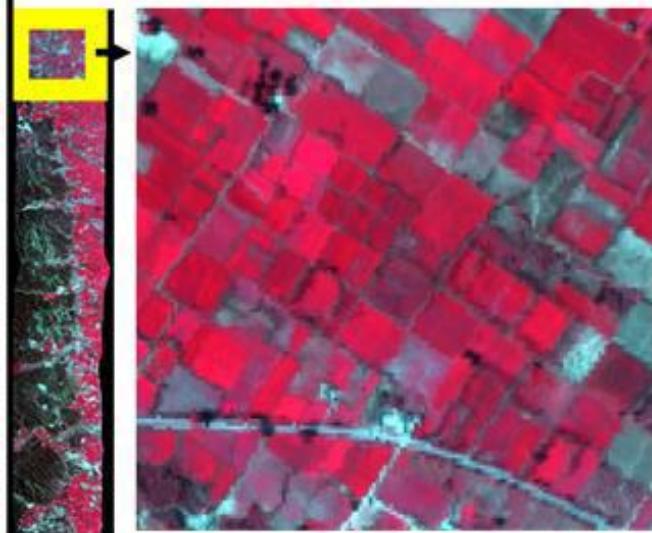


Spectral Profiles of Red Chilli and Green vegetation

Spectral analysis of AVIRIS-NG data over Kurnool, Andhra Pradesh



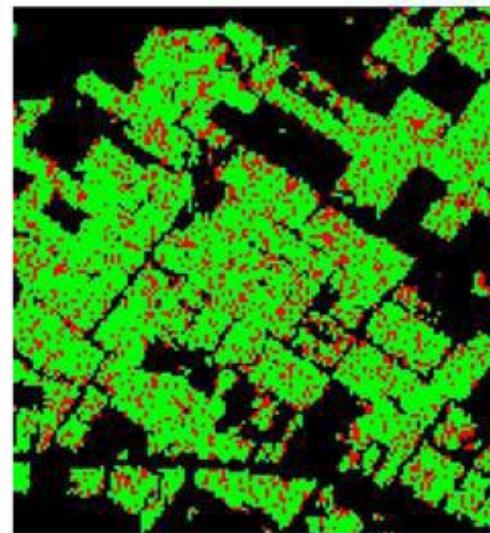
Wheat rust disease Identification using AVIRIS-NG Data in Ropar District, Punjab



AVIRIS
FCC Zoomed view
Ropar



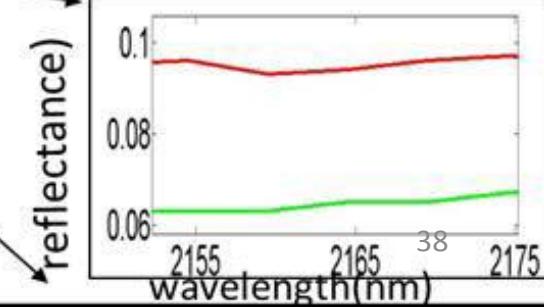
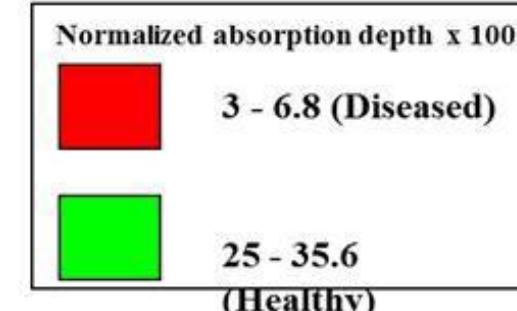
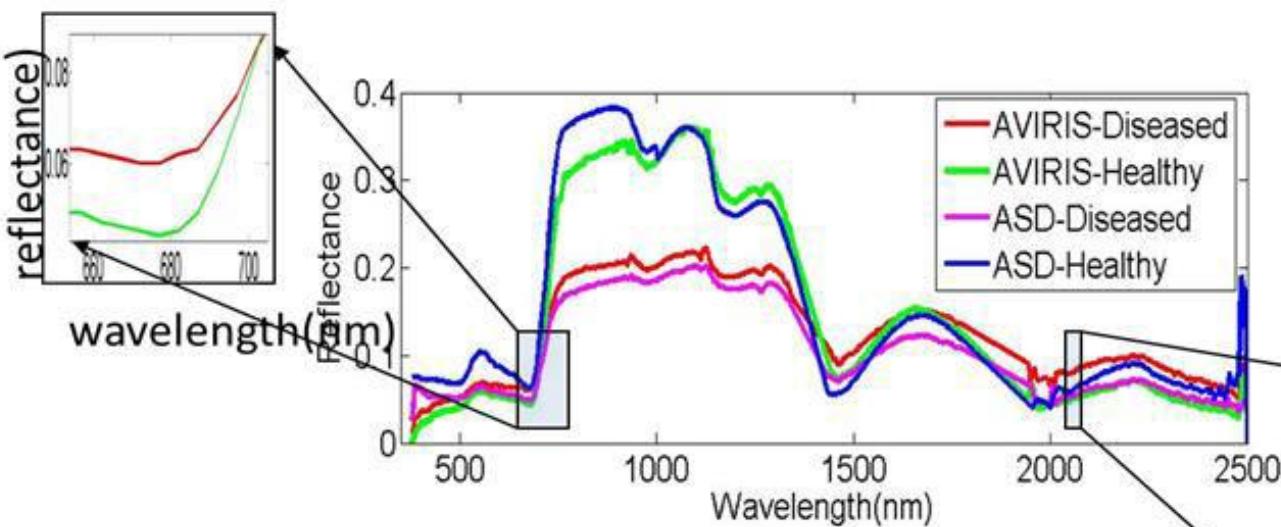
wheat mask



healthy

diseased

Absorption depth based classification in the range between 662 to 702 nm and 2155 to 2175 nm

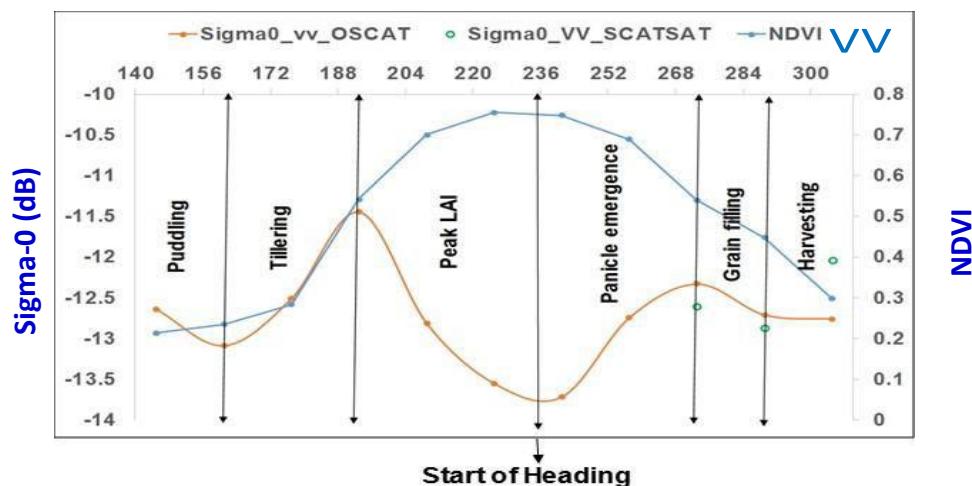


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Oceania Region” Hanoi, Vietnam, 18-20

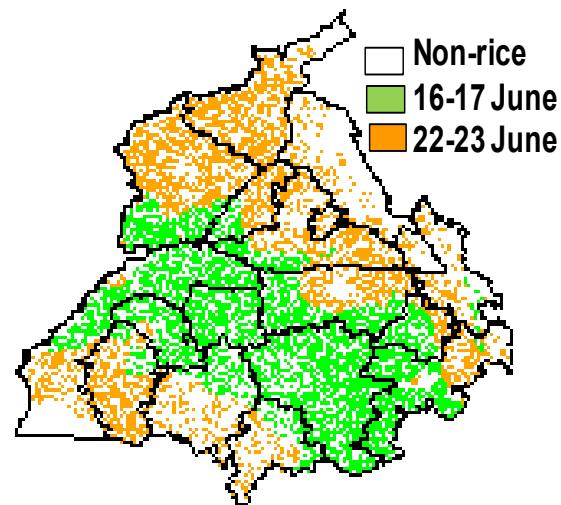
Rice crop phenology

- Rice transplanting date was derived for Punjab at spatial scale using high frequency scatterometer data (Ku band)
- The dual peak characteristics of time series sigma-0 could identify all important growth stages of rice
- Initial analysis also showed significant correlation of sigma-0 at heading stage and the rice grain yield, though the relationship needs to be proved at time and space

Rice Phenology using Ku band sigma-0 (VV)

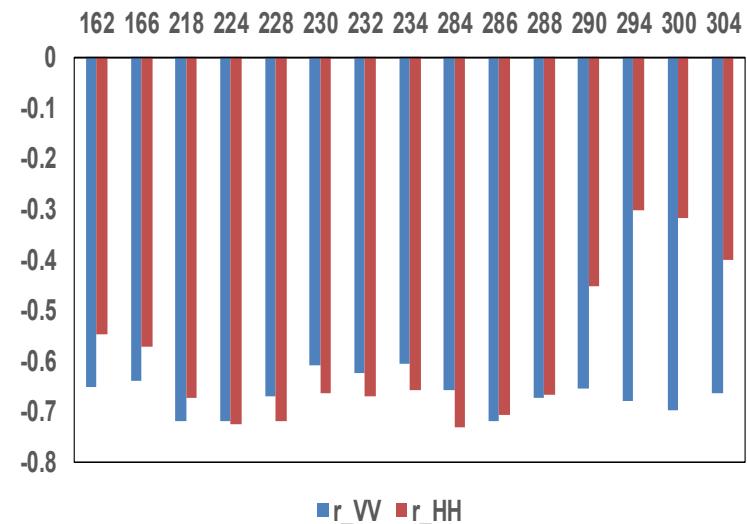
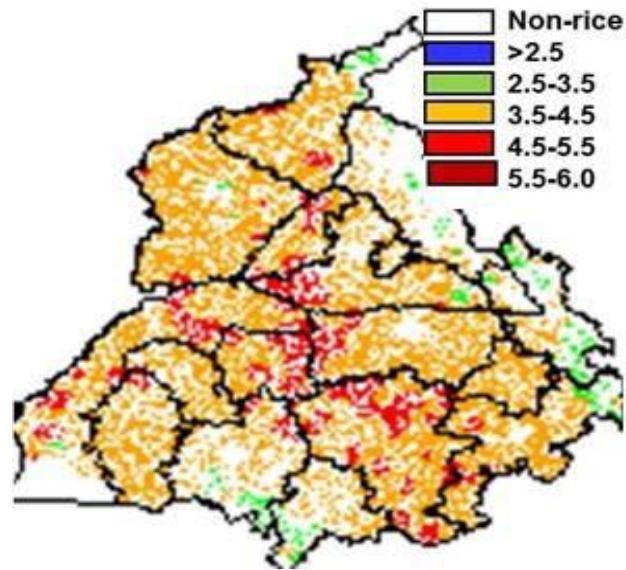


