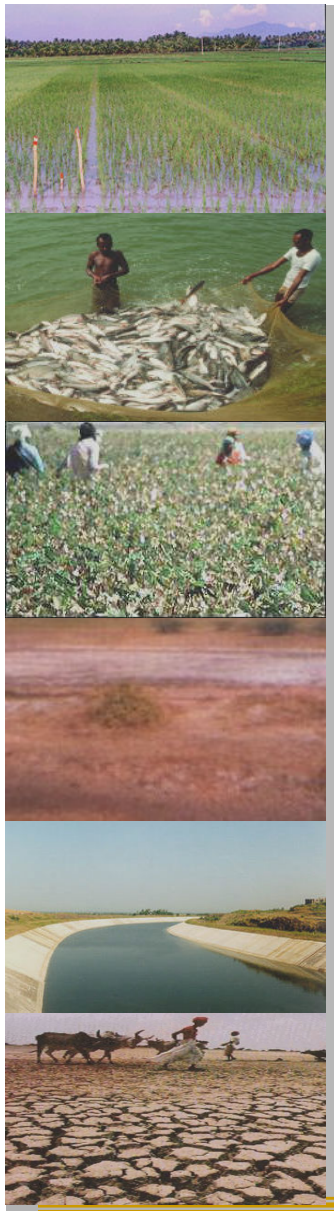


Space Observations for Agriculture

Ranganath R. Navalgund

Space Applications Centre, ISRO
Ahmedabad, India
Email: director@sac.isro.gov.in

Space for Agriculture



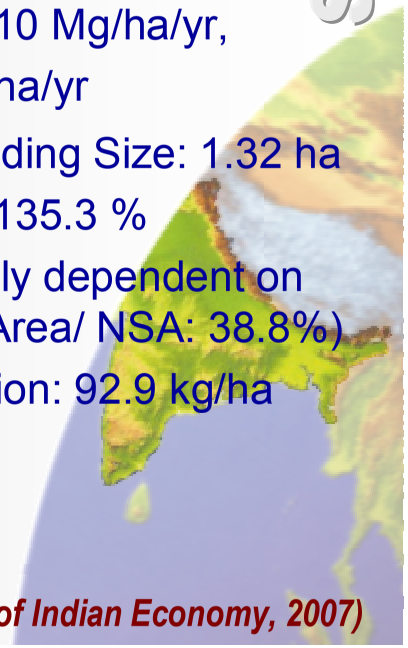
February 19, 2008, CRIDA, Hyderabad

Indian Agriculture: Overview

- India is home to 23.3% of the world's farming population
- 2nd in Worlds wheat & Rice Production, 1st in pulses production
- Highest irrigated area (55 Mha) in the world
- 51.8% of India's population are involved in agriculture
- Agriculture provides 57% of India's total employment and 73% of India's total rural employment
- Net Area Sown: ~ 142 Mha
- Total Food grain production- 201.56 Mt (avg. of 5 years)
- Agrl. and allied sector share of GDP is 18.3 % (at current prices)
- Average annual growth rate of Agrl & Allied sector during 10th FYP: 2.3 % (GDP: 7.6%, Population: 1.63 %)

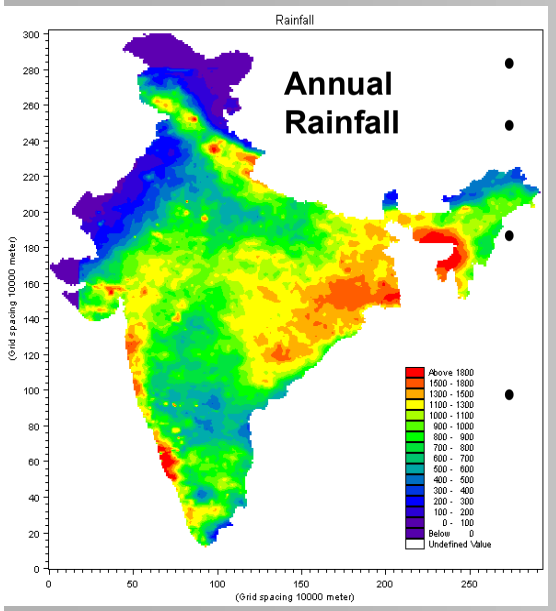
- Low Crop Productivity (t/ha, 2004-05)
  - Rice - 2.9 (Japan: 6.4)
  - Wheat - 2.71 (UK: 7.77)
  - Maize – 1.18 (US: 9.15)
  - Cotton – 4.64 (China: 11.10)
  - Oilseeds – 0.86 (China: 2.5)
- High Degraded Land (% Geogr. Area): 187.8 Mha (~57%)
  - China : 30.0
  - Asia-Pacific : 31.3
- Annual erosion: IGP - 5-10 Mg/ha/yr, W. Rajasthan > 80 Mg/ha/yr
- Average Operational Holding Size: 1.32 ha
- Low Cropping Intensity: 135.3 %
- Indian Agriculture is highly dependent on monsoon (Net Irrigated Area/ NSA: 38.8%)
- Low Fertiliser Consumption: 92.9 kg/ha (Japan:249.3)

