

# Earth observations and Agricultural monitoring: ..... *Indian experience*



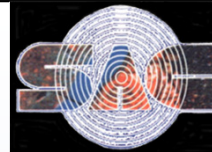
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EO & Agriculture

**“Food Security, Earth Observations and Agricultural Monitoring” November 21, 2013- Brussels**



*'We must be second to none in the applications of advanced technologies to the real problems of man and society'*

## Space Infrastructure

- Launch vehicles (PSLV, GSLV)
- Spacecrafts ( Communication-11, RS- )
- Sensors and Transponders

## Applications – Remote Sensing

- Agriculture
- Water Resources
- Watershed development
- Drinking water
- Drought assessment, monitoring & proofing
- Flood/ cyclone monitoring
- Fuel wood/ fodder assessment
- Land Information Systems
- Wasteland mapping & monitoring
- Groundwater prospecting
- Potential Fishing Zone
- Rural roads connectivity

## Applications -

### Communications

- Education/ Awareness
- Healthcare/ Hygiene
- Training/ Skill development
- Info Dissemination
- Strengthening Panchayat Raj
- Rural Empowerment

## Institutionalization

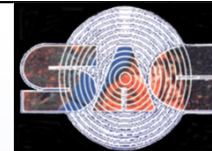
- National Natural Resources Management System
- Involvement of stake-holders from the planning level
- Antrix & NDC

...the focus is on needs and opportunities



# Institutional Framework

.....Bringing the technology to the end-user



- 1) Agriculture & Soils
- 2) Bio-resources & Environment
- 3) Cartography & Mapping
- 4) Geology & Mineral Resources
- 5) Ocean Resources & Meteorology
- 6) Rural Development
- 7) Urban Management
- 8) Water Resources
- 9) Training & Technology

Department of Space  
(Nodal Agency)

PC – NNRMS  
Chair: Member (Science),  
Planning Commission

Secretaries of Ministries,  
Govt. of India

Thematic Standing Committees  
Chair: Secretary of the respective  
Ministry of Government of India

Govt. of India Ministries  
State Departments

Academia  
National Institutes

Implementation

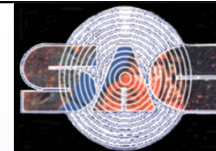
State Governments  
State Remote Sensing  
Application Centers

ISRO/ DOS  
National Institutes

Academia,  
R&D Institutions

Industry  
NGOs

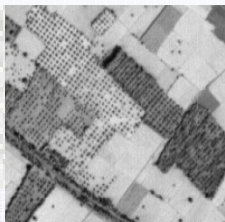
EO & Agriculture



## (Land Observations)

### (High Spatial Resolution & Stereo)

Cartosat-1,2/2A/2B  
(2005,2007,2008, 2010)  
PAN : 2.5 m, 1m  
Fore +26° Aft: -5°



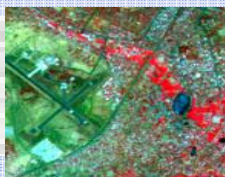
### (Multi resolution, Frequent observations, Better radiometry)

Resourcesat-1/2 (2003, 2011)  
LISS-3: 23 m, 4 XS,  
LISS-4: 5.8 m, 3-XS,  
AWiFS: 56 m, 4-XS



### (High Repetivity/Revisit , High Spatial Resolution)

IRS-1C/1D (1995,1997)  
LISS-3: 23/70 m, Steerable  
PAN: 5.8 m, WiFS: 188 m



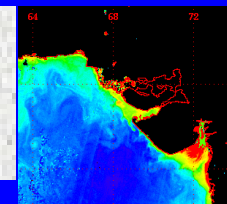
## (Atmospheric Observations)

INSAT  
VHRR (2.0 km Vis,  
8 km IR WV)  
CCD (1 km MS)

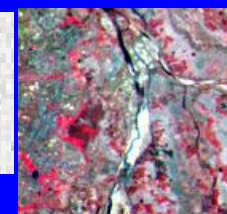


## (Ocean Observations)

IRS-P3 (1996)  
WiFS, MOS, X-Ray  
Oceansat -1 & 2(1999, 09)  
OCM, MSMR, SCAT, ROSA

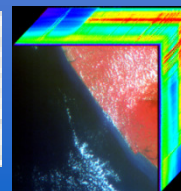


IRS-1A/1B/P2  
(1988,1991,1994)  
LISS-I: 72.5m, 4XS  
LISS-II: 36.5m, 4XS



## (Hyperspectral)

IMS-1 (2008)  
HySI (64 bands, 506 m)  
TWSAT-MX (4 bands, 37 m)



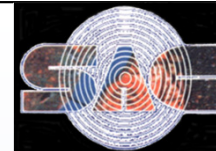
## (Recent)

•**INSAT-3D:** (6 Channel Imager & 19 Channel Sounder)

**Radar Imaging Satellite – RISAT – 1**  
(C-band SAR; 3-50m resolution; 10-240 km SWATH)

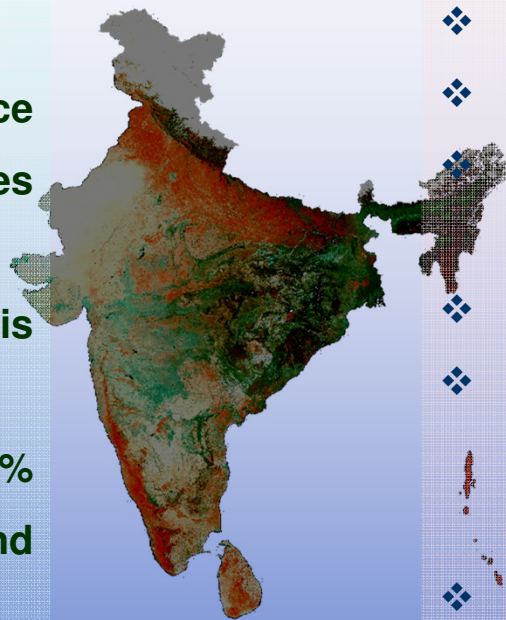
•**SARAL** (Satellite with Argos and Altimeter)  
(Ka-band altimeter; DORIS, Laser Retro-reflector Array)

•**Megha Tropiques**  
(MADRAS, SCARAB & SAPHIR)



## Resources

- ❖ India is home to 23.3% of the world's farming population
- ❖ 2<sup>nd</sup> in world's wheat and rice production, first in pulses production
- ❖ 51.8 % of India's population is involved in agriculture
- ❖ Agriculture provides about 15.7% of India's total employment and 73% of rural employment
- ❖ Net sown area : 142 Mha
- ❖ Total food grain production is around 220 Mt
- ❖ Agri. GDP is about 18.3 %



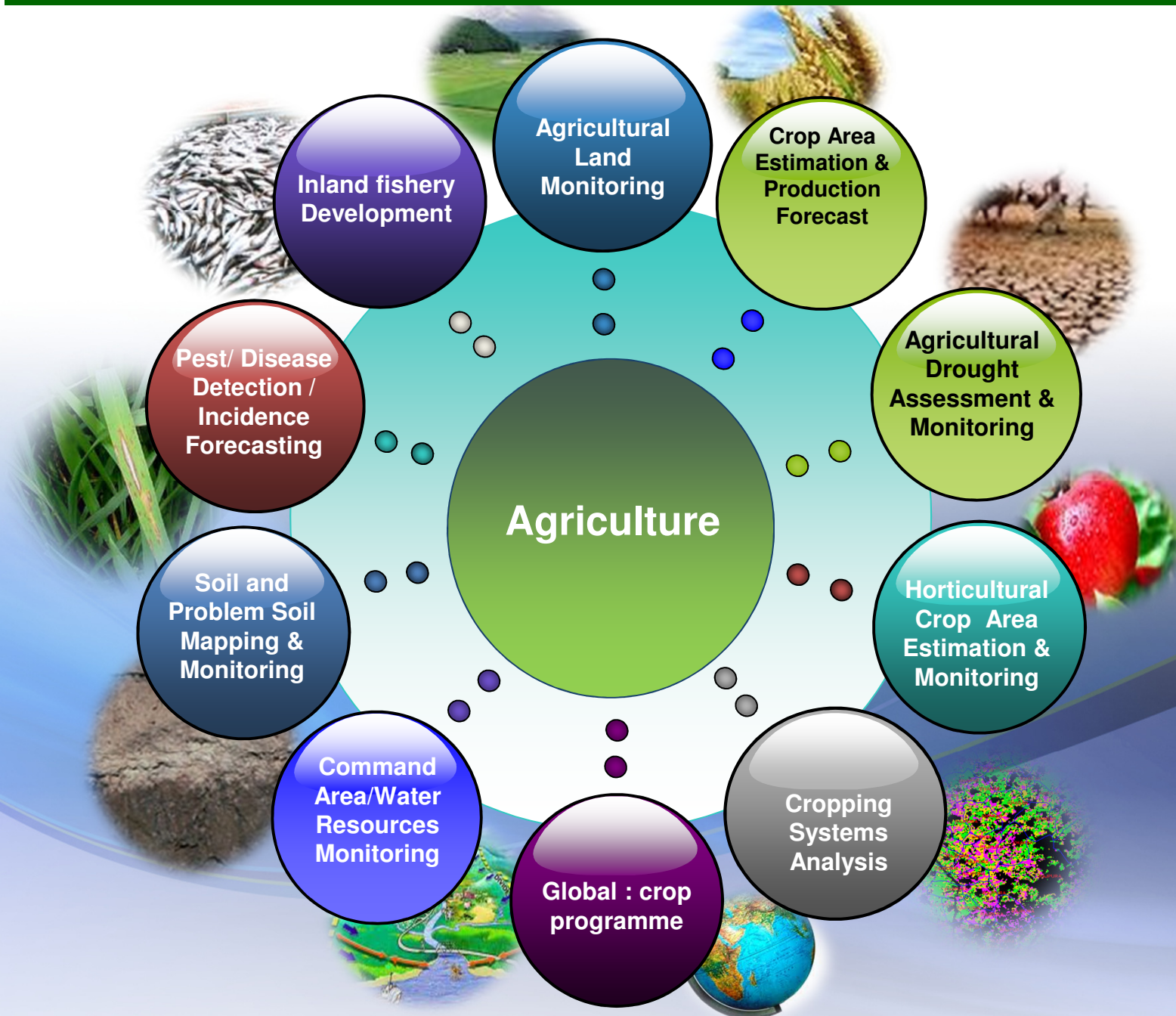
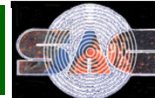
## Constraints

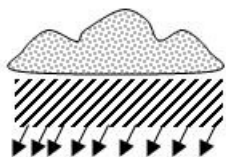
- ❖ Low crop productivity
- ❖ Highly degraded land (~57%)
- ❖ High erosion
- ❖ Average operational holding 1.32 ha)
- ❖ Low cropping intensity (135.3%)
- ❖ Indian agriculture is highly dependent on monsoon (NIA/NSA is 38.8 %)
- ❖ Low fertilizer consumption

BROAD ISSUES : Poverty Alleviation, Food Security, Ecological Crisis, Emerging Global Environmental Change

GOALS: Within Existing Land Holdings & Other Constraints, the Goals are:

- To increase crop yield, To diversify/intensify agriculture
- To reduce cost of cultivation (by optimizing agricultural inputs)
- To reduce the environmental impact
- *To enrich the agricultural enterprise – in terms of information, science*



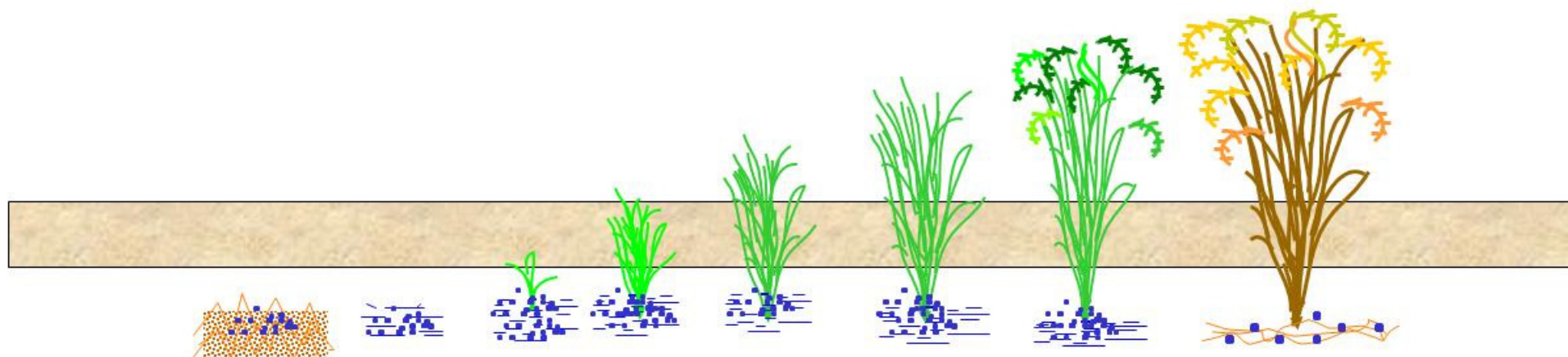


## Information Need in Agriculture and Sources

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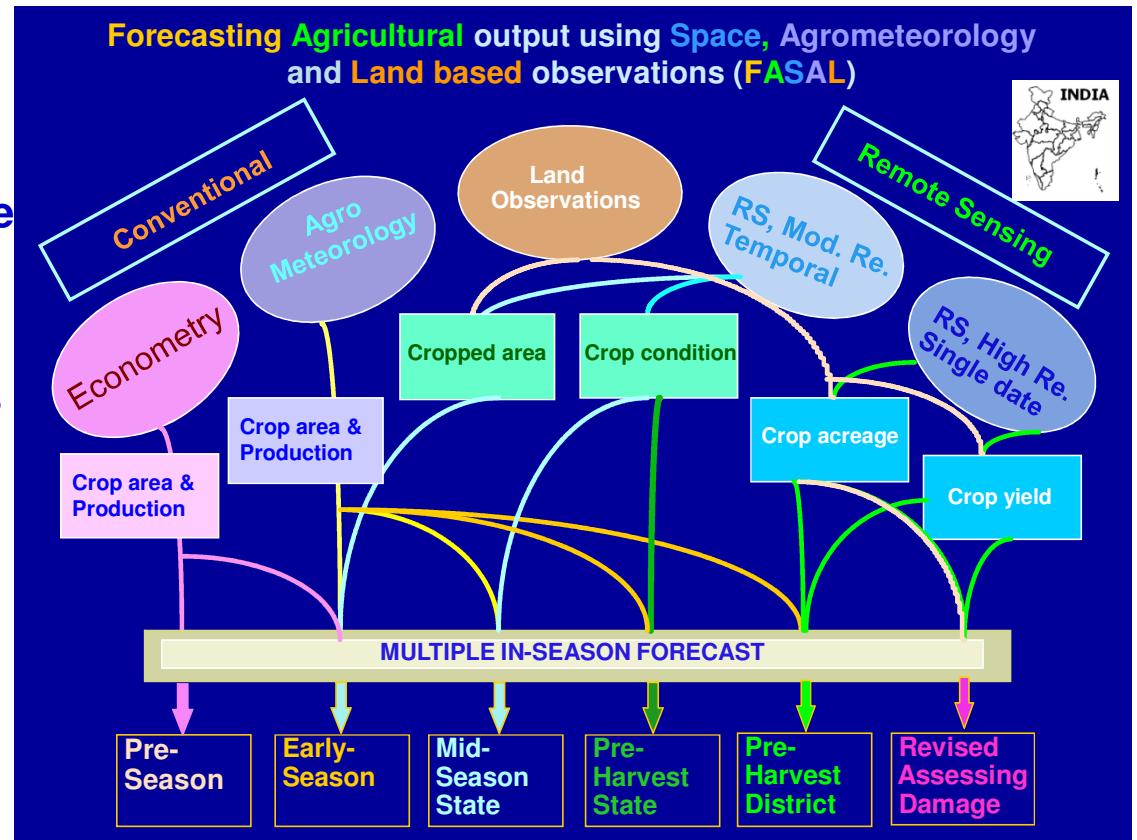
Source: SAR, Optical, Sounders, Field, expert knowledge