Relationship of time-series Sigma-0
(average of 16 days) vs NDVI over rice area
in Punjab



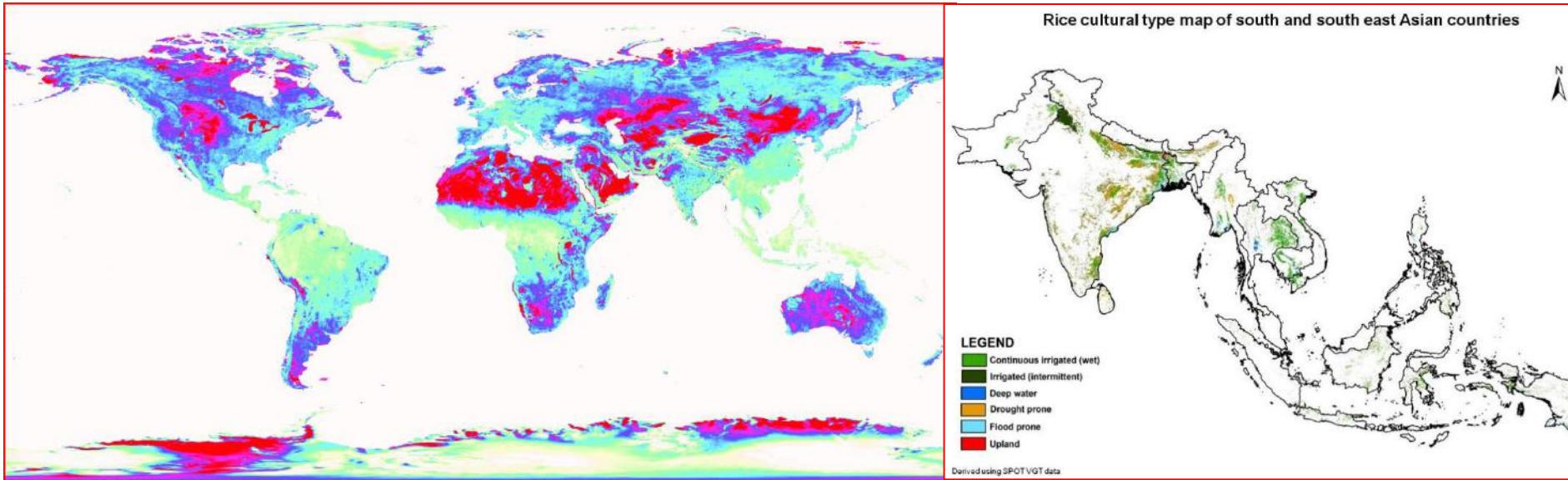
Rice transplanting date

Rice grain yield studies using Ku-band sigma-0

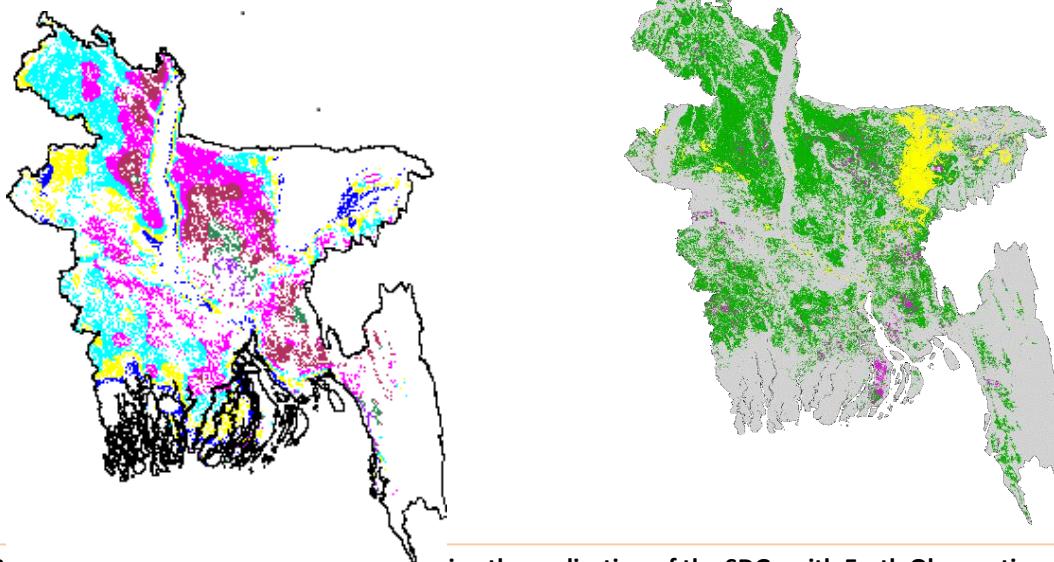


- Correlation of rice yield with VV Sigma-0 found to be higher (0.61 to 0.72) than that with HH sigma-0
- The percent deviation in predicted yield from reported mean is within 20 % except one district
- Moderate coefficient of determination is due to (i) use of historical yield, (ii) model development from past OSCAT data and (iii) use of data for only five dates
- With more validation, this will help in improving the accuracy of rice yield prediction
- Can be applied to large area

Sigma-0 from SCATSAT1 over the globe and rice map of South and SE Asia

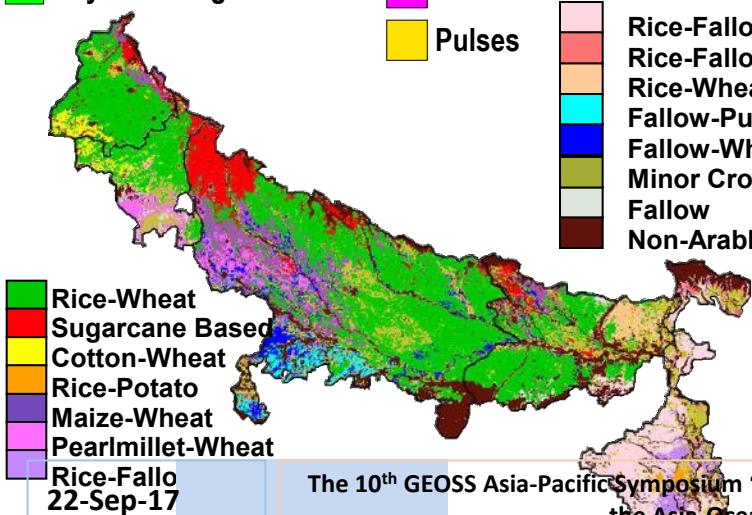
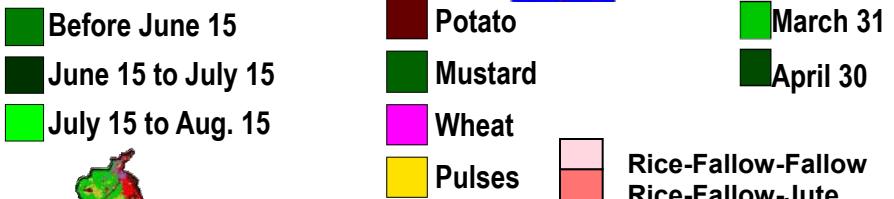
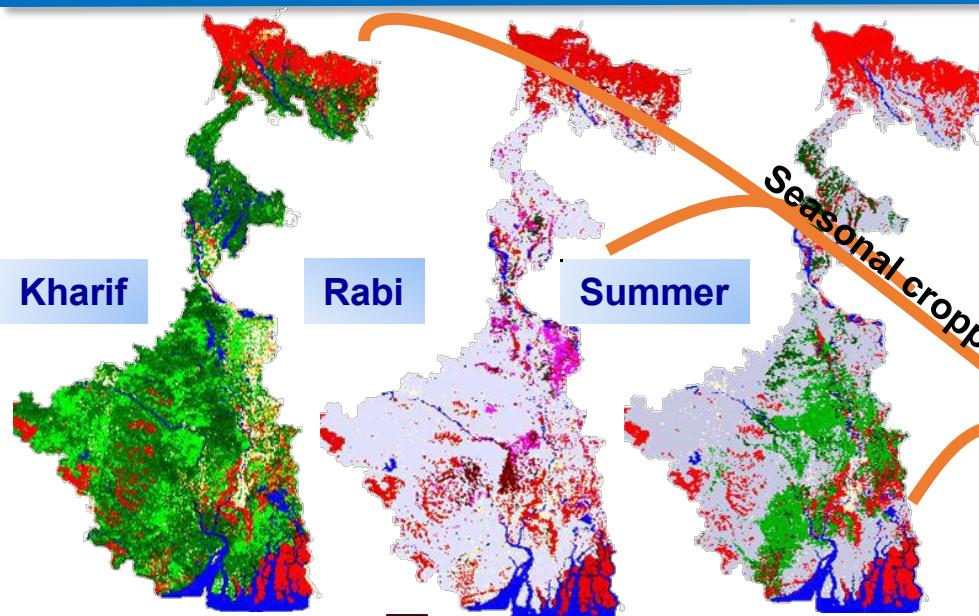