Space for Agriculture

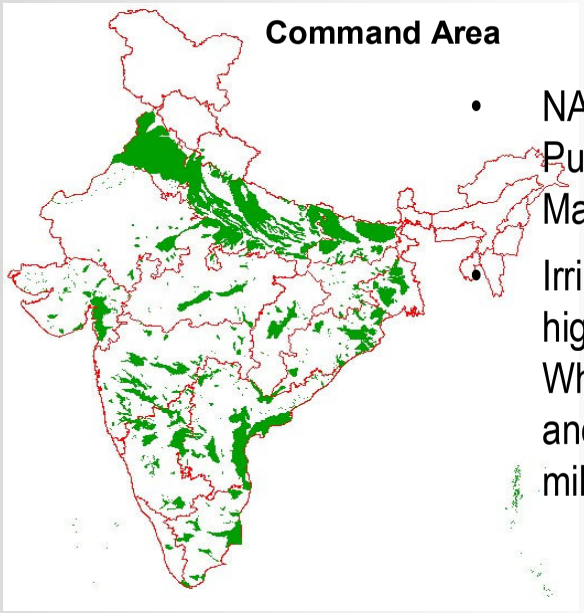


(Source: Agrl. Statistics at a Glance, Survey of Indian Economy, 2007)

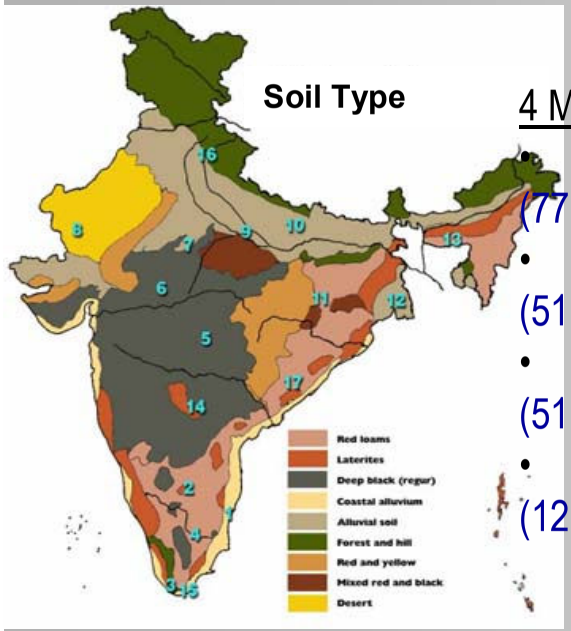
Physical Parameters controlling Indian Agriculture



- 120 cm rainfall
- 75% during southwest monsoon season
- Western coastal plain and NE region >400cm
- Western Rajasthan, Gujarat, Haryana & Punjab < 60cm

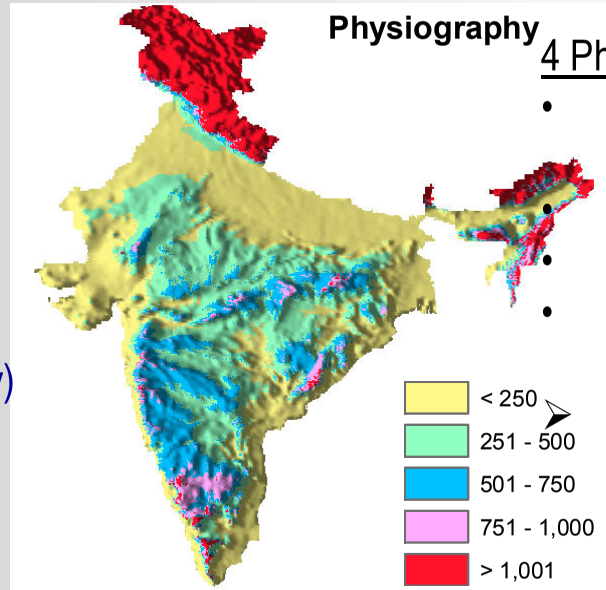


- NAI/NAS is >90% for Punjab and <15% for Maharashtra
- Irrigation coverage high (>80%) for Wheat, sugarcane and low (<15%) for millets, pulses



4 Major Soil types

- Alluvial soils (77.7 Mha, Fertile)
- Black soils (51.8 Mha, Fairly fertile)
- Red soils (51.8 Mha, Differ in fertility)
- Laterite soils (12.7 Mha, Low Fertility)