*krm*

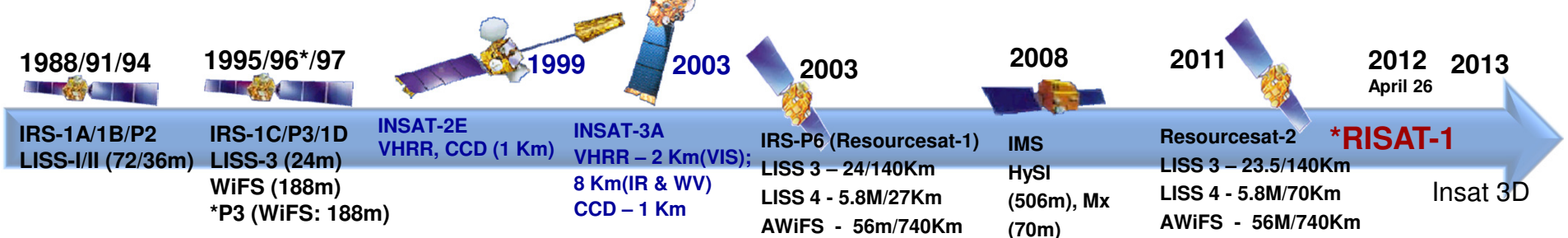
IMD, AWS INSAT	SAR Passive MW	SAR	AWiFS/LISS SAR	AWiFS SAR	Multi- source	Multi- source	Multi- source	Integrated
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# Remote Sensing based Crop Monitoring in India

- The methodology has evolved over past 25 years.
- Remote sensing, field observations, meteorological and ancillary data are used.
- Major crops (wet season rice, dry season rice and other crops such as Jute, wheat, mustard, potato) are covered.
- Other crops are at various stages of operationalisation.
- Multiple in-season assessments are being made.
- User agencies have their own institute with complete infrastructure for RS data based crop monitoring



FASAL Concept: The diagram above illustrates the various sources of data, timing of input and analysis, interlinkages and preharvest estimate time in relation to crop stage





# Rice and Jute Crop Assessment using SAR Data

Three date SAR data is used for assessing Jute and Rice.

The non-agricultural area is masked and rice crop proportion is used as basis for stratification. Stratified random sampling approach with 5 X 5 km grid with 15% sample size is used.

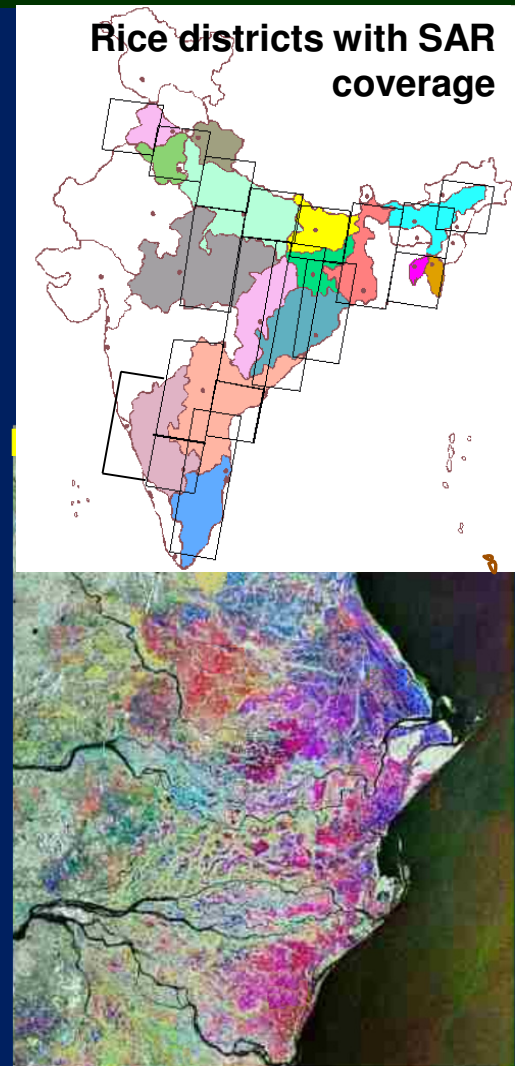
Groundtruth during the cropping season is carried out.

Hierarchical classification is used for extracting rice pixels based on backscattering pattern.

This covers 90 % of the area and three estimates are given.

The yield models are based on agrometeorological models.

**Three estimates are given during cropping season**



Pre-transplantation



Transplantation



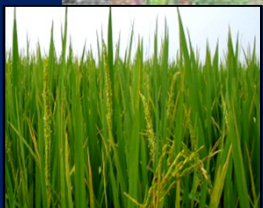
Tillering



Vegetative



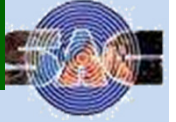
Peak-vegetative



Heading



Maturity



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

### FOCUS

#### **FASAL- operational -multi-forecast**

- Rice (Kharif & Rabi)
- Jute
- Wheat
- Rapeseed / Mustard
- Winter potato

#### **In the developmental stage-II**

- Sugarcane- AWiFS(K)
- Cotton- SAR/AWiFS(K)

#### **In the developmental stage-I**

- Sorghum (KR)
- Maize(K)
- Pearl Millet (K)
- Finger Millet (K)
- Groundnut- (KR)

#### Outputs

##### Sugarcane:

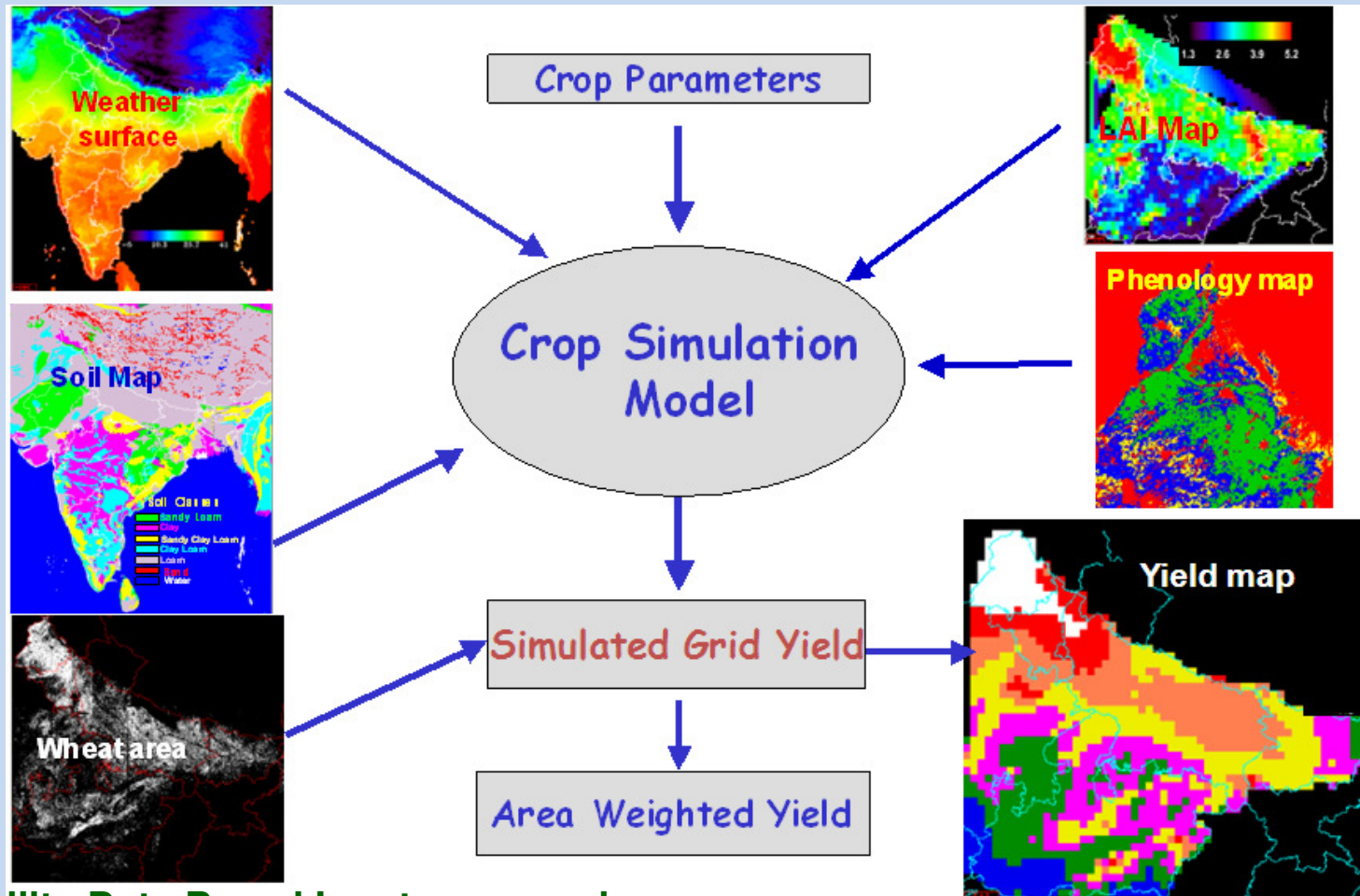
- Early area estimation of Sugarcane crop, two estimates (UP, Maharashtra, Gujarat, Karnataka).
- Current year first estimate for UP and Maharashtra is complete.

##### Cotton :

Identification using multirate SAR data, analysis is in progress

##### Inputs from State agencies:

Early inputs on location information on current seasons increase/decrease for groundtruth



- **Satellite Data Based Inputs are used**
- **Use of Spectral indices in empirical Models**
- **Satellite Based Crop Parameters are derived**
- **Tested for wheat crop**

### Periodic soil moisture assessment and crop suitability

#### Inputs:

1. Soil Texture
2. Daily PET
3. Crop Coefficient
4. Agricultural/Crop Maps
5. Crop Calendars
6. Daily Gridded Rainfall
7. Daily Gridded Irrigation Data

#### Outputs (at 1: 5 M scale map eqv.) (Daily/Weekly/Monthly/Any):

1. **Daily Available Soil Moisture**  
Various Indices: ASM, Moisture Avail. Index, Aridity Index
2. **Drought Status**
3. **Crop Sowing Suitability**
4. **Crop Growth Suitability**
5. **Progressive Crop Acreage**
6. **Irrigation Requirement**
7. **Flood Risk Assessment**

#### Usage

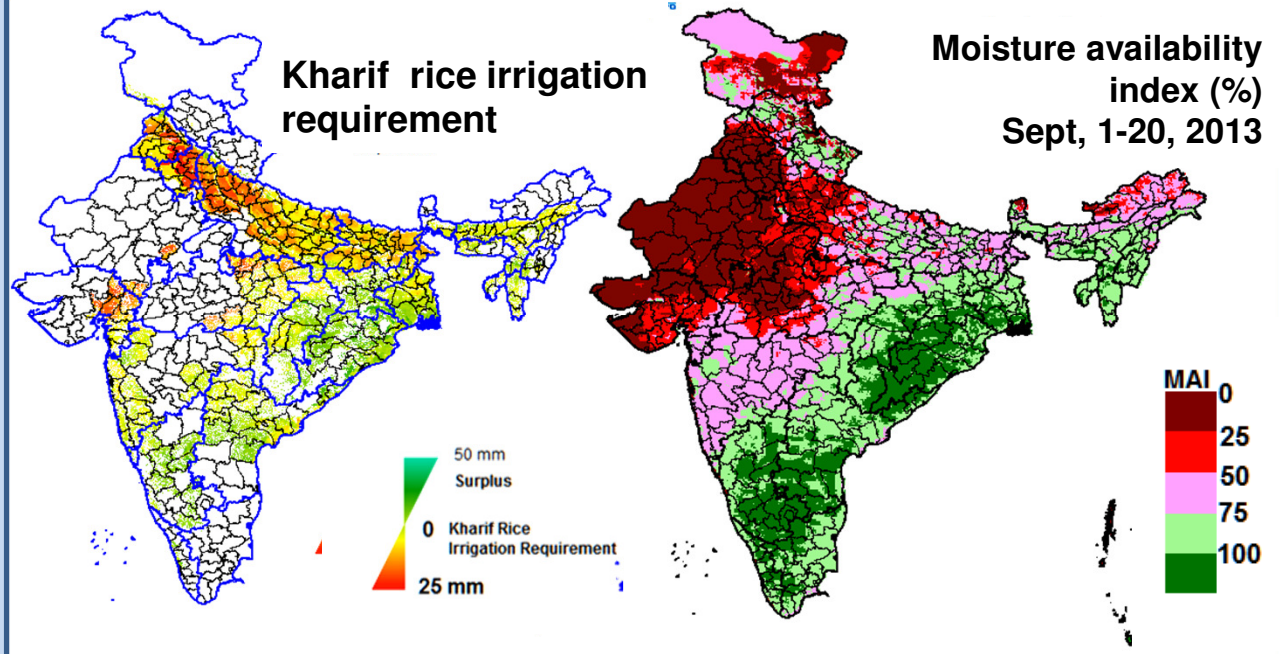
**District and State wise:**  
(Daily/Weekly/Monthly/Any):