Sigma-0 from SCATSAT1 over Bangladesh and the Boro rice map of Bangladesh



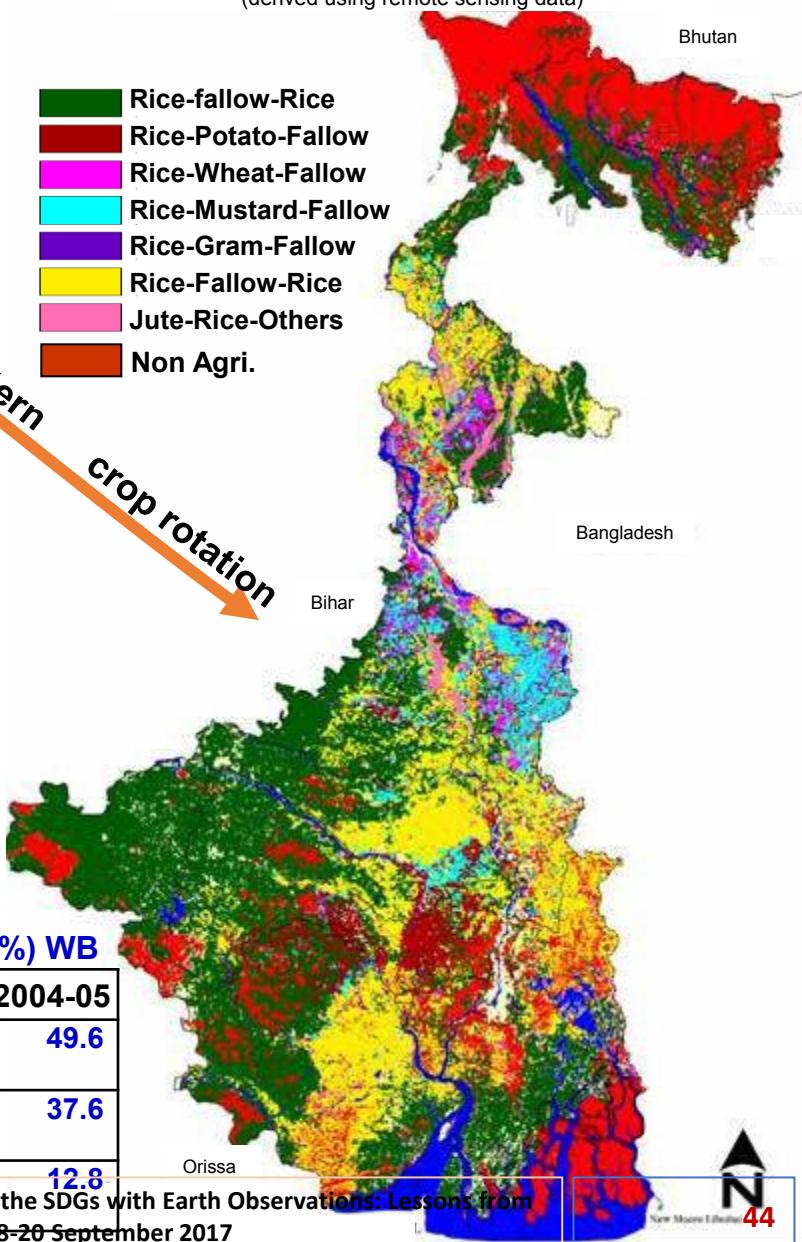
Agriculture System Analysis

Cropping Pattern and Crop Rotation



Crop Rotation Map of West Bengal
(derived using remote sensing data)

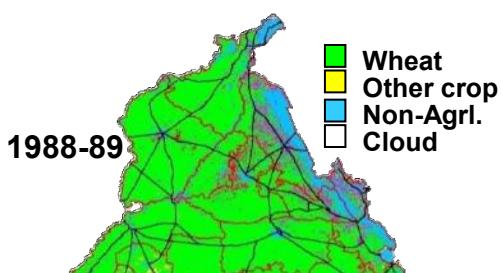
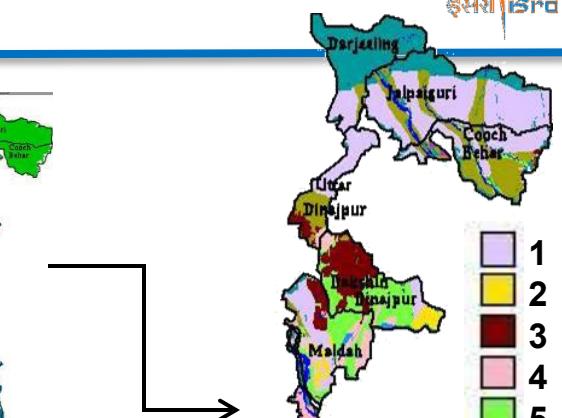
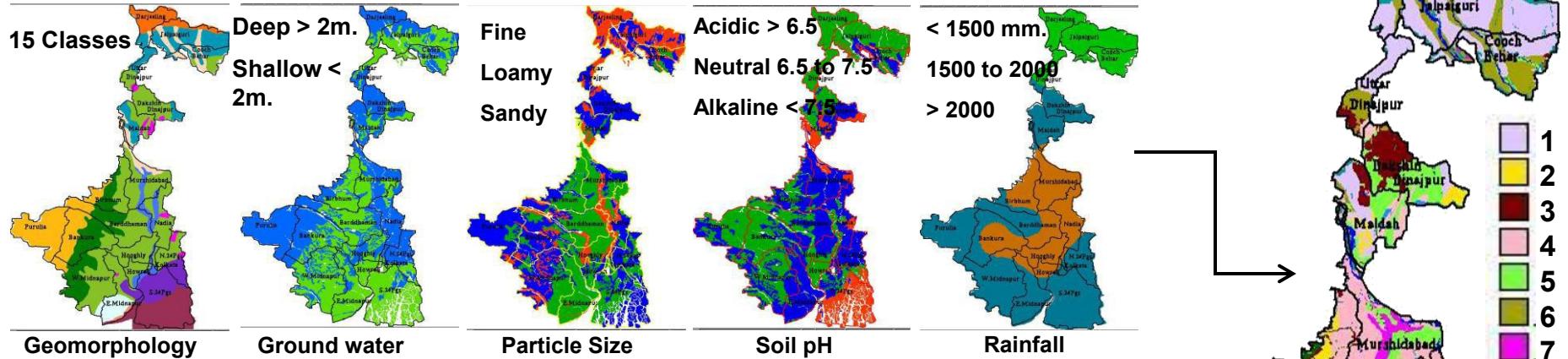
- Rice-fallow-Rice
- Rice-Potato-Fallow
- Rice-Wheat-Fallow
- Rice-Mustard-Fallow
- Rice-Gram-Fallow
- Rice-Fallow-Rice
- Jute-Rice-Others
- Non Agri.



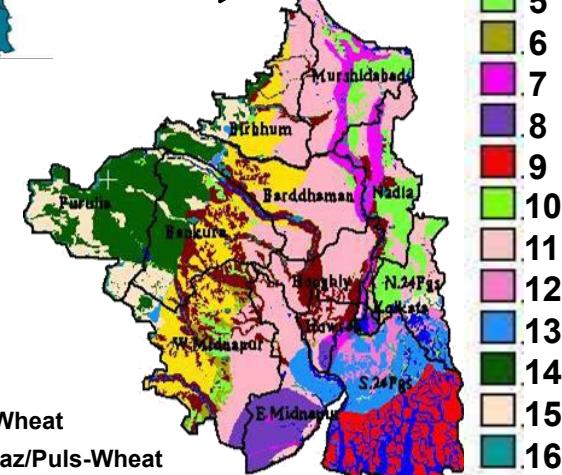
Crop Intensification and Diversification