4 Physiographical divisions

- Northern mountain region
- Great plains of the north
- The Peninsular plateau
- The Coastal plains and Islands

Altitude ranges from > 1000 m to <250 m

Space for Agriculture

Indian Agriculture: Priorities

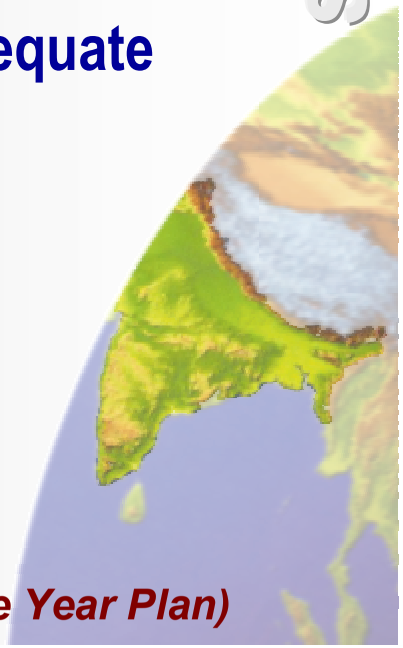
Sustainable Increase in Agricultural Production

(The urgent need for taking agriculture to a higher trajectory of 4 % annual growth)

- **Enhancing the productivity;**
- **Doubling the rate of growth of irrigated area;**
- **Improving water management, rain water harvesting and watershed development;**
- **Reclaiming degraded land and focusing on soil quality;**
- **Diversifying into high value outputs, with adequate measures to ensure food security;**
- **Promoting animal husbandry and fishery;**
- **Refocusing on land reforms issues;**
- **Capacity building to bridge the knowledge gap.**

(Adapted from: The Approach Paper to the XI Five Year Plan)

Space for Agriculture



Evolution of Indian Earth Observation System

.....towards enabling solutions

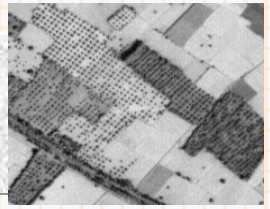
(Atmospheric Observations)

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



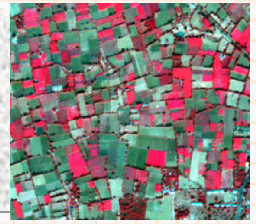
(High Spatial Resolution & Stereo Capability)

Cartosat-1&2 (2005,2007)
PAN : 2.5 m, 1m
Fore +26° Aft: -5°



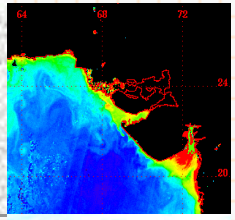
(Multi resolution, Frequent observations, Better radiometry)

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

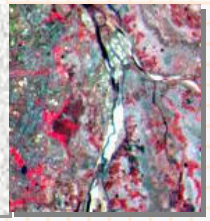


(Ocean Observations)

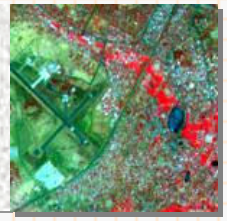
IRS-P3 (1996)
WiFS, MOS, X-Ray
Oceansat –1 (1999)
OCM, MSMR