1. Crop Sowing Suitability
2. Crop Growth Suitability
3. Progressive Crop Acreage
4. Irrigation Requirement
5. Drought Status

#### Inputs/States

- Ground Validation of output
- Updated Crop Calendars (district wise)

Kharif Rice Area: 39.1 Mha (Projected)

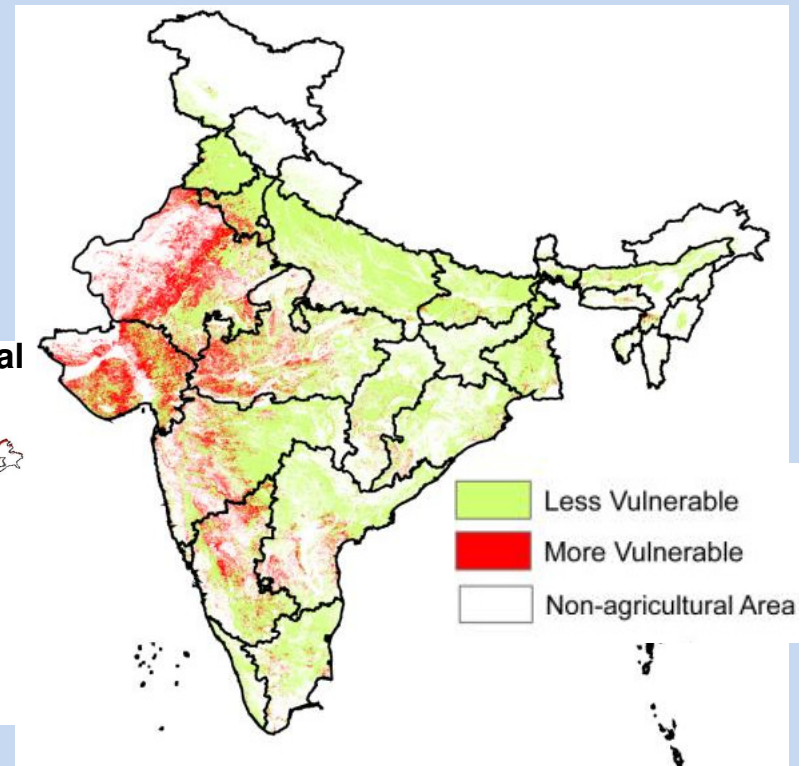
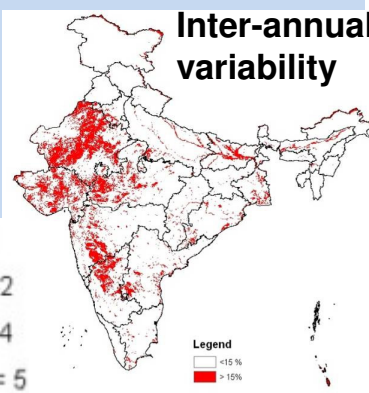
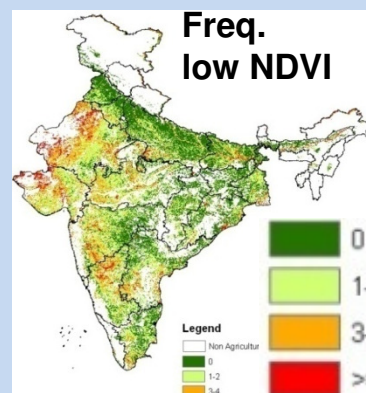
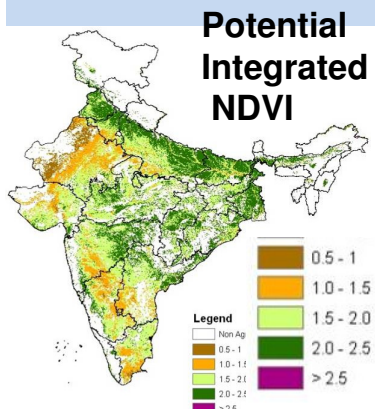


- **NADAM - Operational drought assessment is being made by MNCFC.**
- **Agricultural drought vulnerability Analysis with time series NDVI.**
- **Agricultural Drought Vulnerability is referred as exposure, sensitivity and adaptability of agricultural area to the reduced soil moisture availability.**
- **1173 blocks in 185 districts of 13 states – 120 M ha as drought prone.**

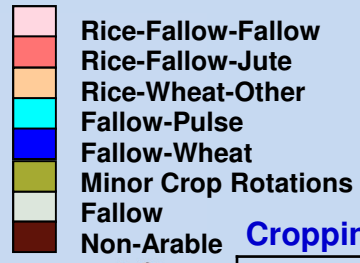
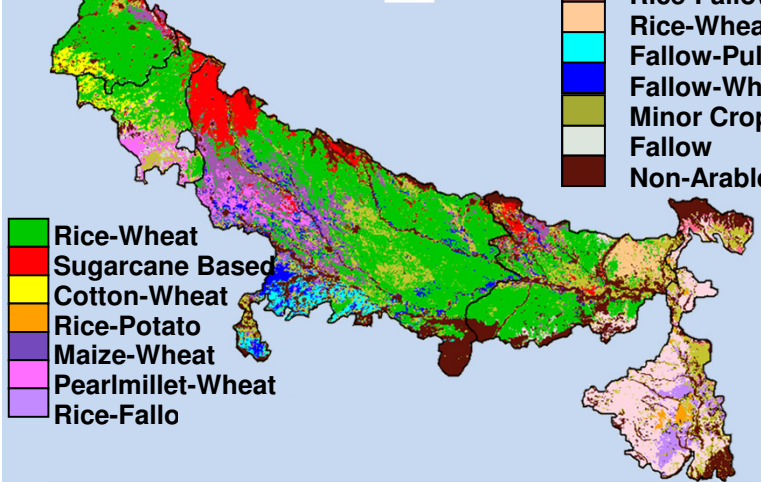
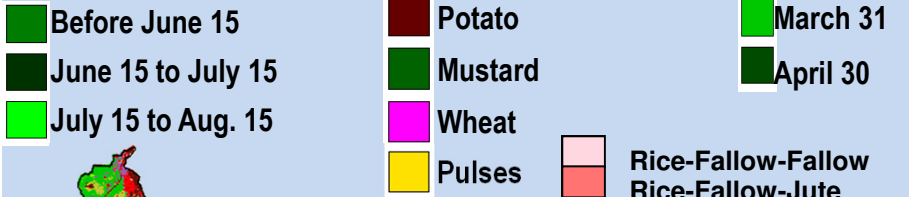
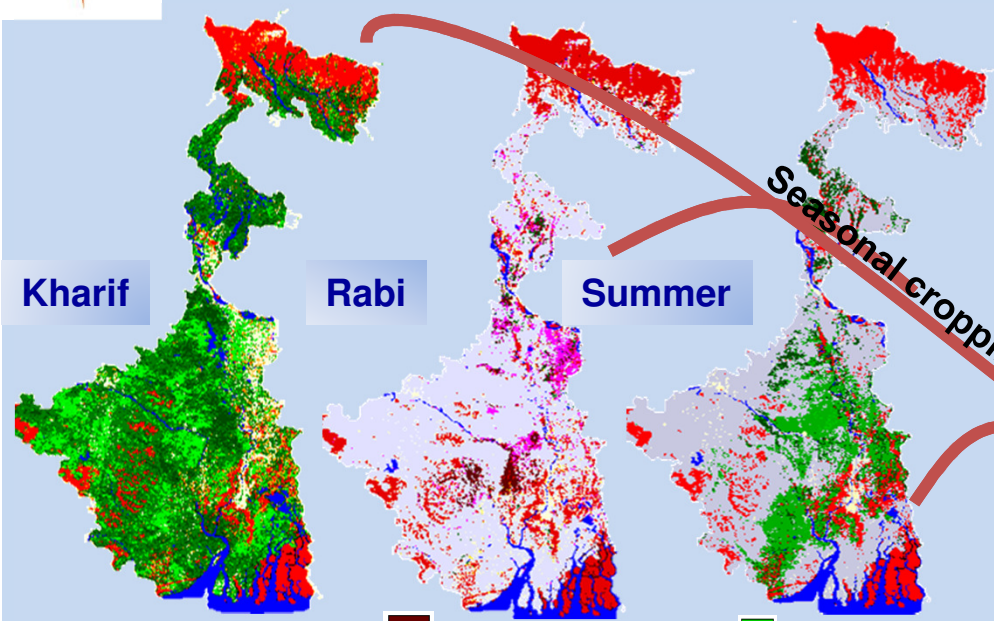
## Usage/Application

- Sub-district level planning for drought.
- Preparing contingency plan.
- Longterm strategies