Inputs – Intensification in West Bengal

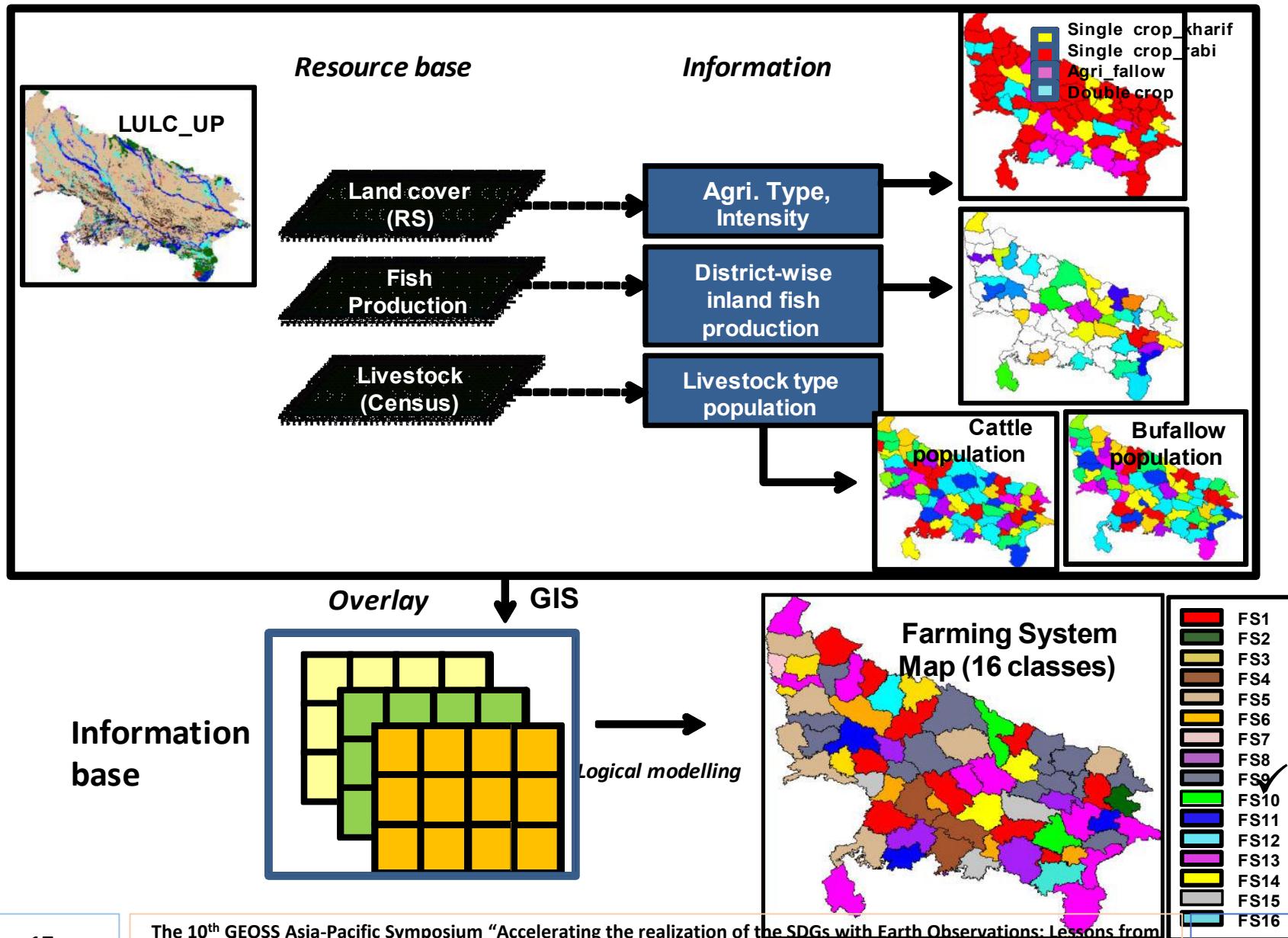


Physiography
Problem soils
Rainfall
Soil texture

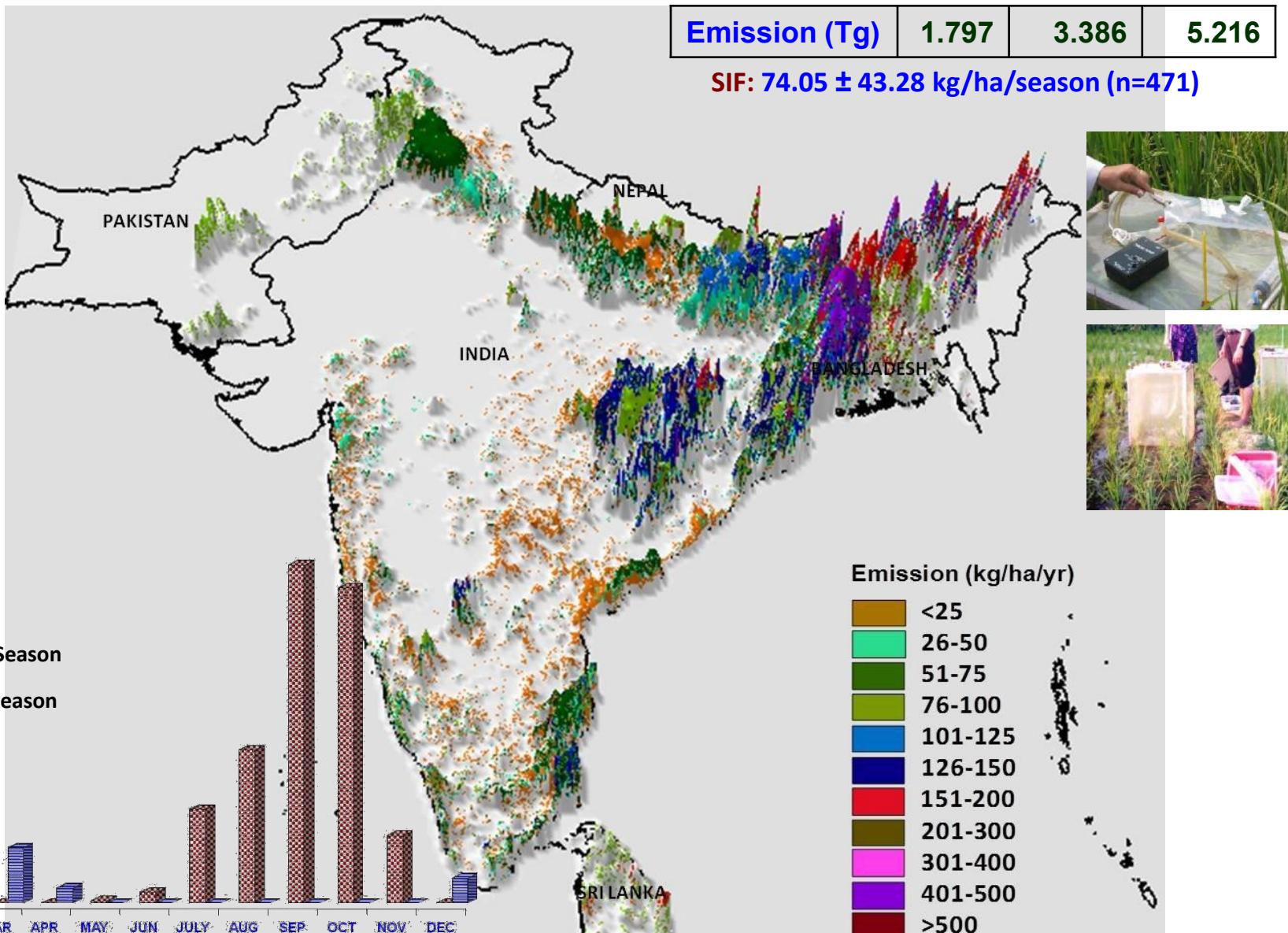


Equipotential zones

Delineation of Major Farming Systems

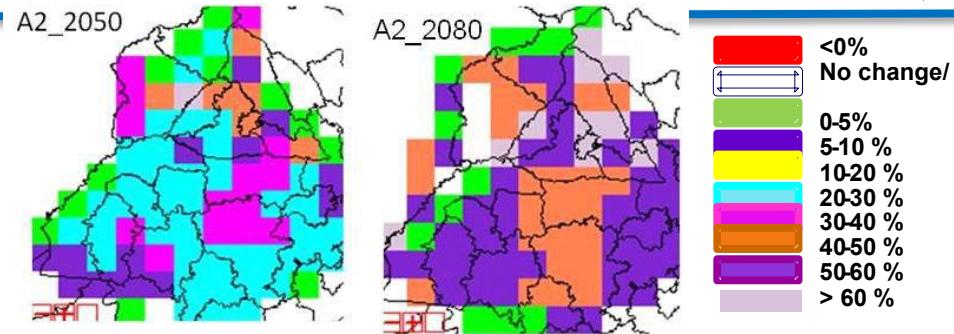


Perspective View of Methane Emission

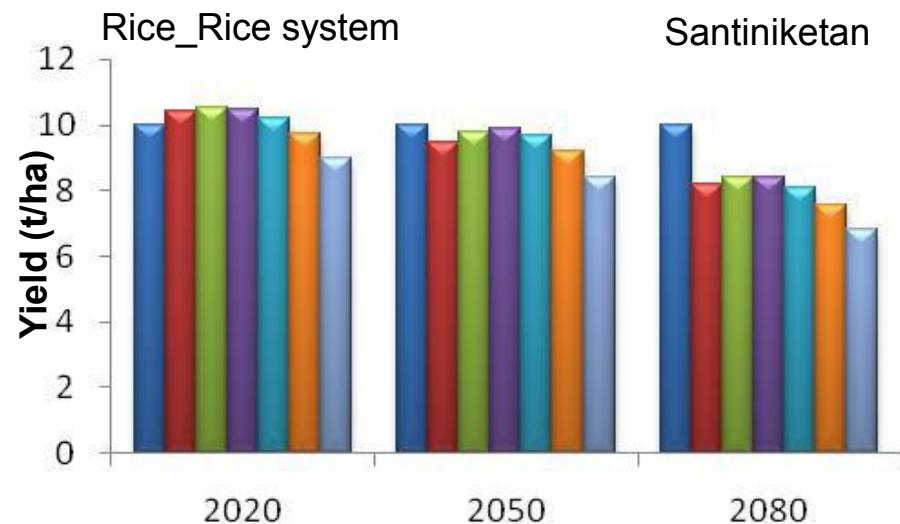


Impact of climate change on agricultural system productivity (PRACRITI)

- Impact of climate change on major cropping systems using climate projections from GCMS (25 km grid).
- Use of future climate projections from the regional climate model (PRECIS) to understand the impact of climate change on cropping system productivity.
- Statistical downscaling of GCM projections and their use for studying the impact.
- Adaptation study (through adjustment in Planting date) in Rice-wheat system.
- Analysis of extreme events under climate change and their impact on crop productivity.
- Through alteration of planting date the yield reduction could be partly compensated.