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

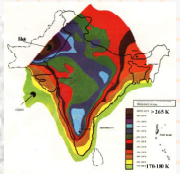


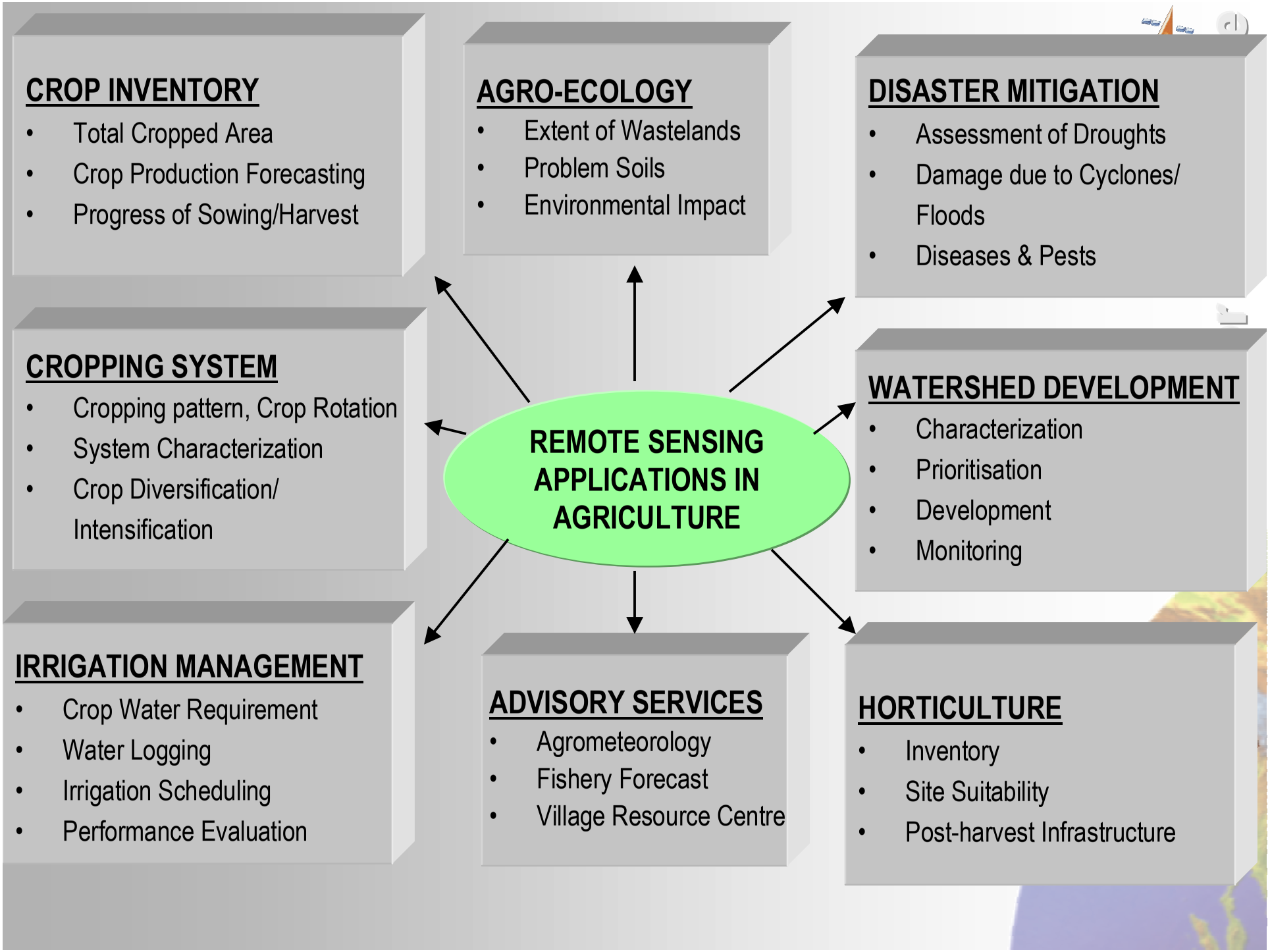
IRS-1C/1D
(1995,1997)
LISS-3: 23/70 m, Steerable
PAN: 5.8 m, WiFS: 188 m



(High Repetivity/Revisit , High Spatial Resolution)

BHASKARA 1 /2 (1979,1981)
TV Camera, Microwave Radiometer

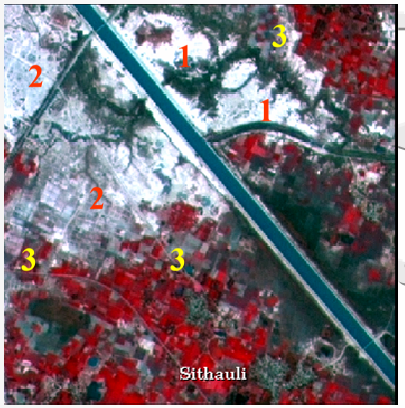



CROP INVENTORY
• Total Cropped Area
• Crop Production Forecasting
• Progress of Sowing/Harvest
AGRO-ECOLOGY
• Extent of Wastelands
• Problem Soils
• Environmental Impact
DISASTER MITIGATION
• Assessment of Droughts
• Damage due to Cyclones/ Floods
• Diseases & Pests
CROPPING SYSTEM
• Cropping pattern, Crop Rotation
• System Characterization
• Crop Diversification/ Intensification
REMOTE SENSING APPLICATIONS IN AGRICULTURE
WATERSHED DEVELOPMENT
• Characterization
• Prioritisation
• Development
• Monitoring
IRRIGATION MANAGEMENT
• Crop Water Requirement
• Water Logging
• Irrigation Scheduling
• Performance Evaluation
ADVISORY SERVICES
• Agrometeorology
• Fishery Forecast
• Village Resource Centre
HORTICULTURE
• Inventory
• Site Suitability
• Post-harvest Infrastructure