## Time series NDVI derived metrics

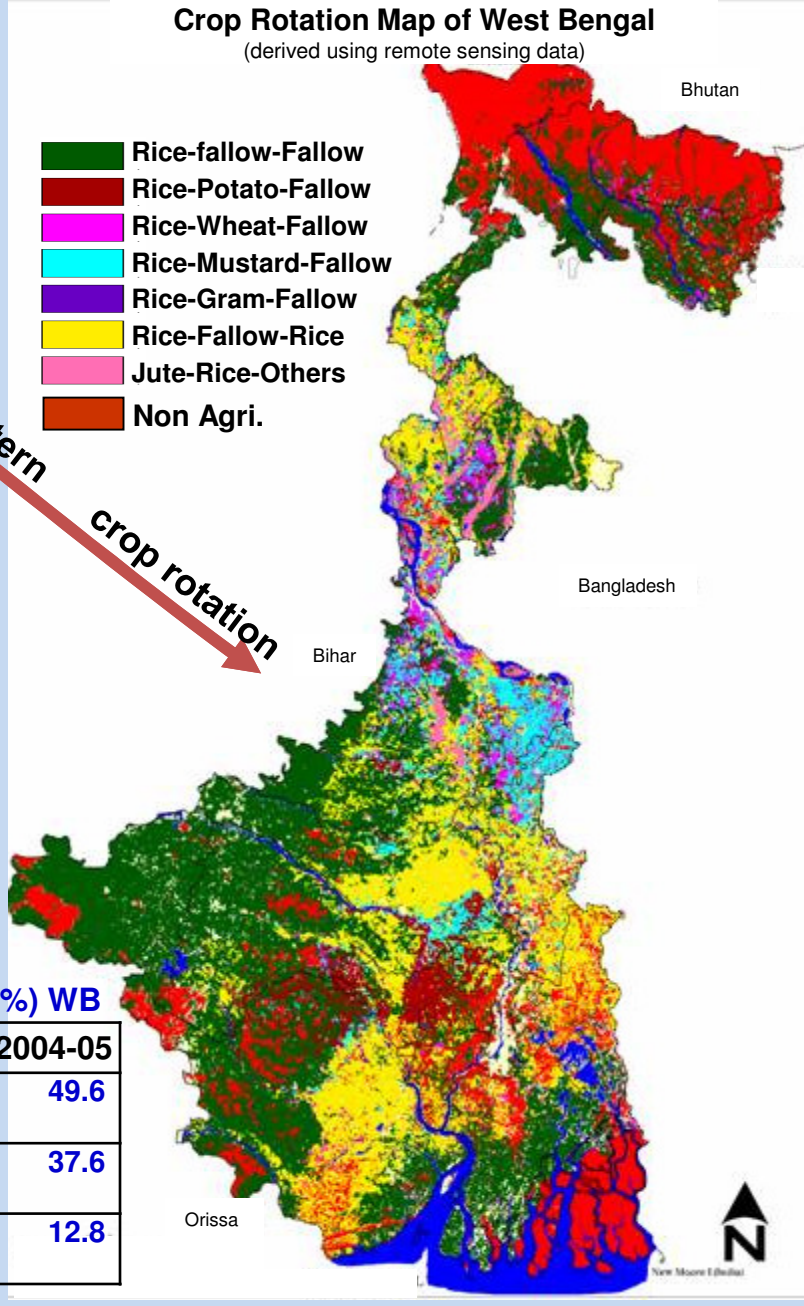


# System Studies: Cropping Pattern and Crop Rotation



**Cropping intensity (%) WB**

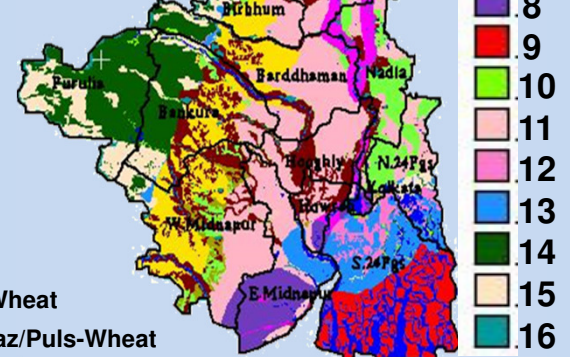
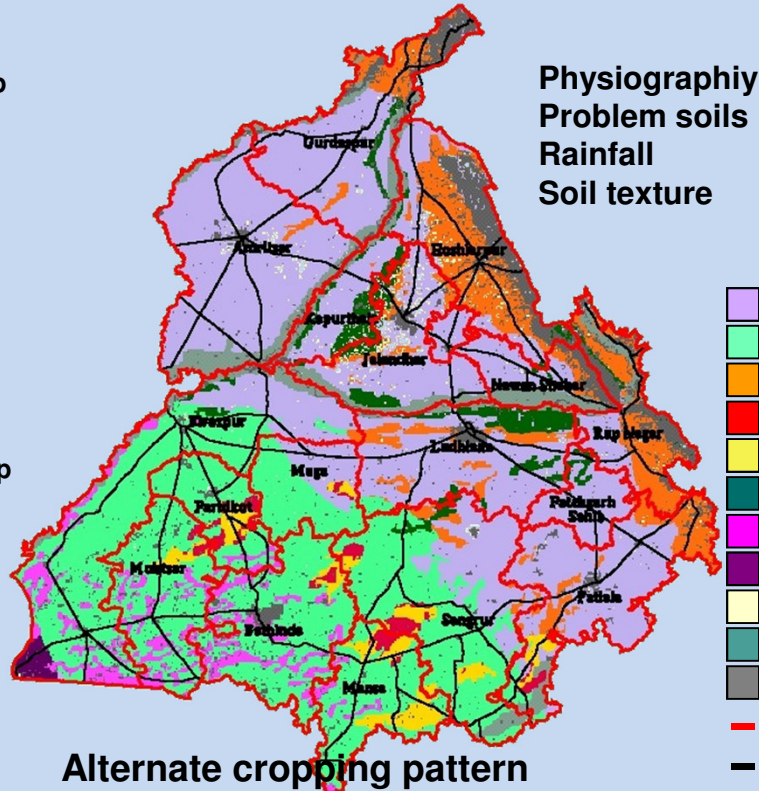
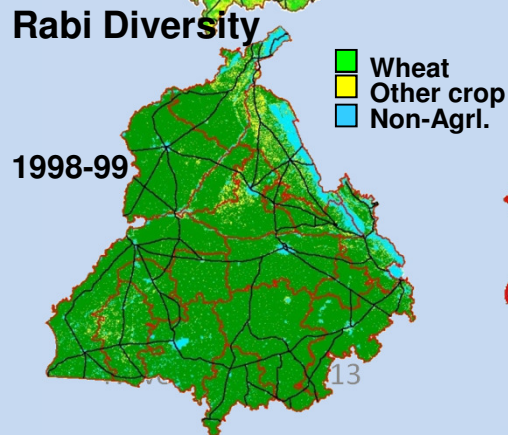
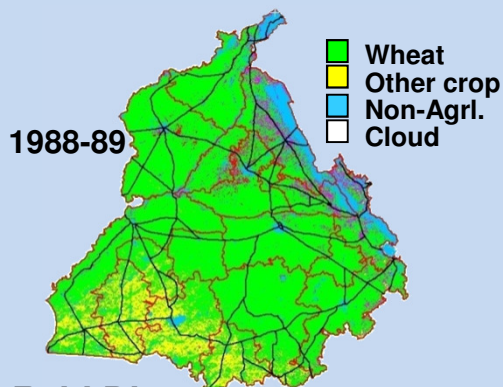
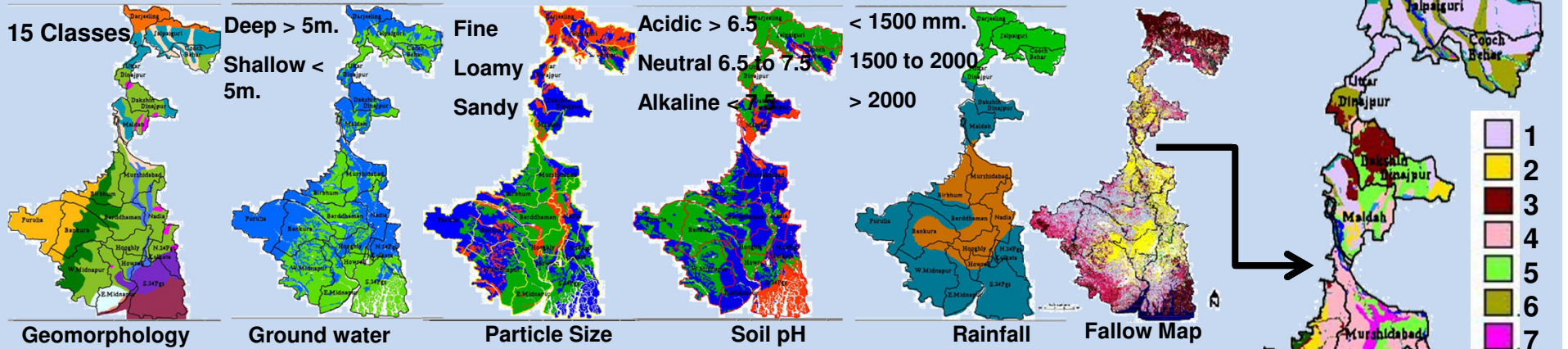
Type	1998-99	2004-05
Single Cropped	55.4	49.6
Double Cropped	42.1	37.6
Triple cropped	2.5	12.8



# Crop Intensification and Diversification

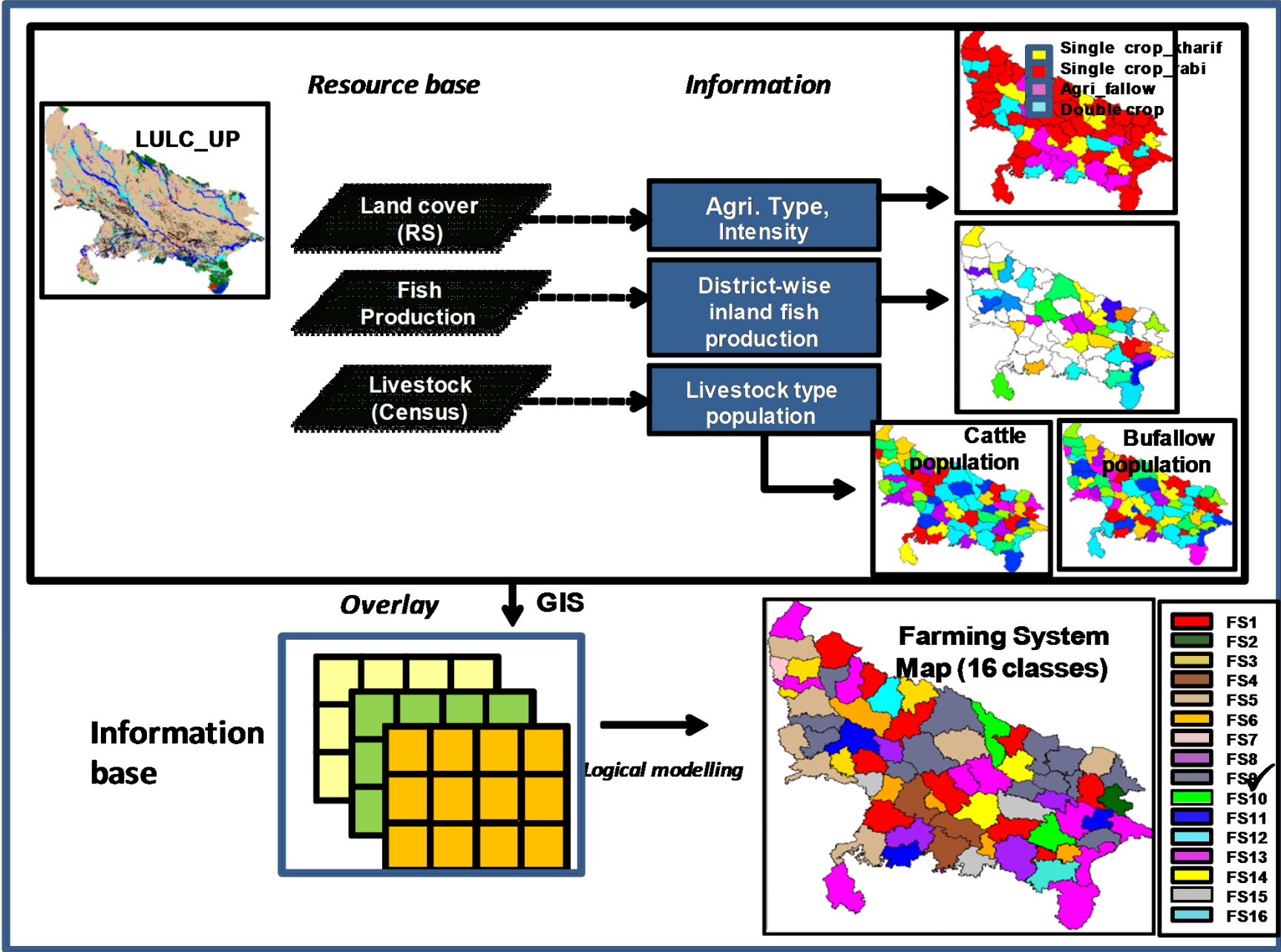


## Inputs – Intensification in West Bengal



- 1 Rice-Wheat
- 2 Cot/Maz/Puls-Wheat
- 3 Maize-Sugarcane
- 4 Rice-Mustard
- 5 Cotton-Mustard
- 6 Groundnut/Maize
- 7 Bajra-Gram
- 8 Baj/Fod- Mustard
- 9 Vegetables
- 10 Agroforestry
- 11 Non-Agriculture
- 12 District Boundary
- 13 Major Road

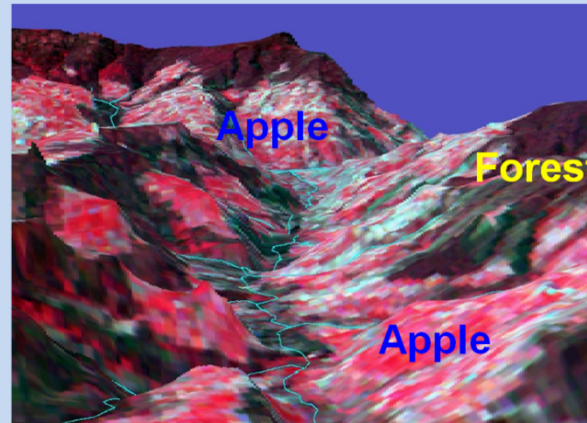
# Farming Systems



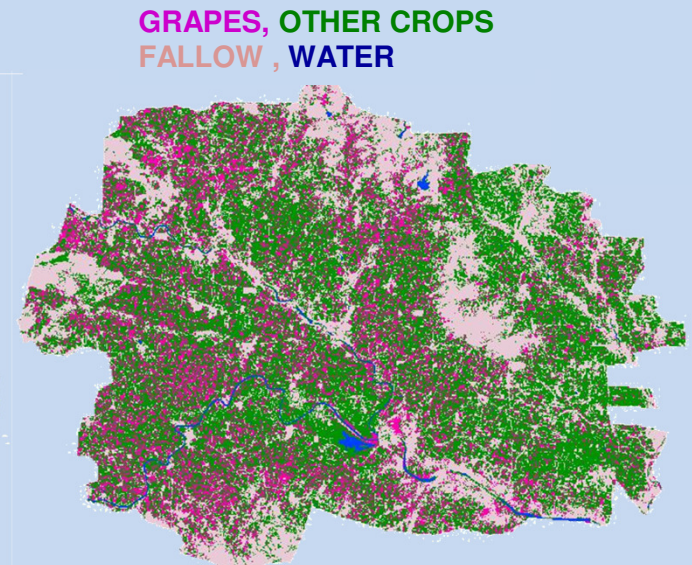
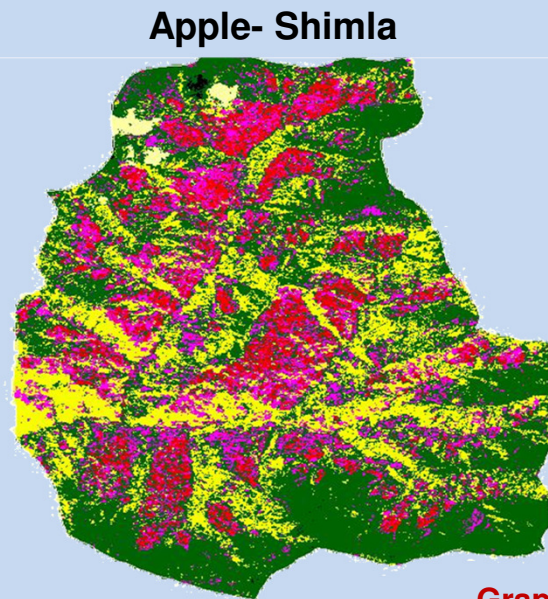
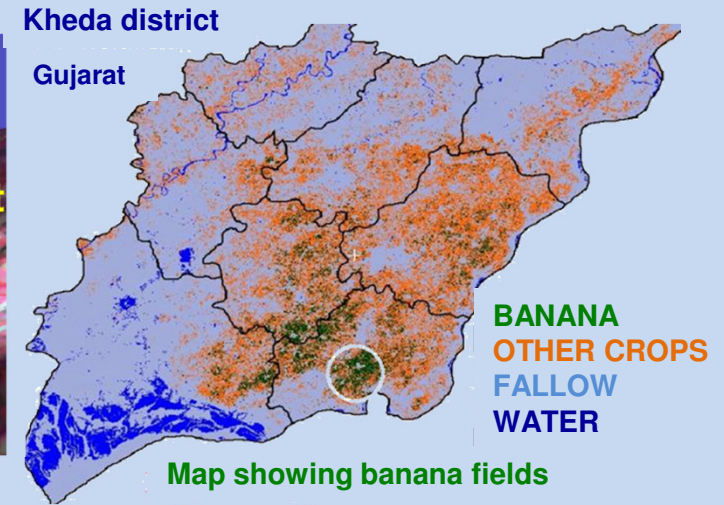


# HORTICULTURAL APPLICATIONS

- National database of creation of major horticulture crops
- Seasonal and early trends of major crops
- Inventory, characteristics and monitoring of orchards/plantations
- Site suitability and integrated plan for development of commercial horticulture
- Monitoring of peri-urban horticulture crops
- Post-harvest infrastructure information
- Hot-spot monitoring
- Crop/Spectral library