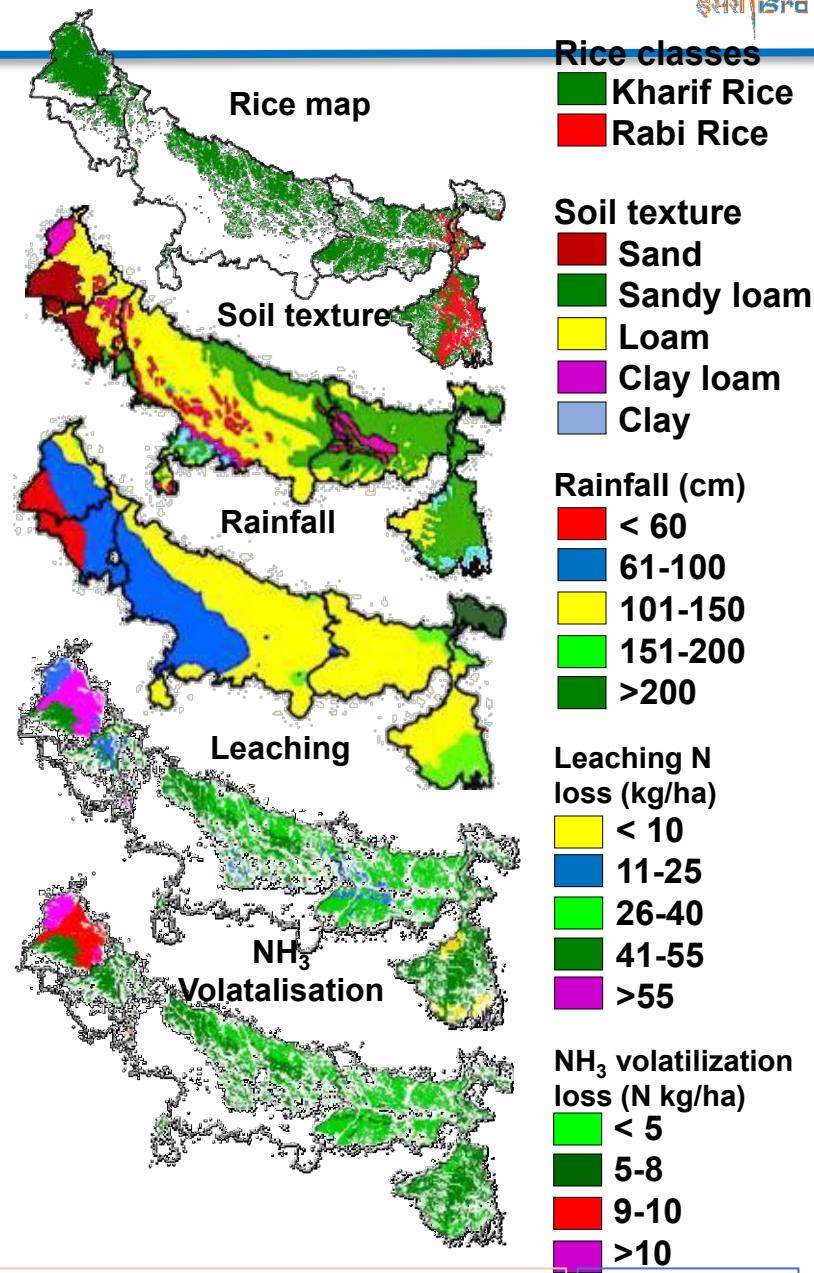
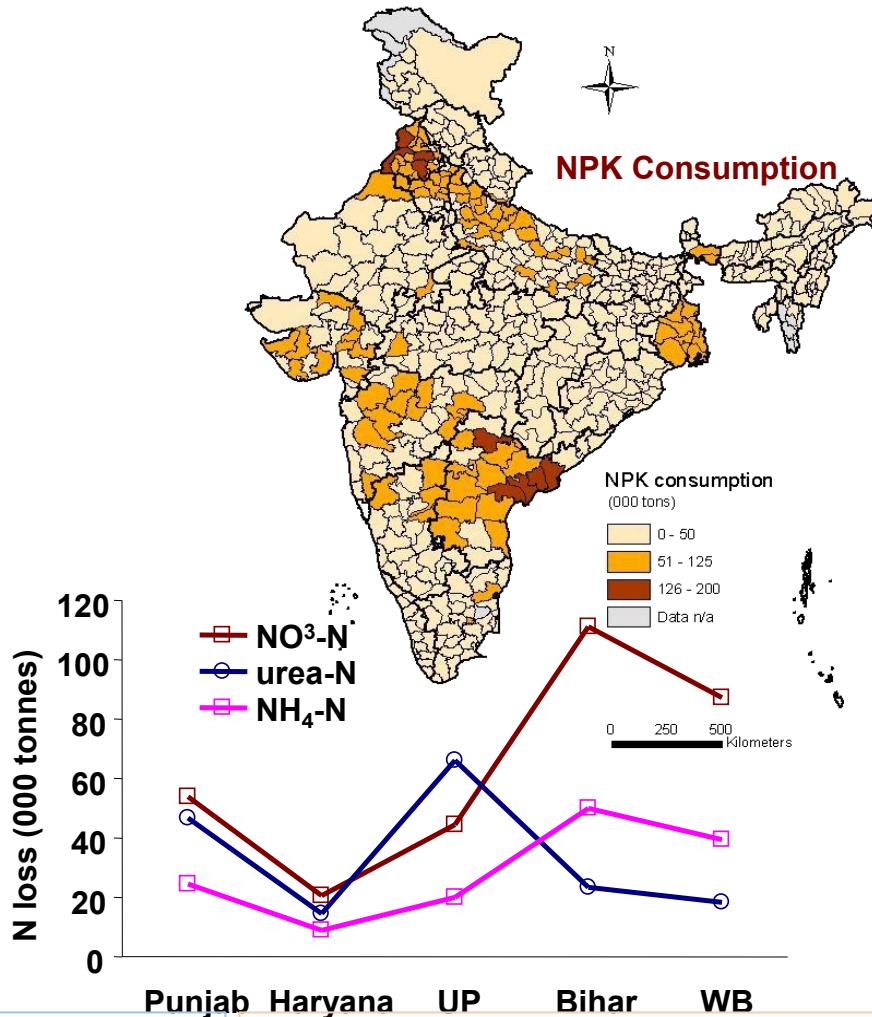
Spatial response of cropping system productivity to future climate change scenarios (GCM) in Punjab



Adaptation study through adjustment in sowing date

Fertilizer Consumption and Non-Point Source Pollution

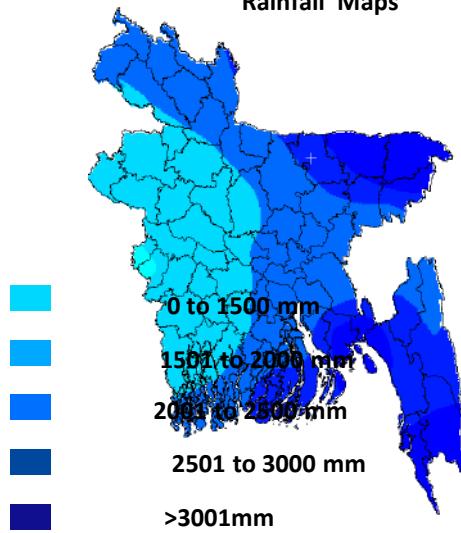
- All-India Total NPK consumption: 16.8 Mt, $\sim 90 \text{ kg ha}^{-1}$
- 'vulnerable districts' of NPS pollution - intensive agriculture areas in North (Punjab), coastal areas in the East (AP, WB), and peri-urban area (Bangalore)



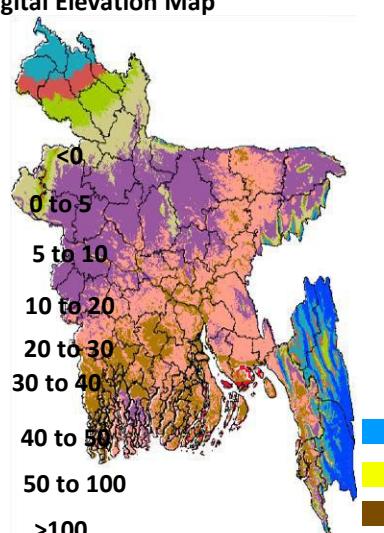
Global Crop Monitoring

Global Crop Monitoring

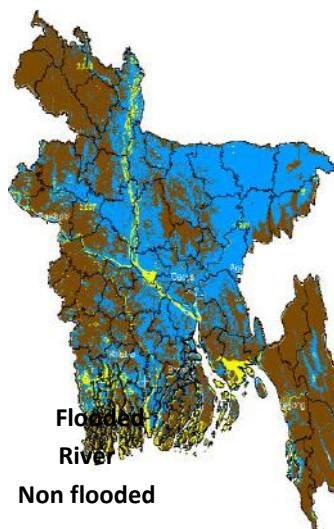
Rainfall Maps



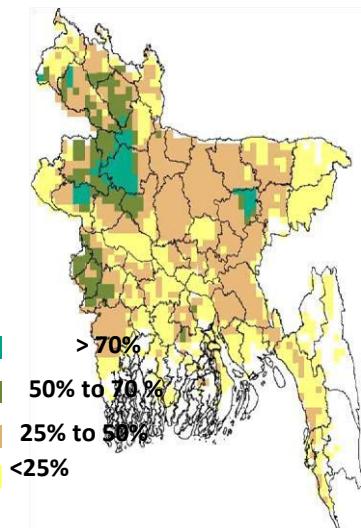
Digital Elevation Map



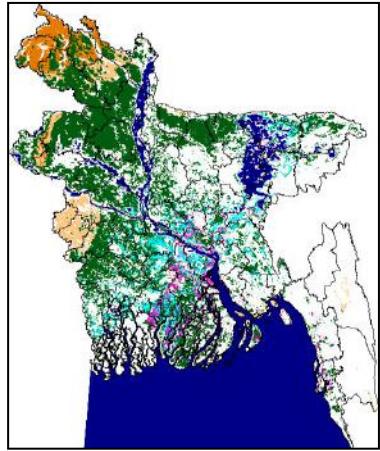
Flood Map



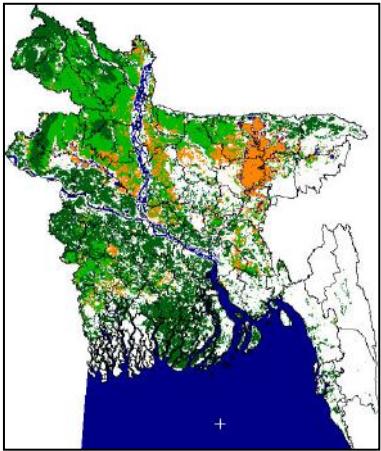
Irrigation area Map



Bangladesh rice cultural type map
(2008-09)



Bangladesh rice cropping pattern map
(2008-09)