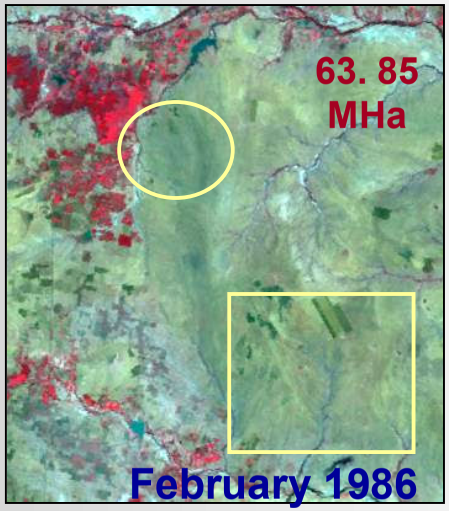
Increase Area under Agriculture (Wasteland Mapping)

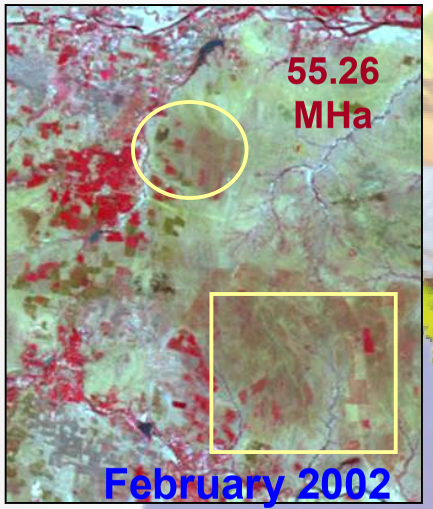
- 187.8 Mha of land constituting 57% of TGA subject to various kinds of degradation.
- 162.4 Mha: Soil erosion (water and wind), 21.7 Mha : Salinity and waterlogging, 4 Mha : Depletion of nutrients
- Remote sensing has been used for
  - Identifying culturable wastelands/ marginal lands
  - Monitoring wasteland development