Nagar block, Kullu district

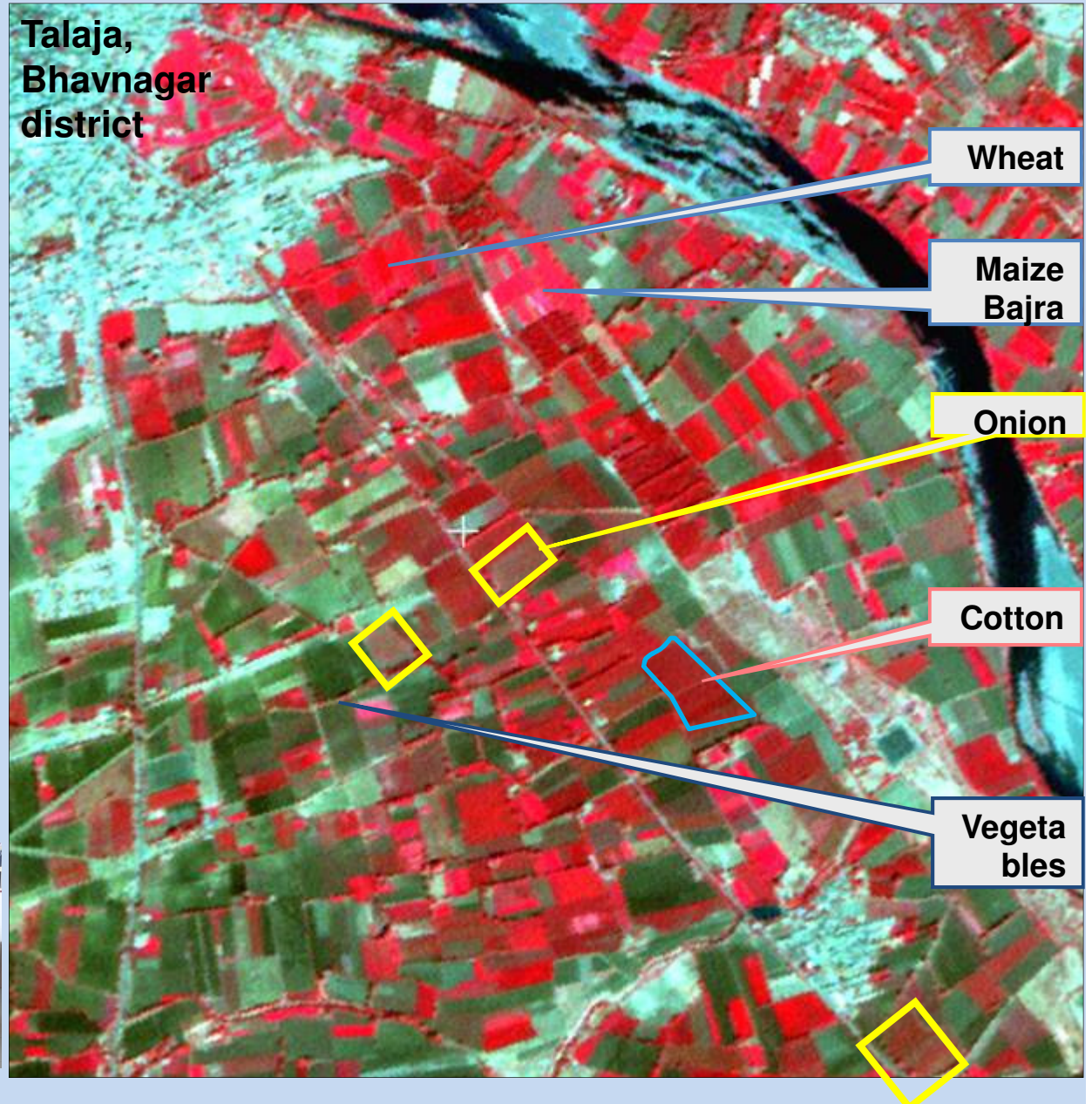


Grape Orchard distribution in Niphad Taluq (Nashik)  
IRS 1D LISS-III (26 Dec 1998, 20 Jan 1999, 14 Feb 1999)

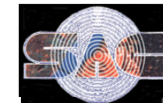
Early assessment of annual horticulture crops:

Winter potato area estimation

Onion crop area estimation was initiated at NHRDF, Nashik

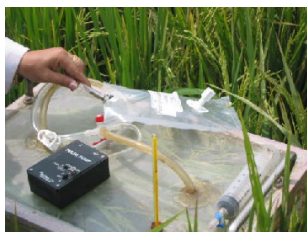
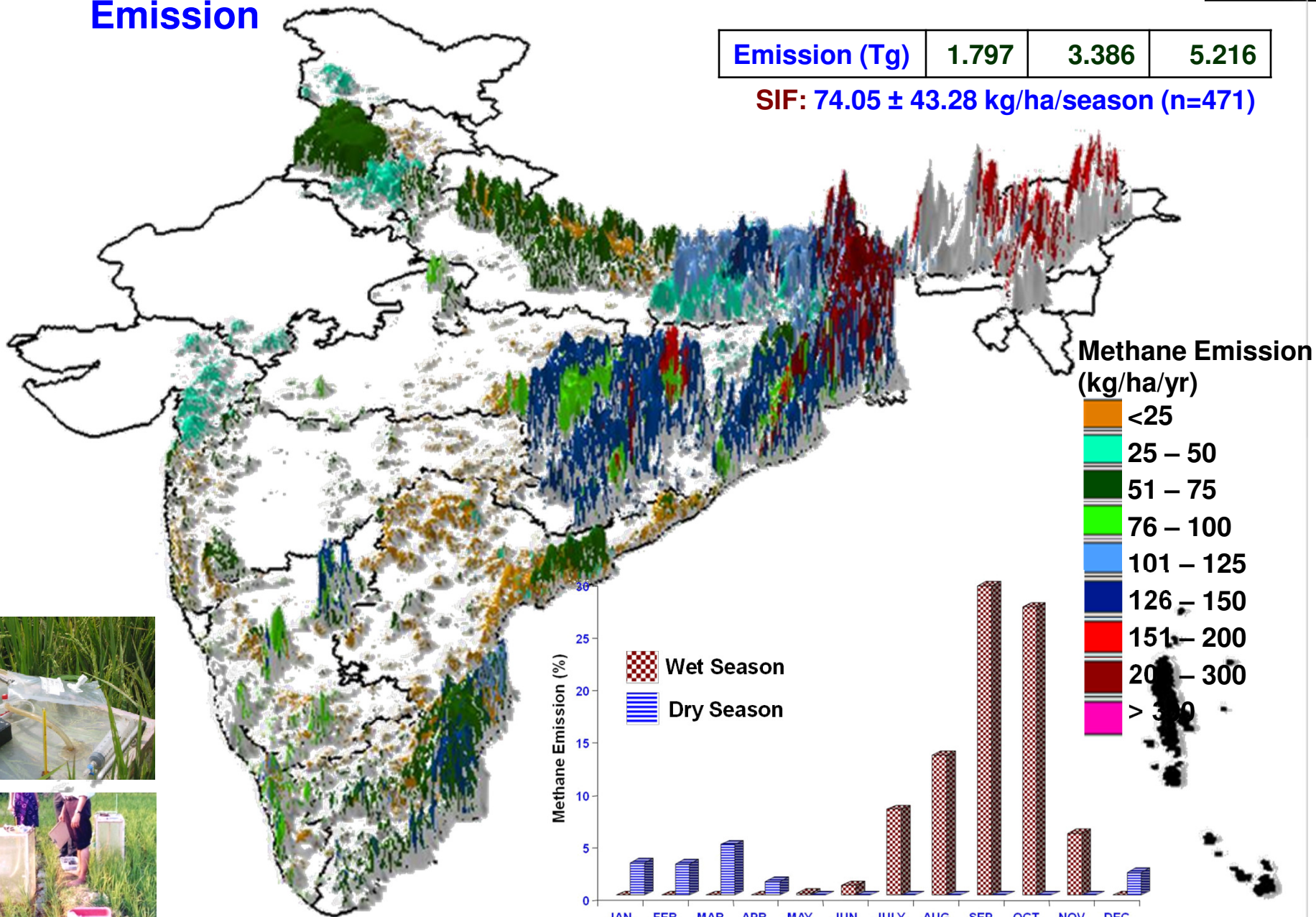


# Impact of Agriculture : Perspective View of Methane Emission



Emission (Tg)	1.797	3.386	5.216
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SIF:  $74.05 \pm 43.28$  kg/ha/season (n=471)

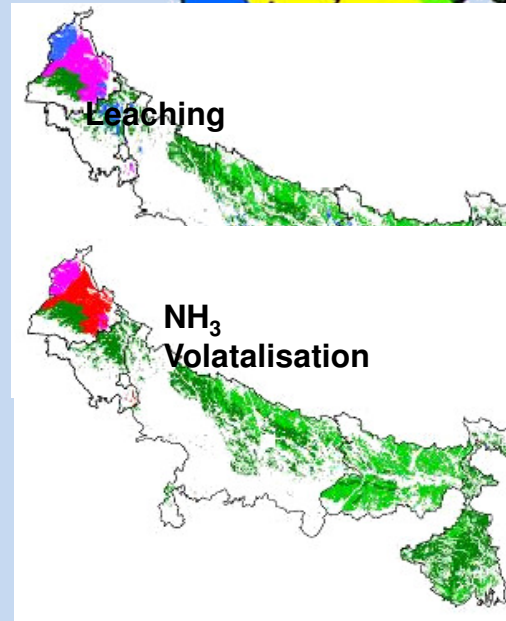
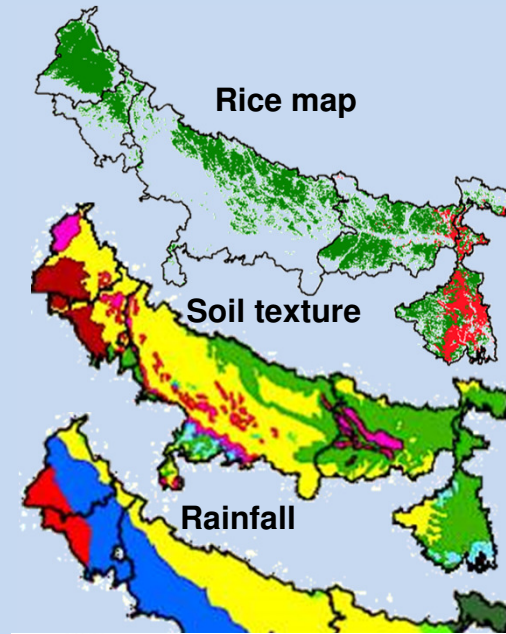
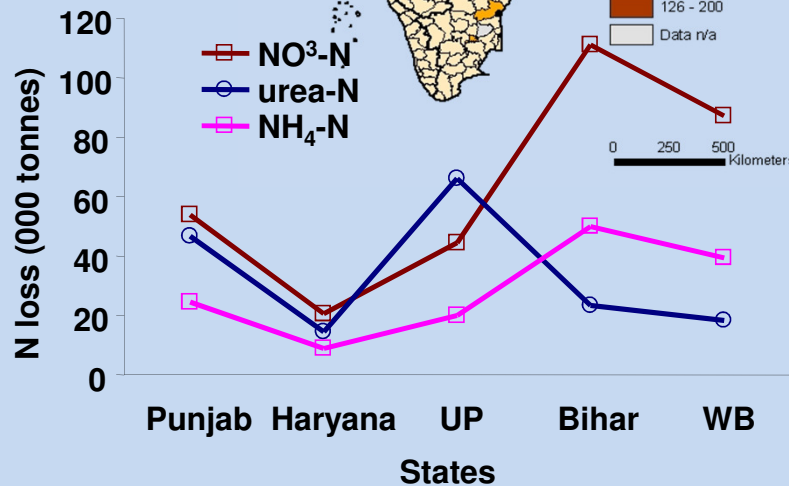
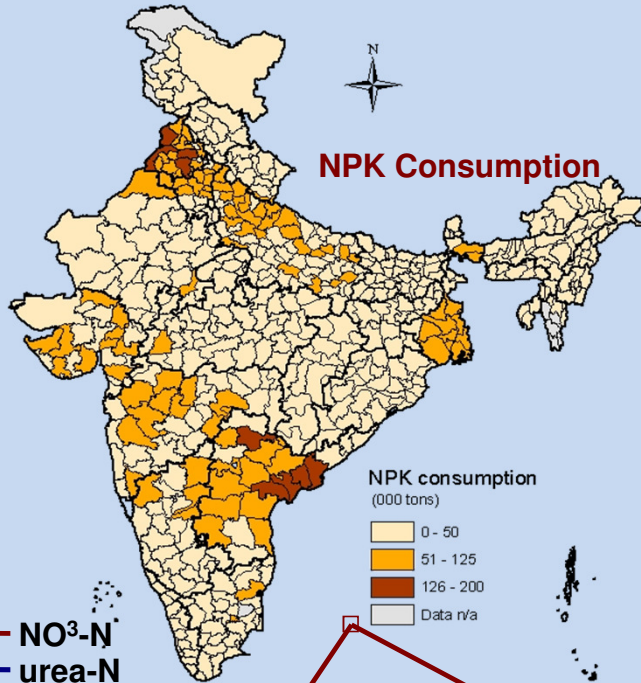


Temporal Emission Pattern

# Fertilizer Consumption and Non-Point Source Pollution

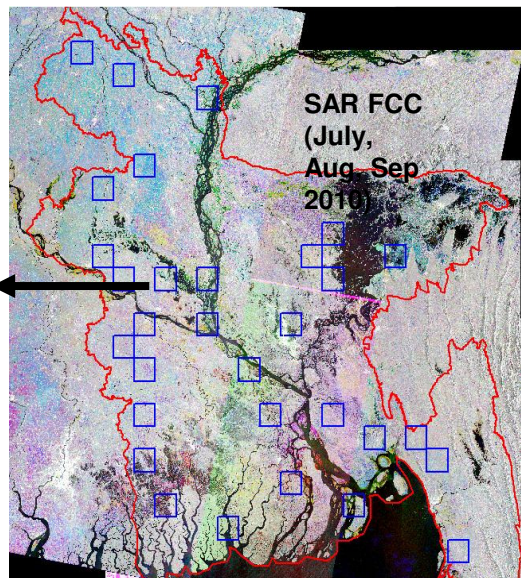
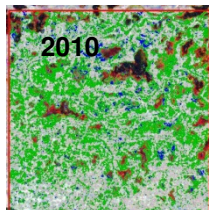


- All-India Total NPK consumption: 16.8 Mt, ~ 90 kg/ha<sup>-1</sup>
- 'vulnerable districts' of NPS pollution - intensive agriculture areas in North (Punjab), coastal areas in the East (AP, WB), and peri-urban area (Bangalore)

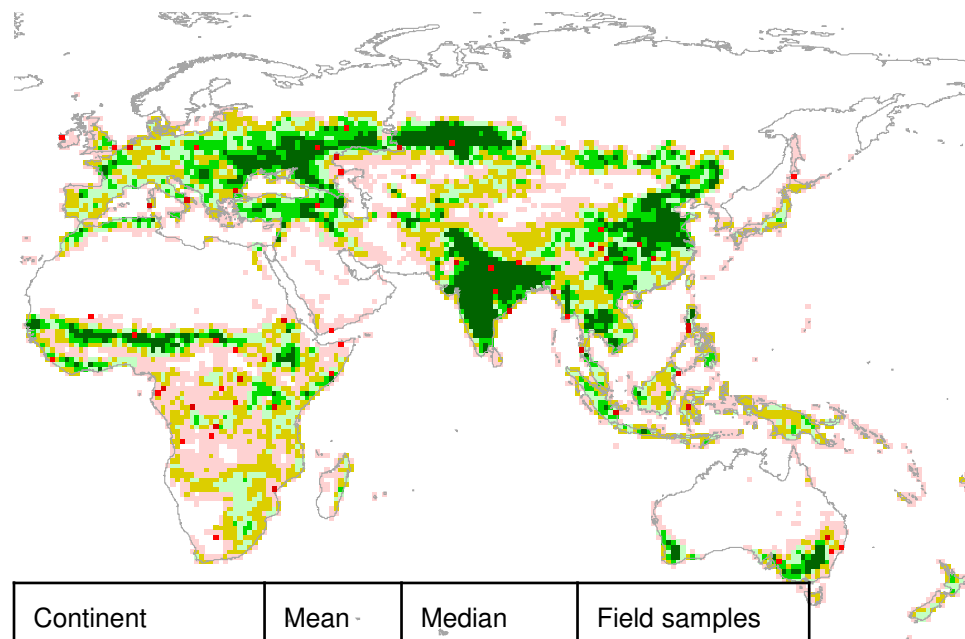


Non-point source - input and outputs

Kharif rice: Bangladesh using C band SAR data



Global Field size : Continent wise



Continent	Mean	Median	Field samples
Africa	1.04	0.97	1361
Asia	1.30	1.12	2186
Europe	8.15	10.78	786
N America	25.31	27.99	295
S America	35.19	29.03	1705
Australia	55.82	55.82	847