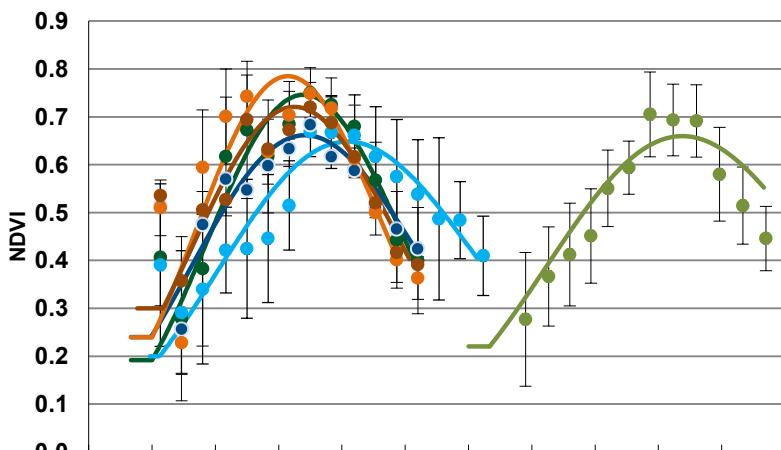


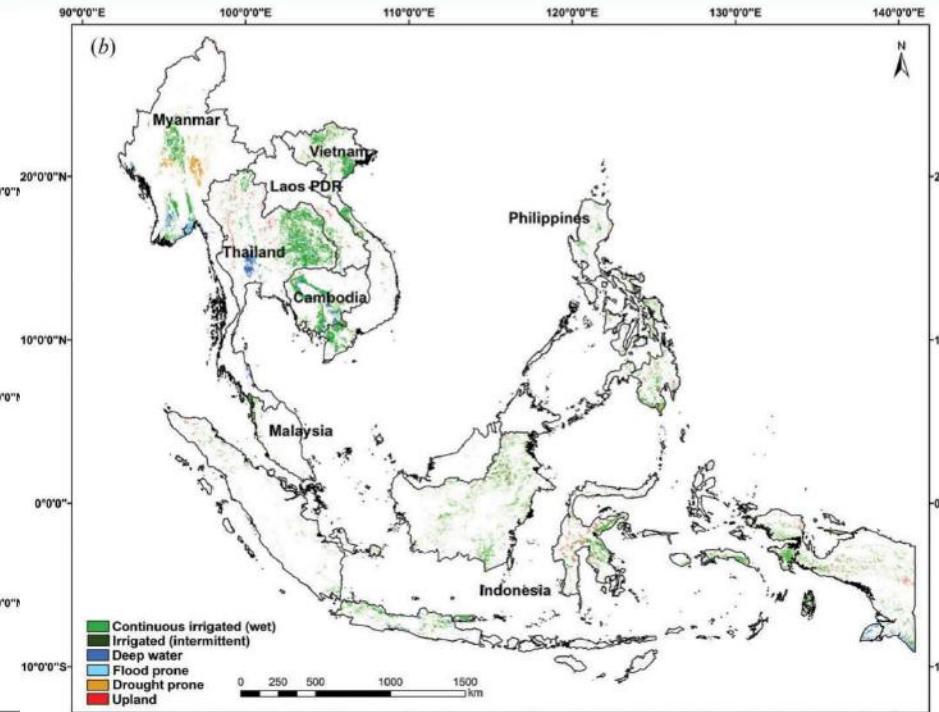
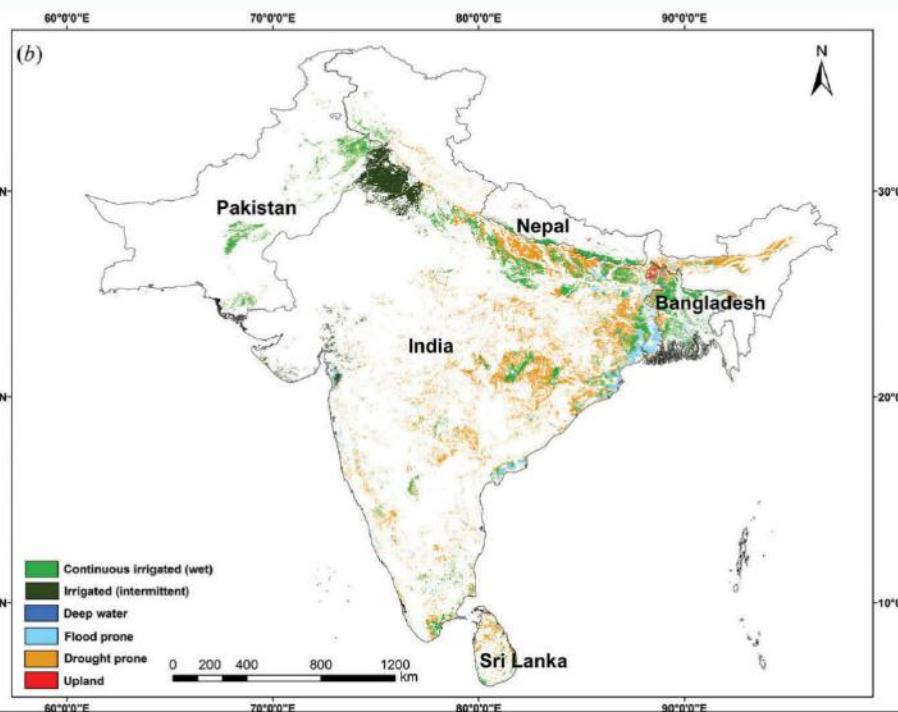
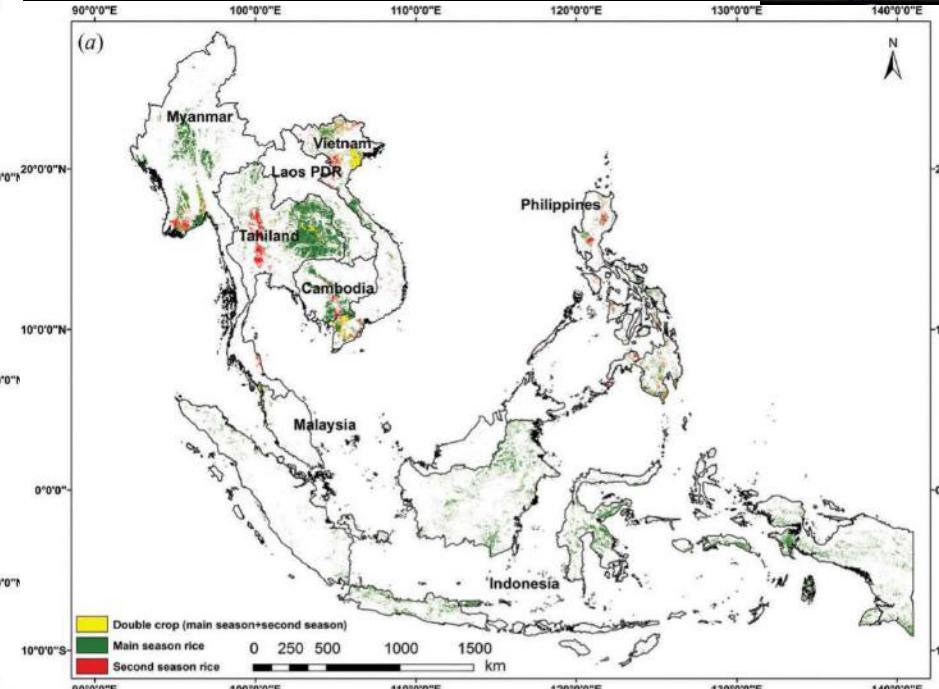
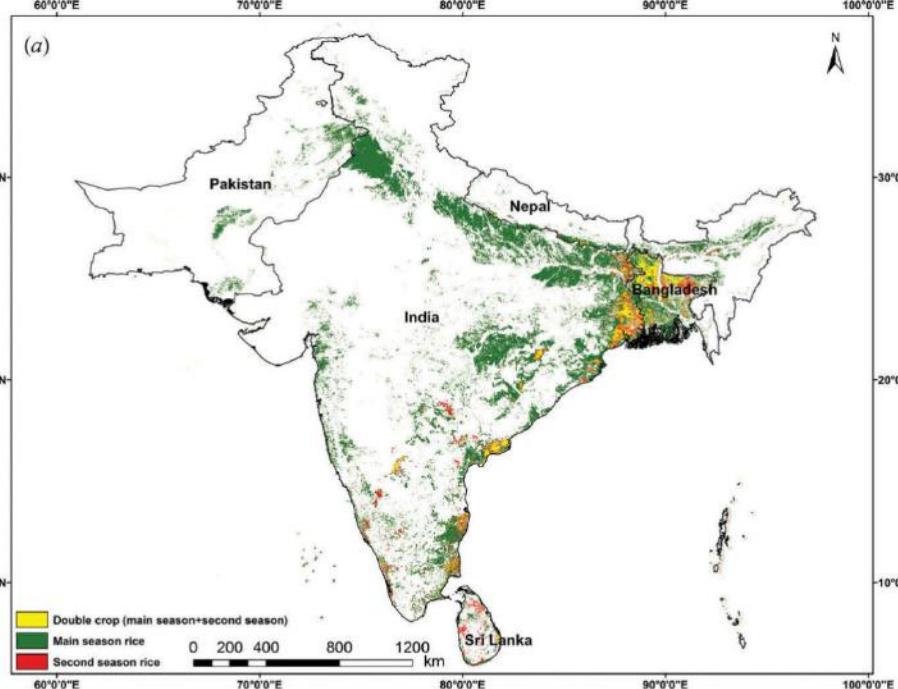
Spectral Rice Crop Profile : Bangladesh 2008-09