1 Strongly Saline- sodic Soils 2 Moderately saline –sodic Soils
3 Slightly saline – sodic soils

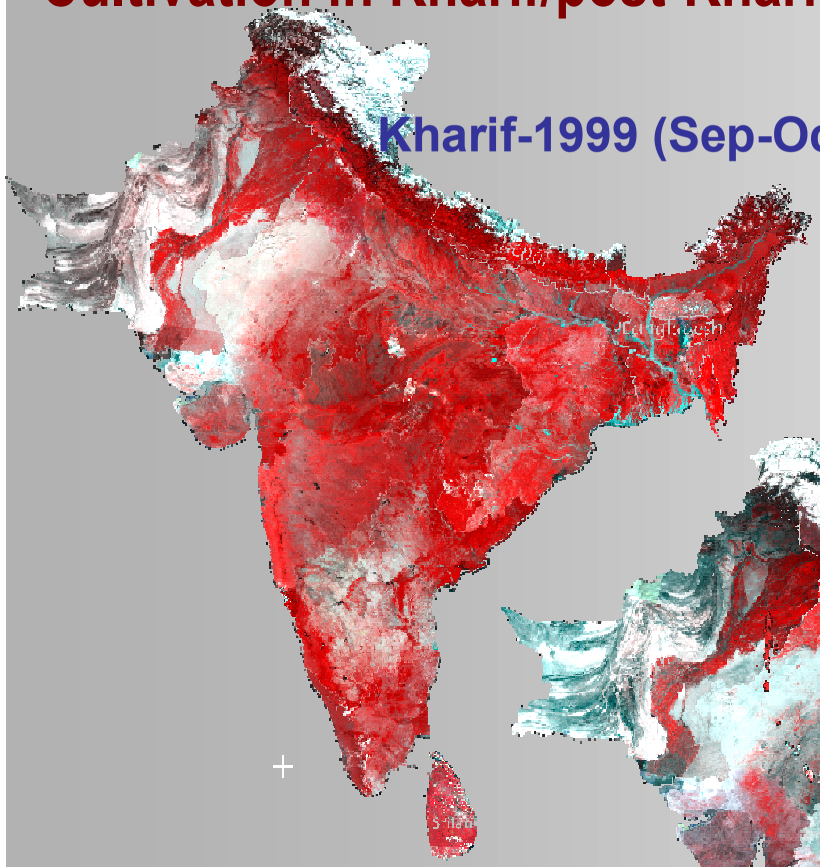




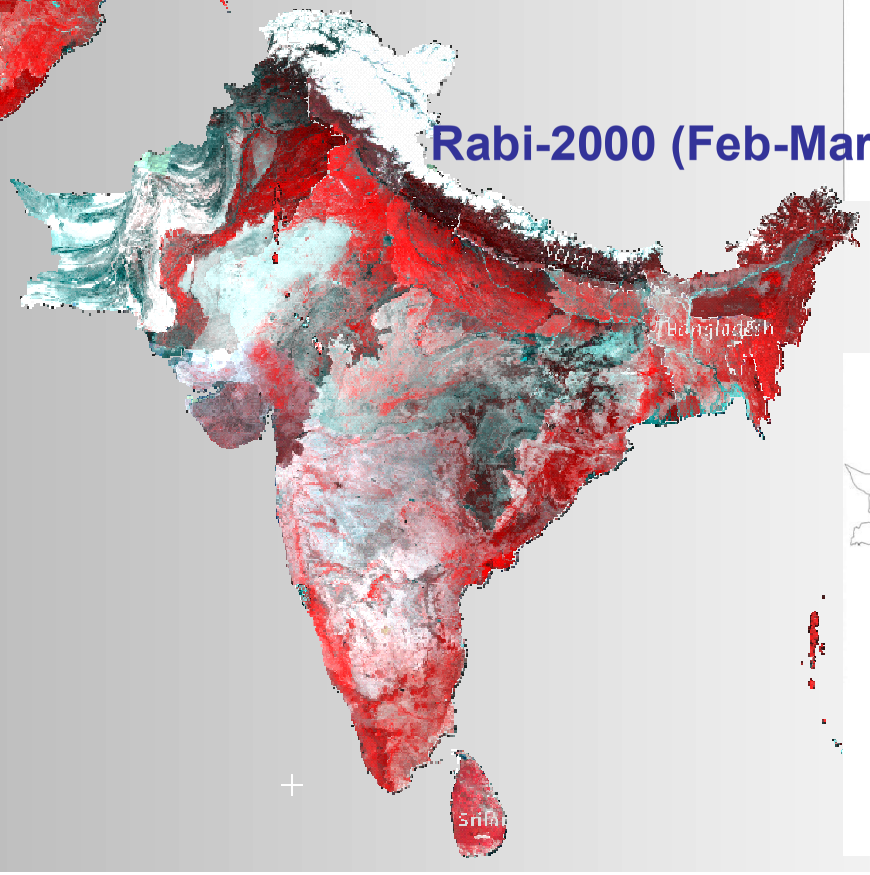
Space for Agriculture

Improving Cropping Intensity

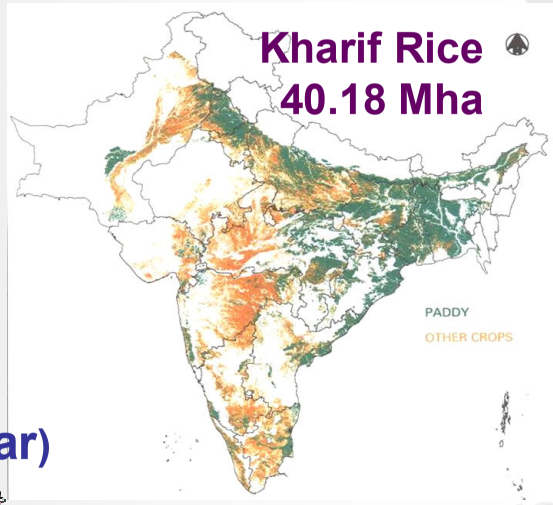
Cultivation in Kharif/post-Kharif fallows

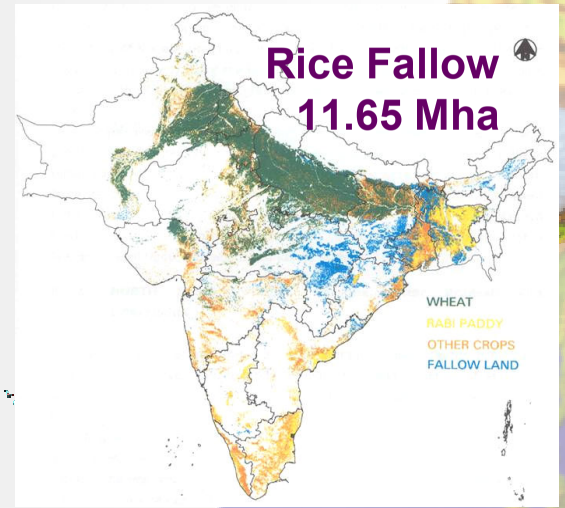


Kharif-1999 (Sep-Oct)



Rabi-2000 (Feb-Mar)