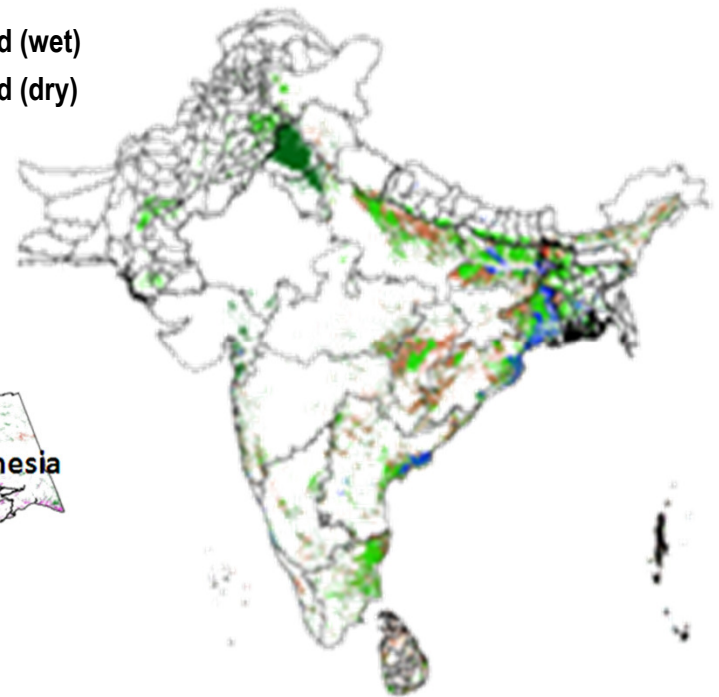
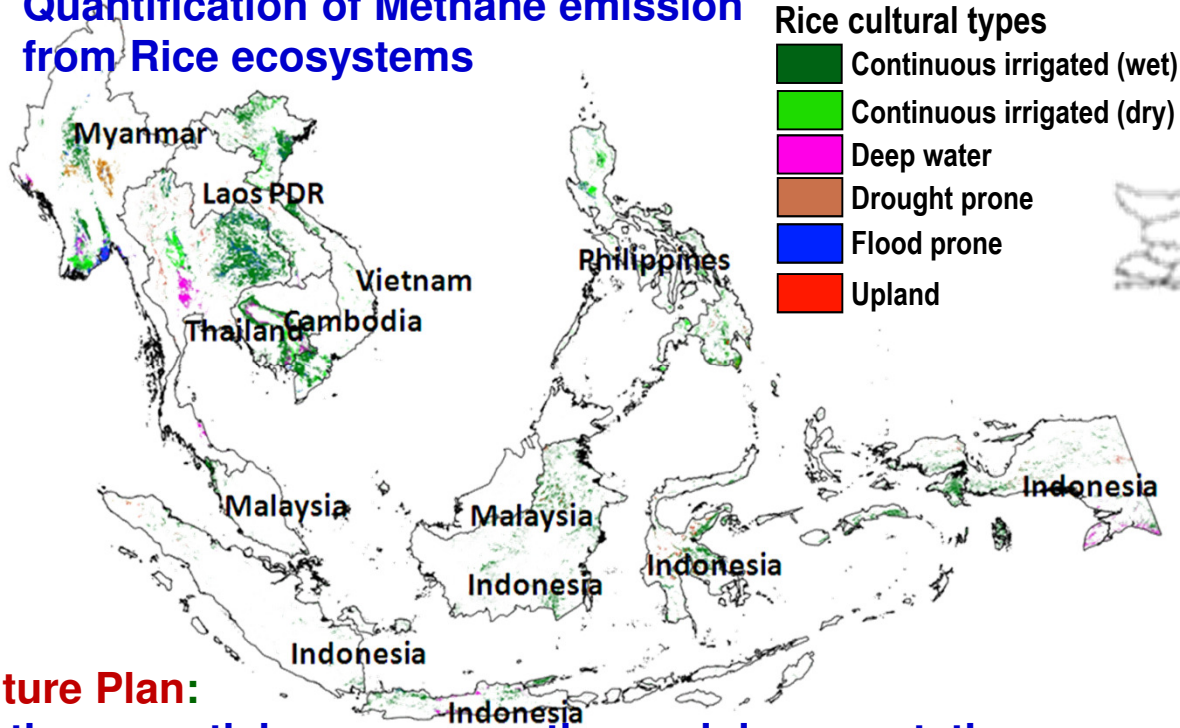
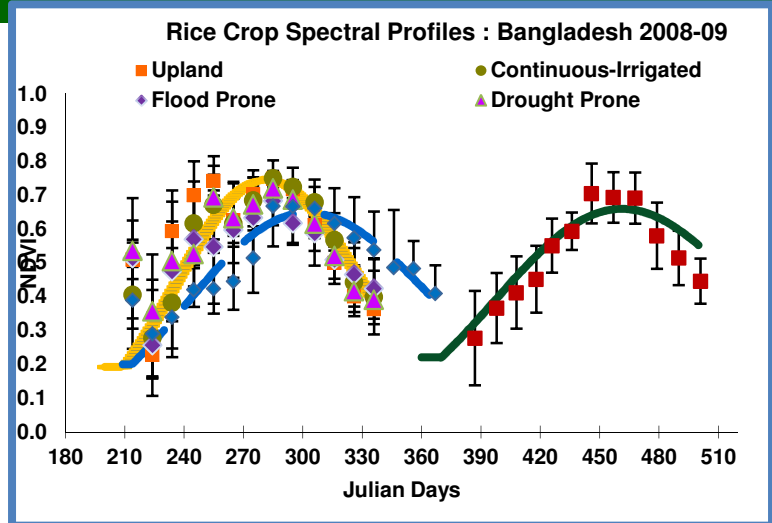
# Rice Cultural Types of South and Southeast Asia

**The south Asia (7):** 43.7 % of rice area , Bangladesh, Nepal, India, Pakistan, Sri Lanka).

**The Southeast Asia (11):** 30.4 % of ricearea, (Philippines, Indonesia, Malaysia,Vietnam, Burma, Laos, Cambodia, Thailand)

## Major Objectives :

- Derivation of Rice cultural type maps.
- Quantification of Methane emission from Rice ecosystems



**Future Plan:**  
Methane spatial maps generation and documentation

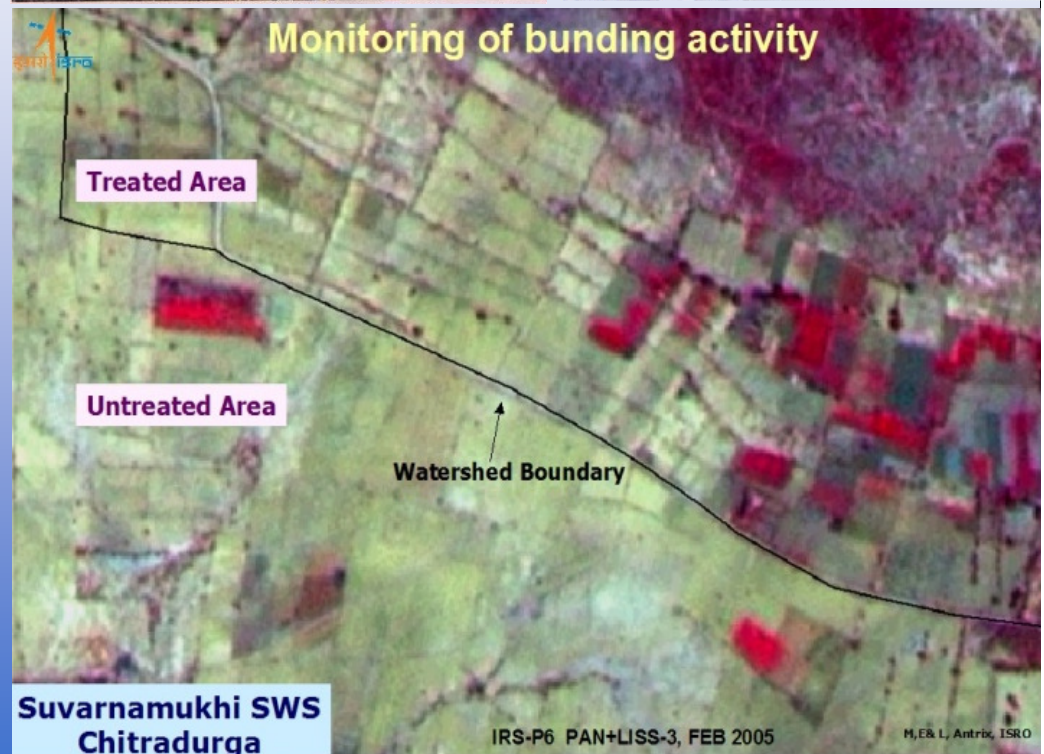
- Inventory of surface water bodies (tanks, reservoirs), Performance evaluation of irrigation commands, Ground water prospecting/recharge structures, Glacier inventory, retreat



**Improve productive potential of degraded watersheds and poverty alleviation**

## Constraints and Problems of Study Area

- **Low, uncertain & uneven Rainfall**
- **Recurring occurrence of drought**
- **Considerable area under wastelands**
- **Migration for employment**
- **Degraded Lands - Erosion, overgrazing**
- **Lack of infrastructure and facilities**



**Implementation**  
Watershed Dept., Gov

**Funding**  
NGO

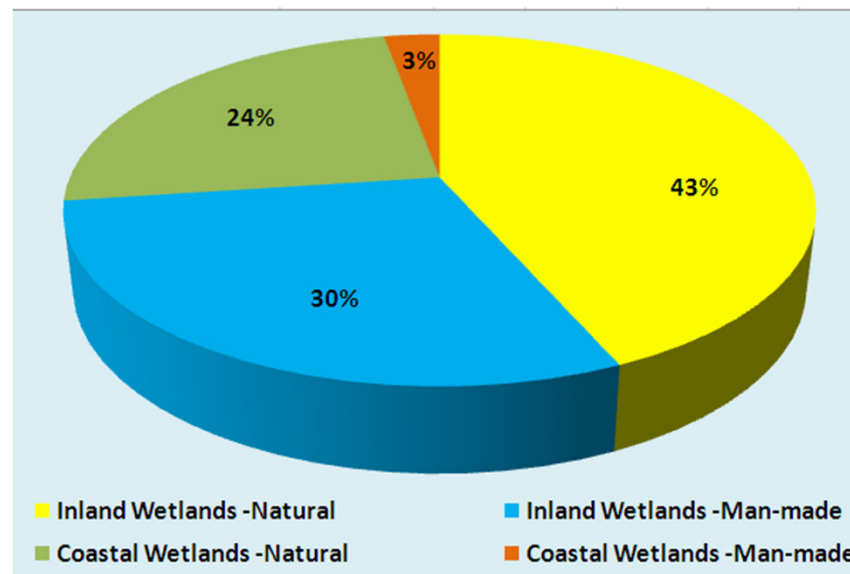
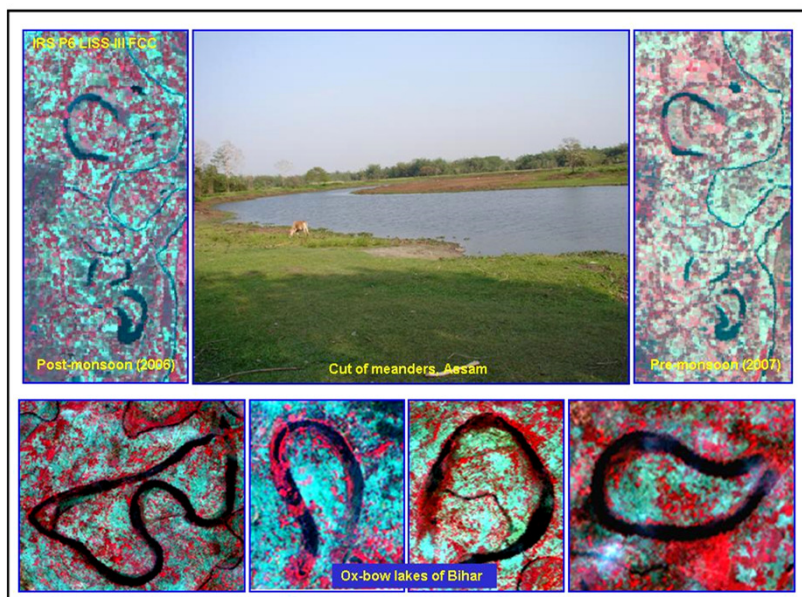
**M & E**  
Gov, NGO

- Wetland (of > 2.25 ha in size) map of entire country has been generated at 1:50,000 scale using IRS Satellite data.
- Total wetland area estimated is 15.260 Mha (4.63 % of the geo. Area).
- Total 201503 wetlands. Small wetlands – 5,55,557 (<2.25 ha).
- Data is available in all categories.

## Application

Useful to plan seasonal water needs of crops, crop planning for subsequent seasons.

Useful for inland fisheries as part of Integrated Farming Systems management.