● Continuous irri .(wet)
● Flood Prone

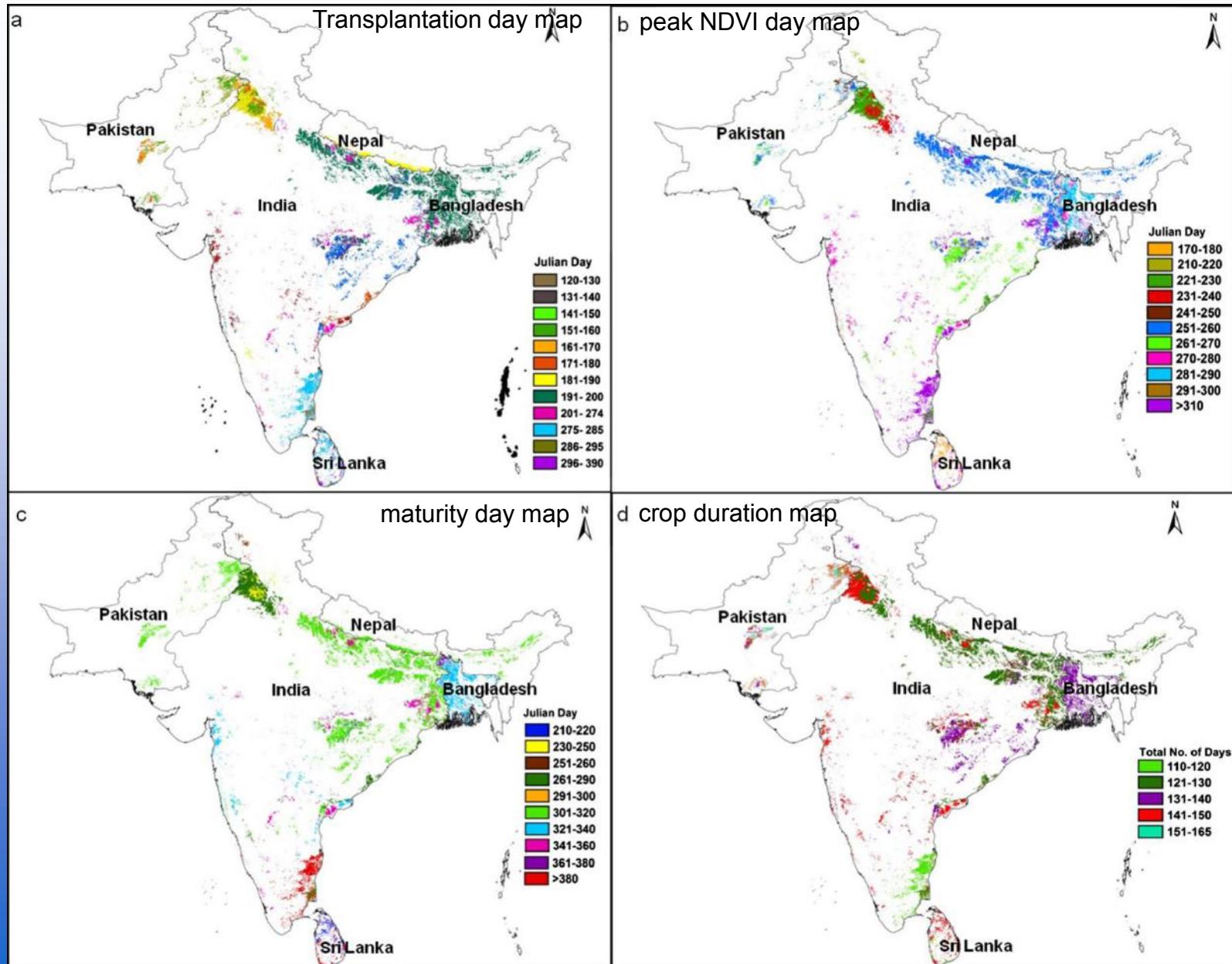
● Continuous irr.(dry)
● Upland

● Deep Water
● Drought Prone

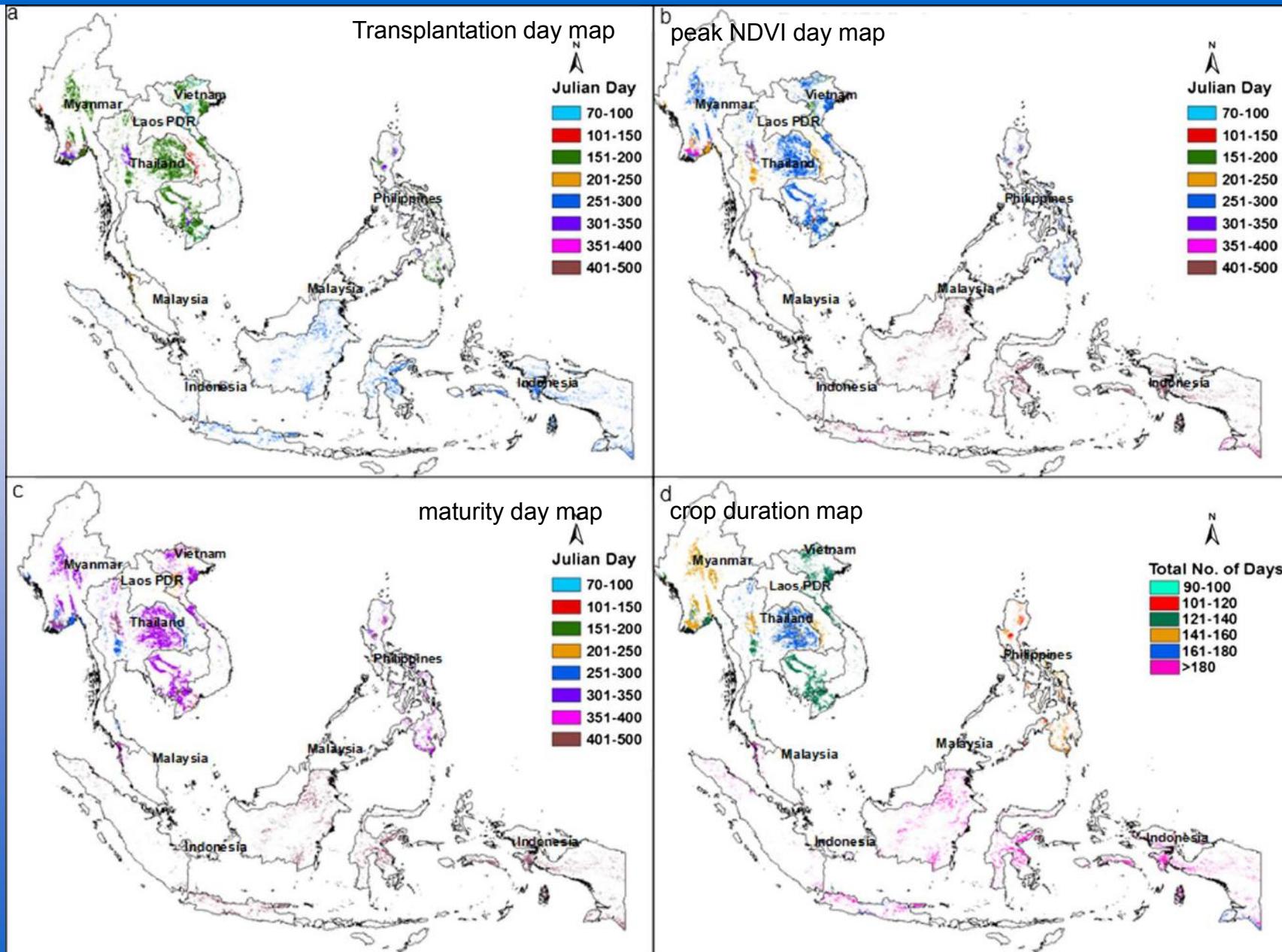




Crop calendar maps



Crop calendar maps



Disasters and Damage Assessment

Disaster Monitoring and Mitigation

Floods

40 M ha flooding
4.2 crore people in 2002



Landslides

Sub-Himalayan/
Western Ghats
8% of TGA
5000 people in 2002

Cyclones

5700 km long coastline
15,000 people in 2002



Earthquakes

55% of area in Seismic Zone III-IV
40,000 people in 2001

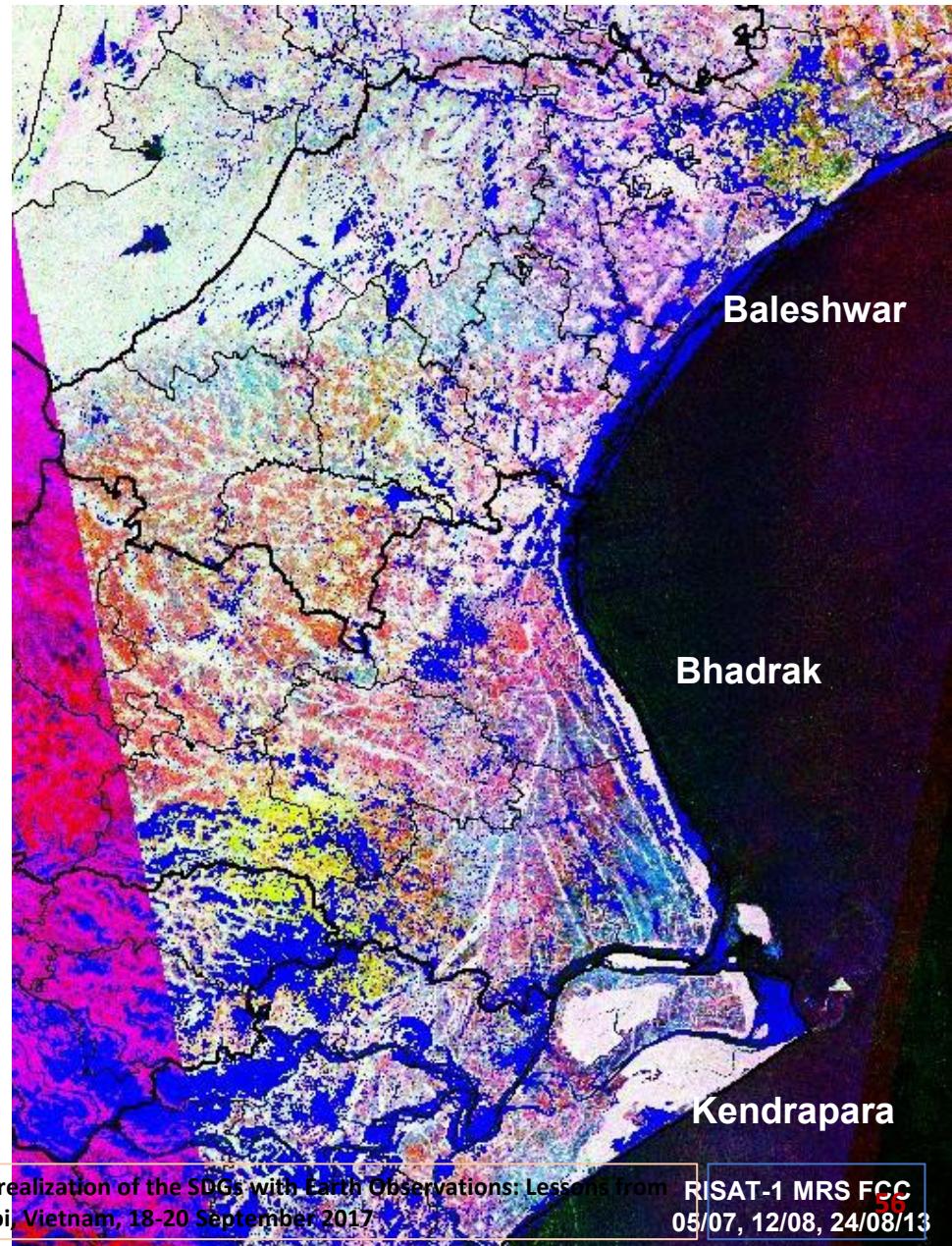
Drought

68% net sown area in 116 dist.
30 crore people in 2002



Forest Fires

≈65% of total forests under potential threat of ground fire



█ Flood affected area as on 14/10/13 (Superimposed on image)

Odisha, October 2013

Information Dissemination

- **Bhuvan (bhuvan.nrsc.gov.in): Gateway to Indian Earth Observation Data and Products**
- **MOSDAC (mosdac.gov.in): Meteorological and Oceanographic Satellite Data Archival Centre**
- **Vedas (vedas.sac.gov.in) : Thematic Derived Data Products, developed by SAC (ISRO)**
- **NICES: Climate change related data**