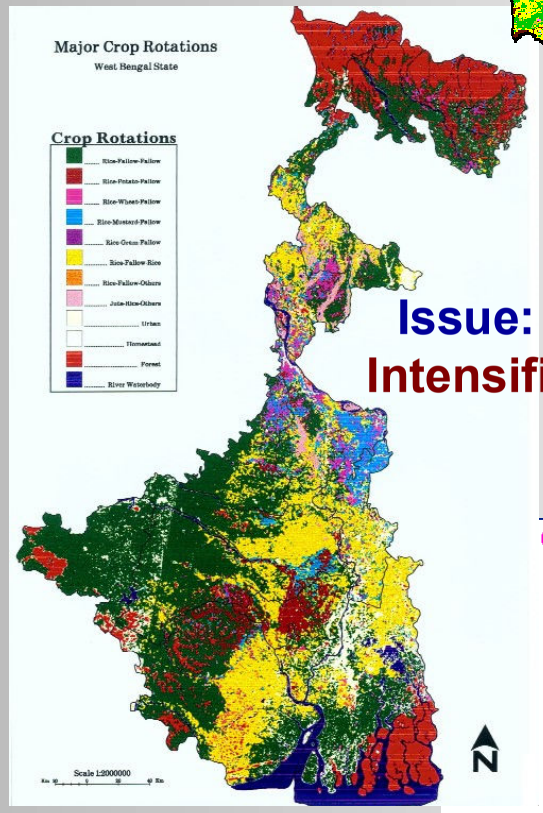




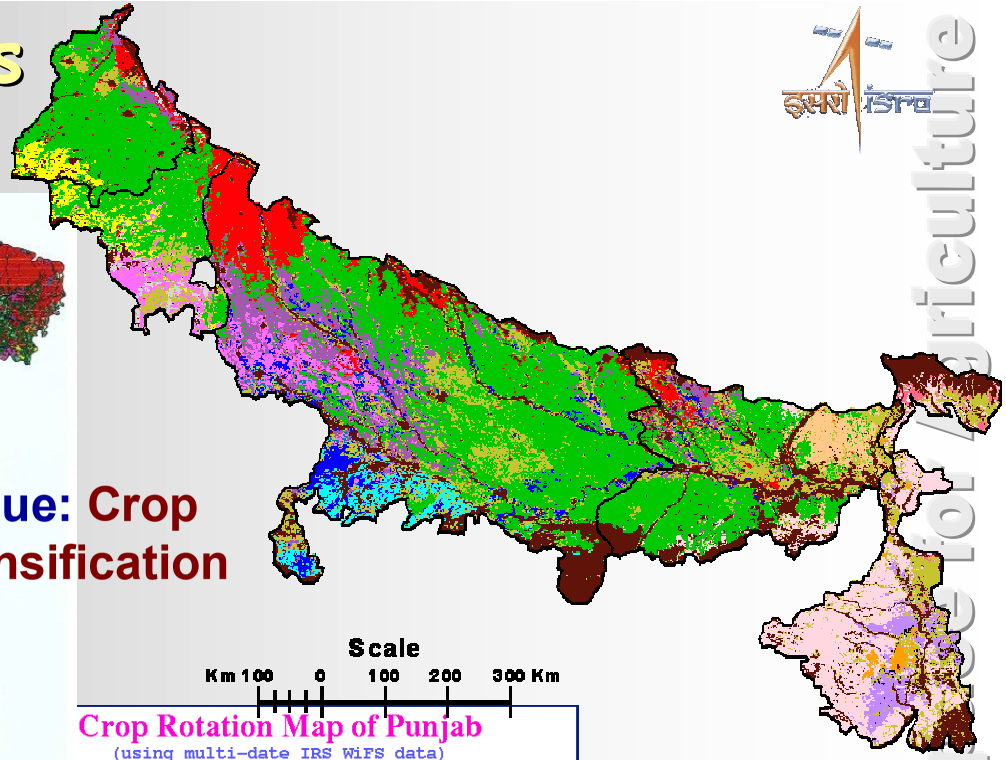
Space for Agriculture

Cropping System Analysis

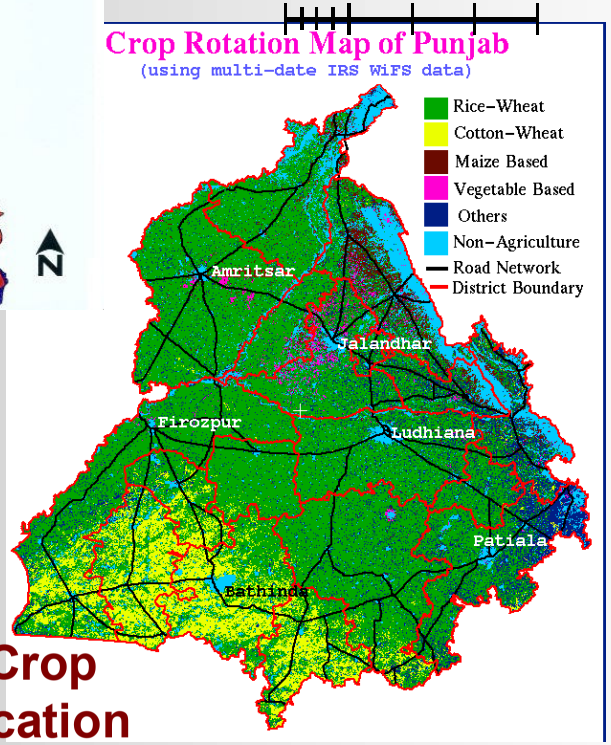
- Cropping Pattern & Crop Rotation Mapping
- Cropping System Characterization
- Alternate Cropping System
- Long-term Impact Assessment
- Impact of Climate Change on Cropping System