## 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

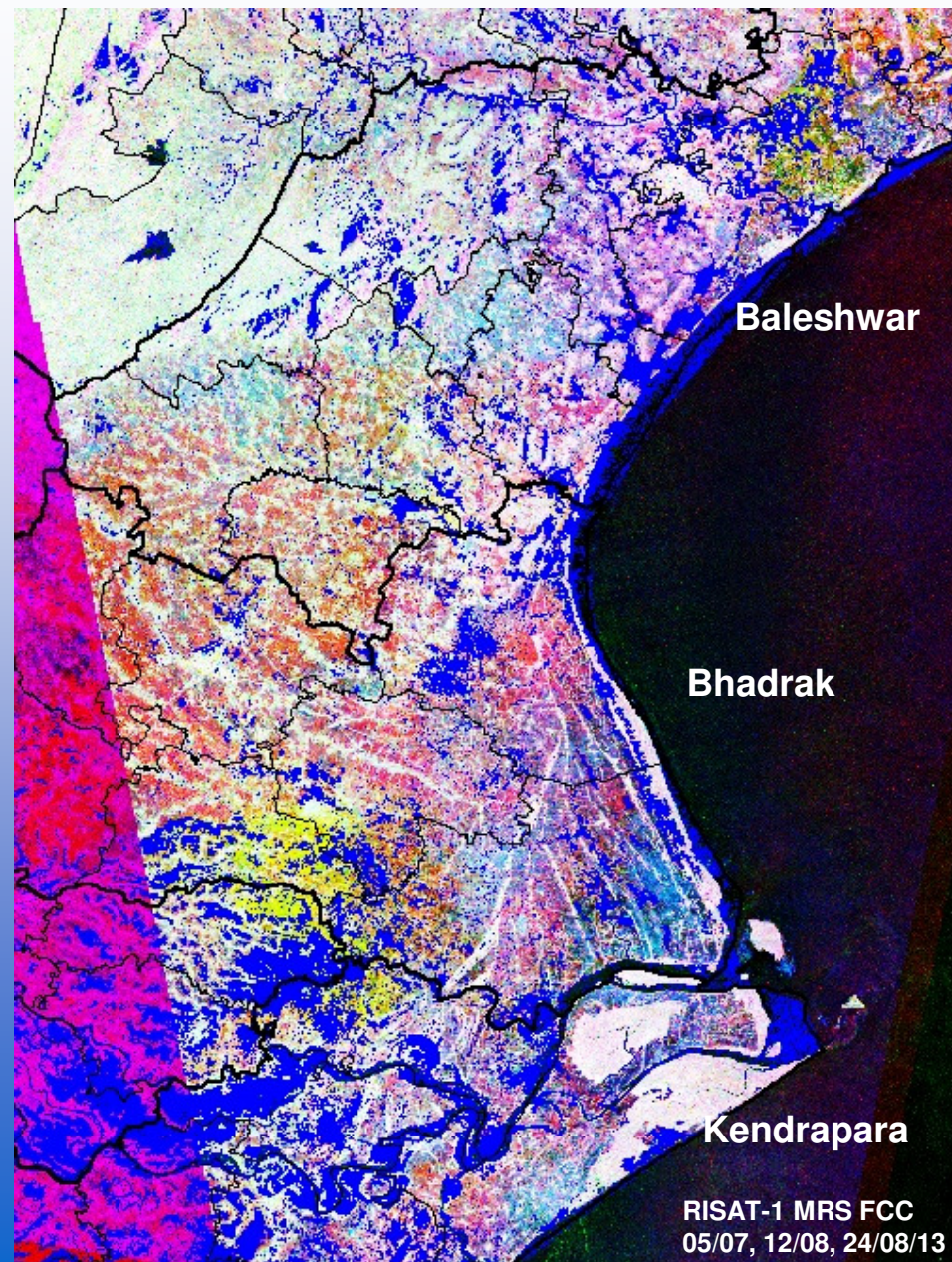
## Drought

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



## Forest Fires

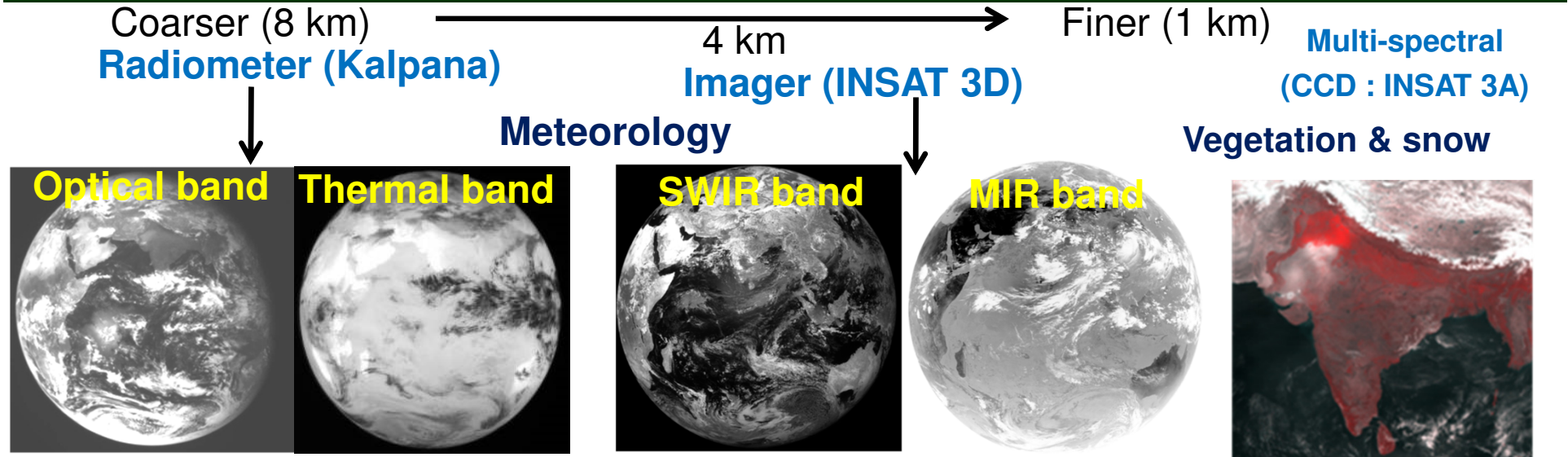
≈65% of total forests under potential threat of ground fire



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

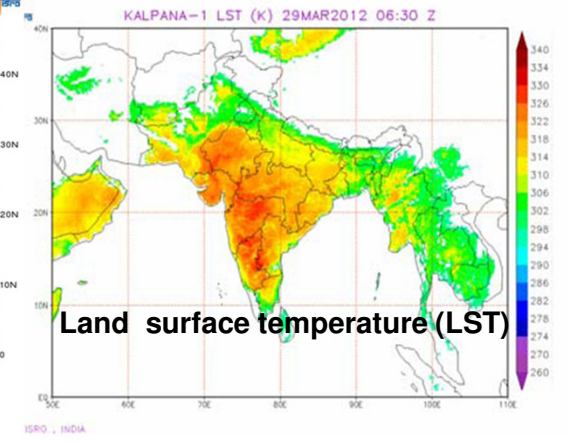
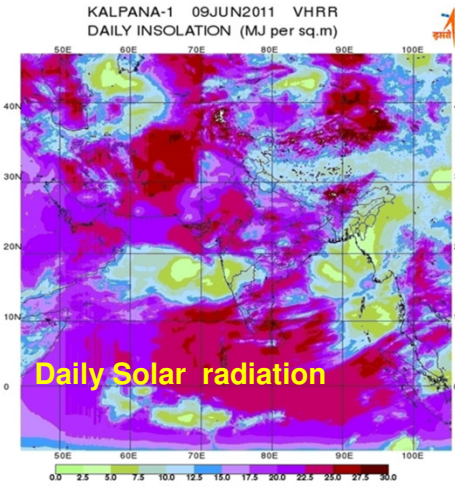
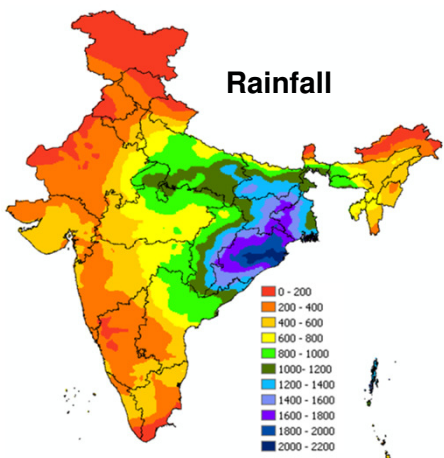
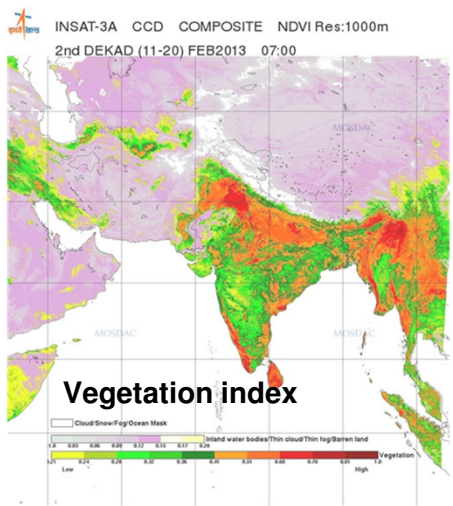
**Odisha, October 2013**

# Agricultural applications from Suite of INSAT satellites



**Advantages :** High temporal frequency, quicker, regular, country-scale monitoring

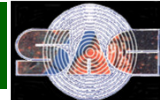
**Current Agro-met products :** NDVI, rainfall, NDVI, LST



**Target applications :** Sowing dates, Crop progress, Drought, Yield prediction  
 Agro- advisory service, Agricultural water management



# Weather forecast



MOSDAC- New Version - Windows Internet Explorer

http://www.mosdac.gov.in/login.jsp

File Edit View Favorites Tools Help

www.mosdac.gov.in Search Ask

Facebook Listen to music Amazon YouTube 27° Bangalore, In

Favorites MOSDAC- New Version

**MOSDAC**  
 Meteorological & Oceanographic Satellite  
 Data Archival Centre

Govt. of India

SAC

2002 KALPANA 2003 INSAT3A

Home Downloads Data Request In-Situ Stations  
 Documents Feedback

### MOSDAC OBJECTIVES

Application of Space Technology **FTP** for the benefit of the common **SITES** man.

Weather forecasting, cyclone prediction & continuous weather & ocean data availability.