Governance and Development for Agriculture

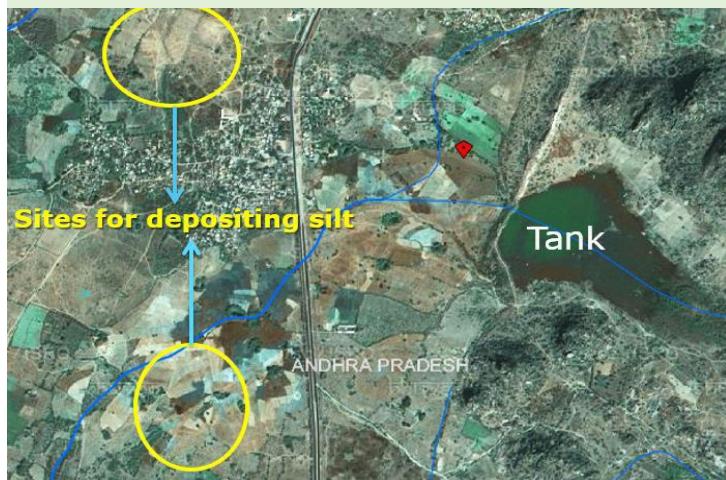
GEOSPATIAL APPLICATIONS FOR GOVERNANCE & DEVELOPMENT



Geo-spatial Services and tools are utilized for planning, implementation, monitoring & evaluation of Public Benefit Schemes and Developmental Projects

- Rural Employment Guarantee Scheme towards Livelihood security: Geospatial integration for transparency and efficiency
- Geospatial monitoring of house construction stages in Housing schemes
- Satellite data, mobile application and geoportal for monitoring the implementation & impact assessment of Watershed Development activities
- Monitoring crop conditions as input for Crop Insurance scheme
- Crowd sourced database and satellite data for Disaster Damage assessment
- Site management plans and online approval process with respect to Heritage sites, through location based service
- Postal services - geotagged post-offices and delivery tracking

Satellite data for planning Desiltation of tank: Activity planning under Rural Employment Guarantee Scheme



More cropped area (2014) with Check dam constructed under Watershed Development (2009)

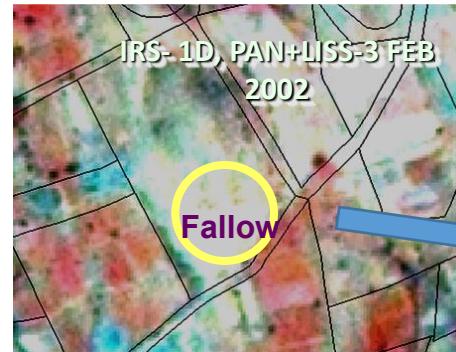


Participatory Land and Water Resources Management

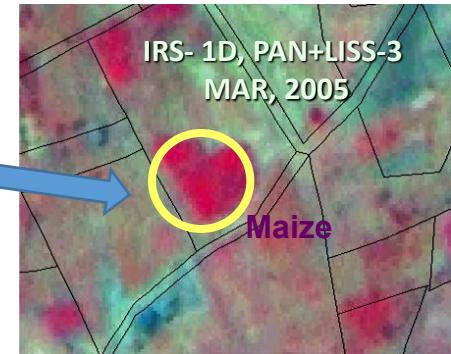


- Phase-wise implementation of Sujala Watershed Project Karnataka
- Work in progress in more than 50 thousand micro watersheds

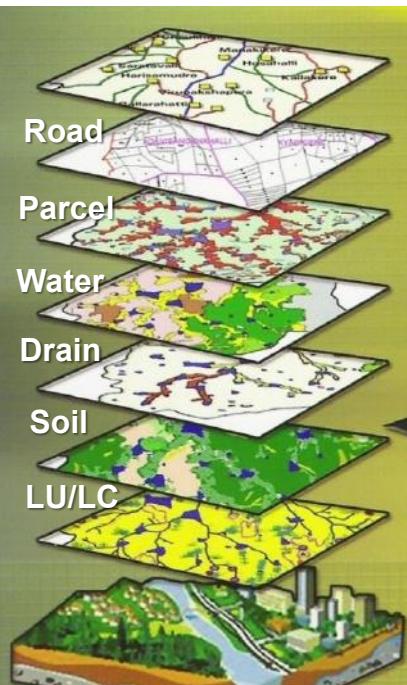
- Watershed prioritization & Development using EO inputs
 - Improve productive potential of degraded watersheds & cropping intensity
 - Create alternate livelihood options
 - Process Monitoring & Mid-course correction
 - Improves the quality of life



Monitoring Land use Changes



Increase in Cropping Intensity



Participatory Implementation



Nala bund

Watershed Community



Outcome

Indian EO Programme: Near Future Satellites (2017-2020)

June 23, 2017

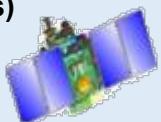
CARTOSAT- 2E

VHR Panchromatic and Multispectral Imaging

- PAN (0.65 m, 10 km swath)
- Mx (2m , 10 km swath, 4 Xs)

Orbit : 505 km

Local time: 0930 hrs



April 2018

CARTOSAT-3

VHR Panchromatic, Multispectral Imaging

- PAN (0.25 m, 16 km swath)
- Mx (1m , 5 km swath)

Orbit : 450 km

Local time: 1030 hrs



Feb, 2019

HRSAT

Constellation of 3 satellites

- PAN (1 m, 15 km swath)
- Mx (1.9/3.84 m , 15 km swath)

Orbit : 660 km

Local time: 0930 hrs



Dec, 2018

GISAT - 1

Geosynchronous Orbit



- HR Mx VNIR : 50m; SWIR: 1.5 Km
- HYSI VNIR: 320m; WIR : 192m

Orbit : 36000 km

Every 30 min

Oct, 2018 & Feb, 2020

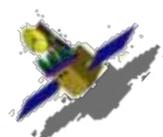
Oceansat-3 & 3A

Continuity for OS-2 with Improvements

- 13 band OCM, IR-SST
- Ku-band Scatterometer ,

Orbit : 720 km

Local time: 1200 hrs



Oct, 2018

RISAT-1A

Continuity for RISAT-1



- C-Band SAR

Orbit : 536 km

Local time: 0600 hrs

Dec, 2019 & 2020

RESOURCESAT- 3 & 3A

Continuity for Resourcesat-2A

- ALISS-3:10m & 12m, 925 km, 5 Bands, ATCOR: 240m, 0.4-1 μ m, , 10 bit)

Orbit : 795 km

Local time: 1030 hrs



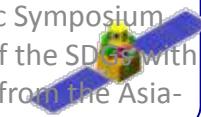
July, 2019 & 2020

RS SAMPLER- 3S & 3SA

High Res. Stereo imaging

- PAN Fore & AFT
APAN: 1.25m, 60Km
Mx: 2.5m, 60Km, 4 Bands

The 10th GEOSS Asia-Pacific Symposium
"Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region" Hanoi, Vietnam, 18-20 Local time: 1030 hrs



2020

NISAR

Joint Mission with JPL/NASA

Payloads

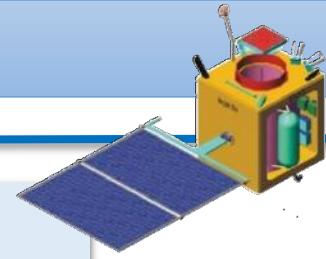
- L & S Band SAR

Orbit : 747 km

Local time: 0600 hrs



GISAT : Geo Imaging Satellite



Geo-stationary imaging satellite for integrated observations of Land, Ocean and Atmosphere with appropriate wavelength regions.

Imaging Sensors	Bands	Spectral Region (μm)	Resolution (m)
Multi-spectral VNIR	6	0.45 – 0.86	50
Hyper-spectral VNIR	60	0.38 – 0.9	500
Hyper-spectral SWIR	150	1.0 – 2.5	500
Multi-spectral LWIR	6	8.2 – 12.5	1500

Applications	Parameters
Improved Crop Monitoring, Forest Mapping, Snow Glaciers, Drought Assessment	NDVI, Albedo, Leaf Area Index, fAPAR, Land Surface Temp.
Fishery Forecast, Coastal Zone Management, Carbon Cycling in Ocean	Chlorophyll, Suspended Sediments, SST, PAR, Downwelling diffuse radiation.
Improved Weather forecast, Cyclone prediction, Dust storm and Fog Monitoring etc.	Aerosols, Water Vapour, Cloud Properties

Focus on Agriculture & Way Forward

Technological Interventions

- Crop production estimates – achieving larger number
- Improving the frequency of estimates
- Drought assessment – improving to weekly assessment
- Crop loss assessment - extreme weather events, pest & disease
- Value added improved agro-advisories and early warning
- Enhancing irrigation & water use in irrigation commands
- Improving dryland productivity - conservation of soil and water
- Identifying rice fallow lands for legume crop intensification
- Managing constraints of land resources
- Generating longterm database and a system approach
- Ground based weather networking

Emerging Needs and Focus

“Value added products, Services, Advanced tools, Short turnaround, accessible on all systems at all times”

SPACE INFRASTRUCTURE - ROADMAP

2017

2020

2024

2030

Spatial 0.65 0.25 m	1.25 Stereo	L&S Band	Constellation of small sat	Thermal	Next generation, Agile HR
Spectral S band	Hyperspectral	5 band Mx			Resource, Ocean, Climate
Temporal 1 day (50 m)	1 day (1 m)	(20 m, Ocean 360m)	½ day(0.60 m)		Meteorology, Small Sat Constellation

- **Field observations – In Situ sensors, Crowd sourcing, cloud computing**
- **The high resolution both temporal and spatial, Evolution new techniques**
- **Wider user network – interlinking with all stake holders and departments**
- **Linking with the stakeholders programme**
- **Addressing management and conditions with variety of data, total solutions**
- **Synergizing with communication and navigation technology**

Policy and Governance

- Developing regional policy framework – schemes and incentives
- Promotion of Investments in agriculture
- Targeting demand driven growth
- Real time market information for better price
- Risk Proofing - Crop insurance, contracts farming, diversification
- Increasing the income of farmers
- Livestock and fisheries - integrated
- Capacity Building – academia interface

Thank You

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PDFSR, Modipuram

Director, EOS

Director, SAC

Dy. Director, SAC

Group Head, SAC

My colleagues at SAC

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