MOSDAC | MEGHATROPIQUES | CALVAL | PRWONAM | SARAL

**ALERTS FROM EXPERIMENTAL FORECAST**  
 Uttarakhand Heavy Rain/Cloudburst image

EVENTS OF JUNE 2013

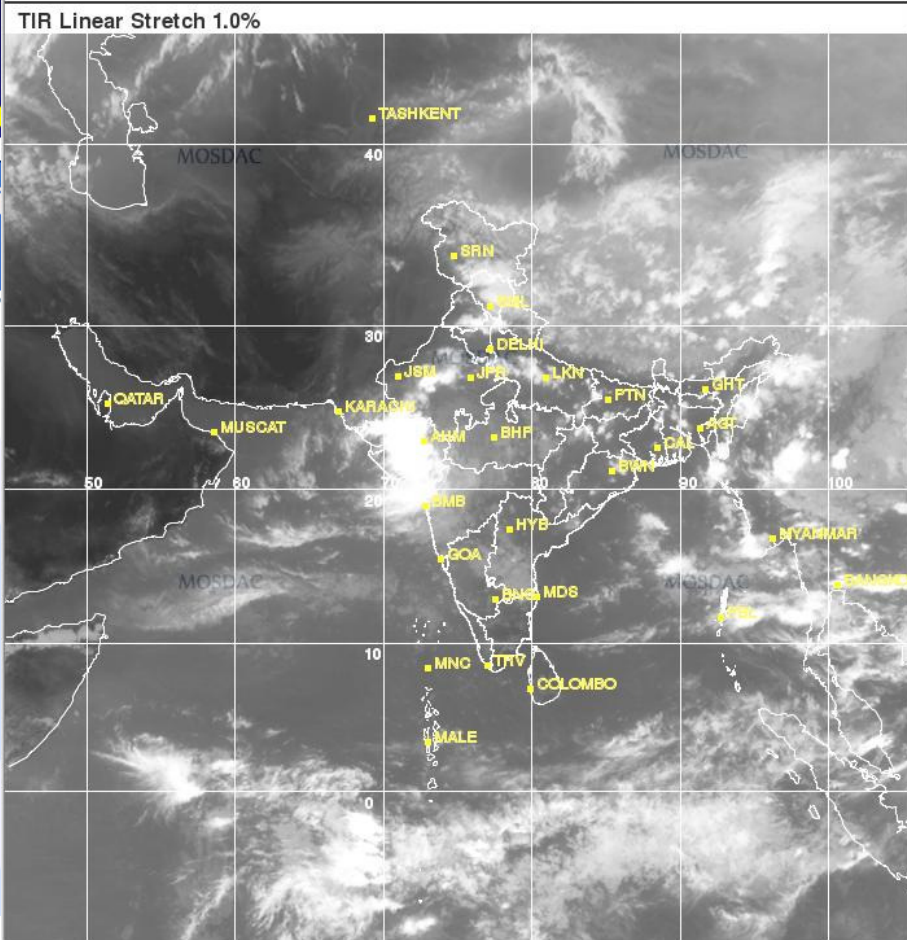
### MISSIONS

KALPANA  
 INSAT3A  
 OCEANSAT2  
 MEGHATROPIQUES  
 SARAL  
 INSAT-3D

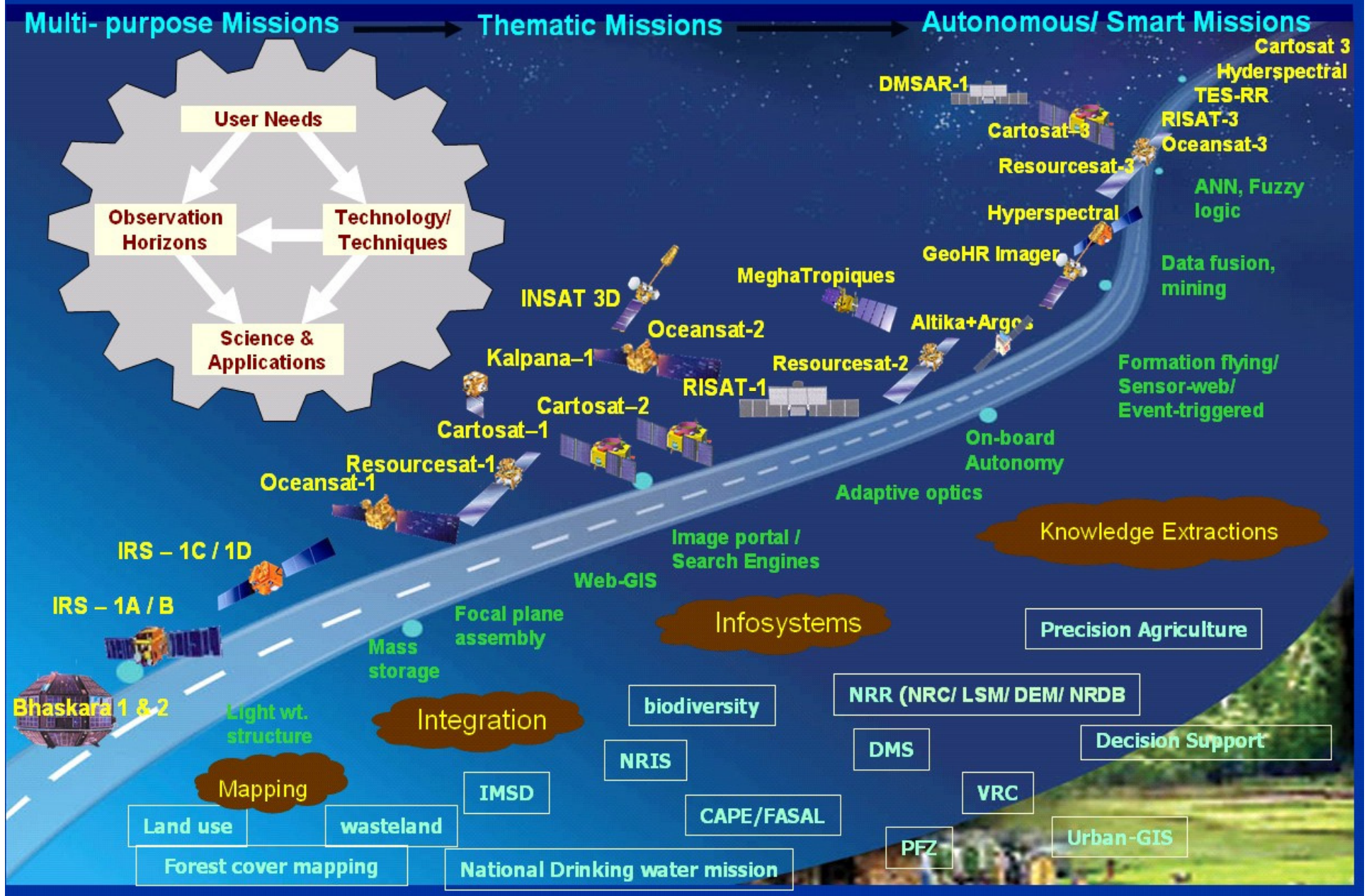
### SERVICES

PRODUCT CATALOGUE  
 SATELLITE DATA  
 IN-SITU DATA  
 FORECAST  
 CYCLONE in  
 CALVAL

Projection : MER 24-09-2013 / 12:00Z Sat: KALPANA-1 ASI\_TIR



# India's EO Road Map



Multi-purpose Missions

Thematic Missions

Autonomous/ Smart Missions

User Needs

Observation Horizons

Technology/ Techniques

Science & Applications

Cartosat 3

Hyperspectral

TES-RR

RISAT-3

Oceansat-3

ANN, Fuzzy logic

Data fusion, mining

Cartosat-3

Resourcesat-3

Hyperspectral

GeoHR Imager

DMSAR-1

MeghaTropiques

Altika+Argos

INSAT 3D

Oceansat-2

Resourcesat-2

Kalpana-1

Cartosat-2

RISAT-1

Oceansat-1

Resourcesat-1

On-board Autonomy

Adaptive optics

Knowledge Extractions

Image portal / Search Engines

Web-GIS

IRS - 1C / 1D

IRS - 1A / B

Bhaskara 1 & 2

Light wt. structure

Mass storage

Focal plane assembly

Infosystems

Precision Agriculture

Integration

biodiversity

NRR (NRC/ LSM/ DEM/ NRDB)

Decision Support

NRIS

DMS

VRC

Mapping

IMSD

CAPE/FASAL

Land use

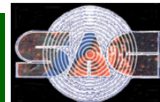
wasteland

PFZ

Urban-GIS

Forest cover mapping

National Drinking water mission



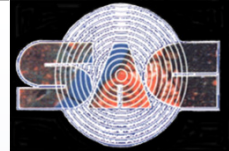
- **India has suite of sensors/satellites in different resolutions for addressing different aspects of agriculture.**
- **The launch of RISAT data has added another dimension to addresss the EO application.**
- **Applications have been demonstrated in many fields.**
- **India has EO capabilities to address various aspects of agriculture.**
- **In-situ observations in support of data'**
- **Portals and outreach.**
- **Advisories by NGOs/kiosks support through institutions**

# Thank you

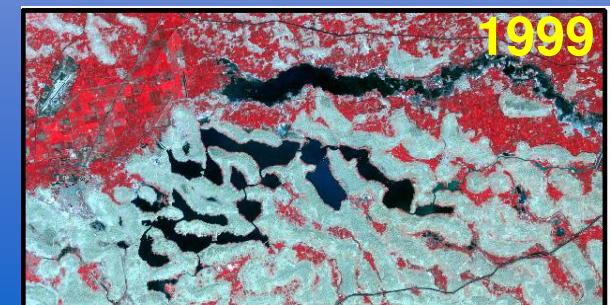
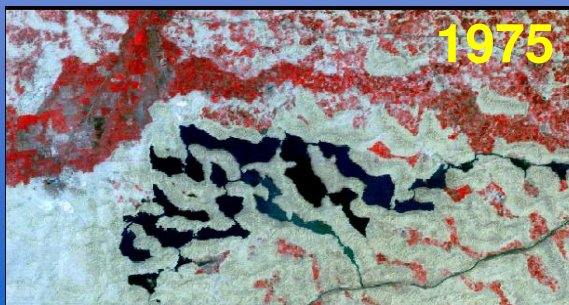
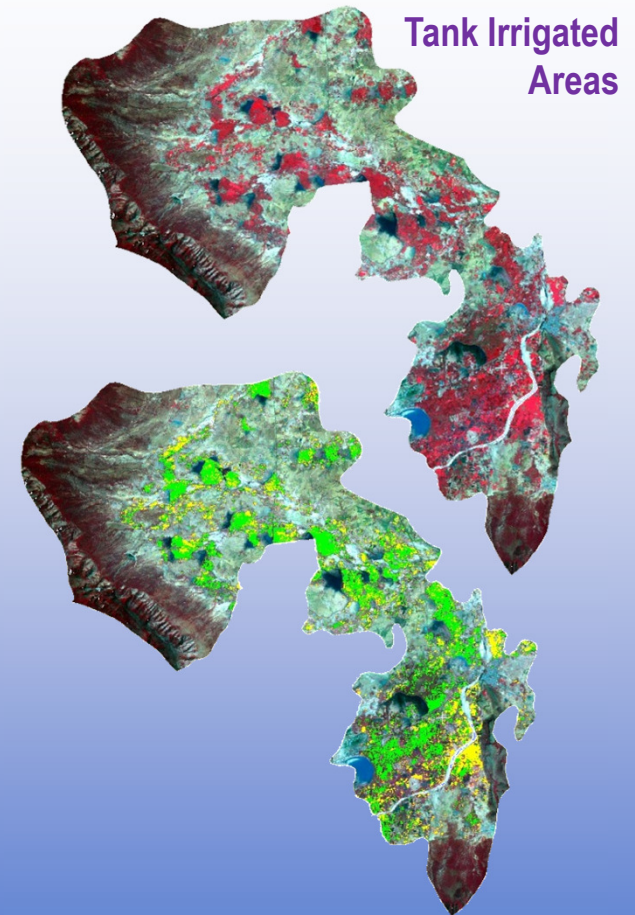
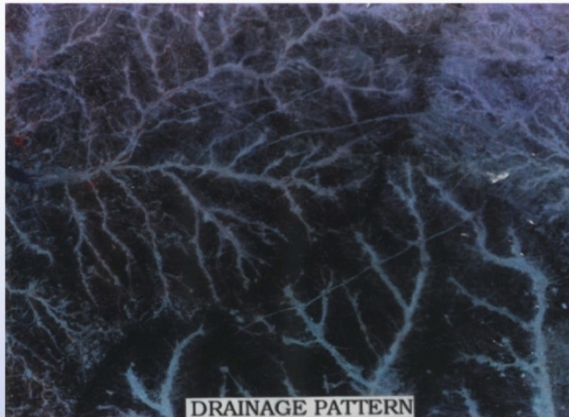
## Acknowledgements

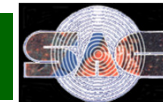
- European Commission
- Ms. Barbara J. Ryan, Secretariat Director, GEO
- GEOGLAM Team
  
- Mr. A.S. Kiran Kumar, Director, SAC, ISRO
- Dr. J.S. Parihar, Dy. Director, SAC
- My Colleagues at SAC, ISRO

# Water Resources



- Inventory of surface water bodies (tanks, reservoirs)
- Performance evaluation of irrigation commands
- Ground water prospecting/ recharge structures
- Glacier inventory, retreat
- Snowmelt run-off, snow physics



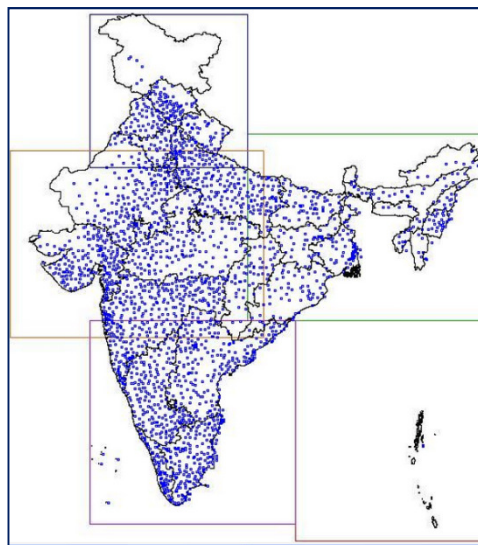


## MOSDAC

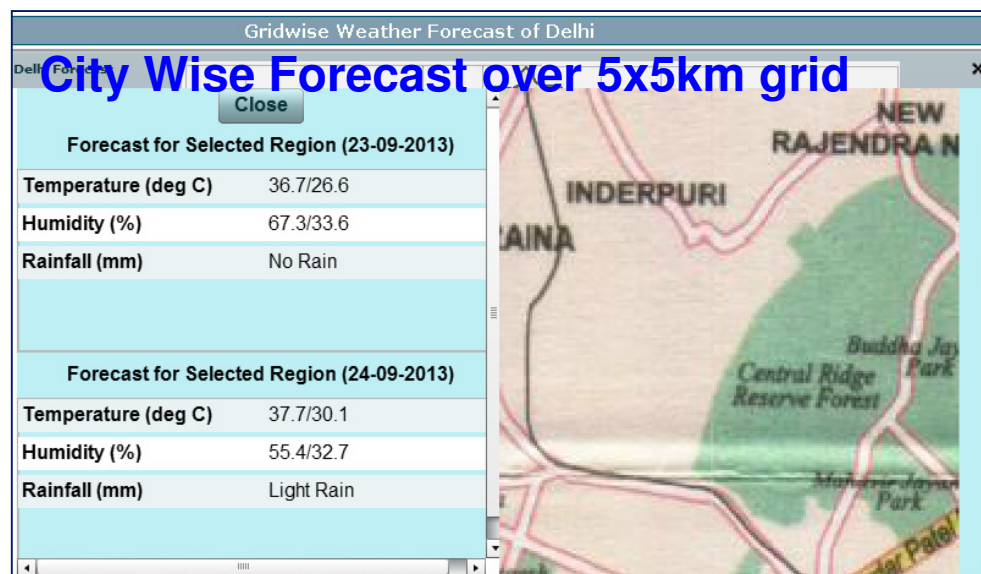
Data Portal to satisfy vast Meteorological & Oceanographic data needs, products from ISRO science missions.

24, 48 & 72 hrs forecast of temperature, humidity, rain, cloudiness, wind speed and wind direction, at each of the locations (blue dots) on the map is available on MOSDAC

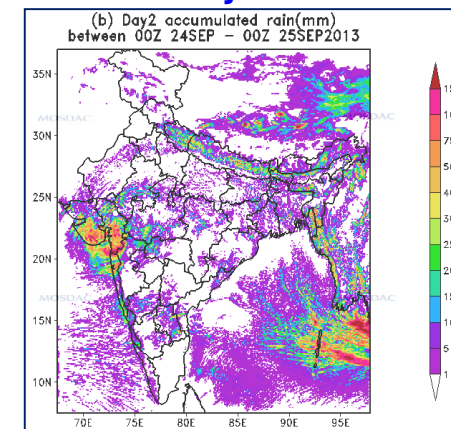
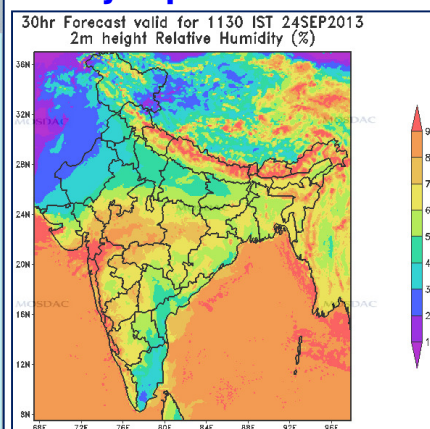
### Half hourly observation of Heavy Rainfall from KALPANA1



District Name	Met-subdivision	Rain (mm/h)
Sabarkantha	GUJARAT -REGION	8.26
Mehsana	GUJARAT -REGION	10.91
GAandhinagar	GUJARAT -REGION	31.32
Kheda	GUJARAT -REGION	17.97



### Synoptic view over India: Humidity & Rainfall





# Application-specific EO payloads

**(Planned)**

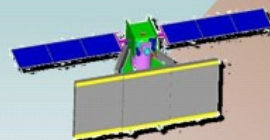
GISAT  
MXVNIR/SWIR/TIR/HySI



RESOURCESAT-3A/3B/3C  
LISS 3/LISS 4/AWiFS



RESOURCESAT-2A  
LISS3/LISS4/AWiFS



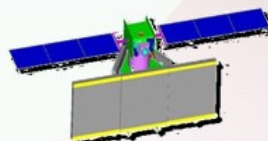
RISAT-3  
L-band SAR



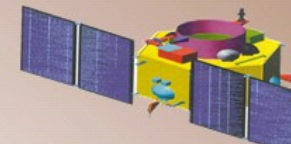
CARTOSAT-3  
PAN



RESOURCESAT-3  
LISS 3/LISS 4/  
AWiFS



RISAT-1R  
C-band SAR



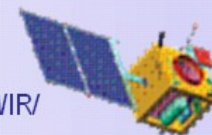
CARTOSAT-2C/2D  
PAN

Land & Water  
Cartography



OCEANSAT-3  
OCM, TIR

Atmosphere & Ocean



GISAT  
MXVNIR/SWIR/  
TIR/HySI