Issue: Crop Intensification



Scale
Km 100 0 100 200 300 Km



Issue: Crop Diversification

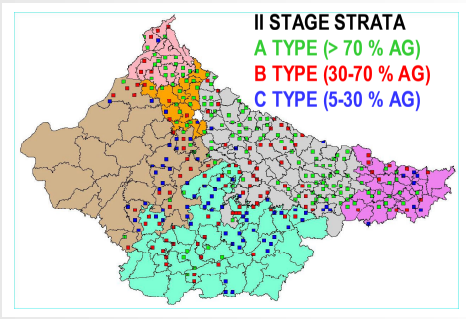
Rice-Wheat
Sugarcane Based
Cotton-Wheat
Rice-Potato
Maize-Wheat
Pearlmillet-Wheat
Rice-Fallow-Rice
Rice-Fallow-Fallow
Rice-Fallow-Jute
Rice-Wheat-Other
Fallow-Pulse
Fallow-Wheat
Minor Crop Rotations
Fallow
Non-Arable

Use for Agriculture

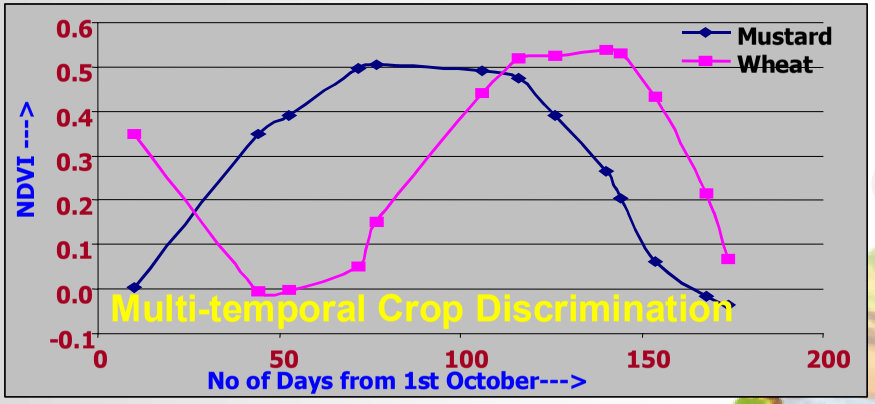
National Crop Forecasting

Forecasting Agricultural Output using Space, Agrometeorology & Land-based Observations (FASAL)

- Pre-harvest production forecast for major crops like Paddy, Wheat, Cotton, Potato, Sorghum, Rapeseed, Mustard, etc.
- Early warning – crop condition, stress scenario
- Multiple Forecasting
- Multi-date Optical (AWiFS) data for wheat and microwave (Radarsat) for Rice
- Meteorological & crop simulation model for crop yield





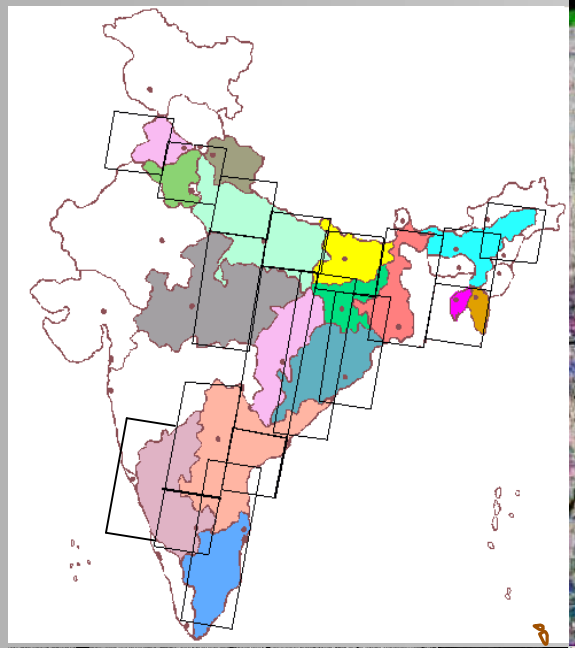


Year 2006-07	Area (Mha)	Production (Mt)
Rice	36.16	73.37
2007-8 (1st)	33.69	72.19
Wheat*	27.30	72.25
Winter Potato	1.04	18.84

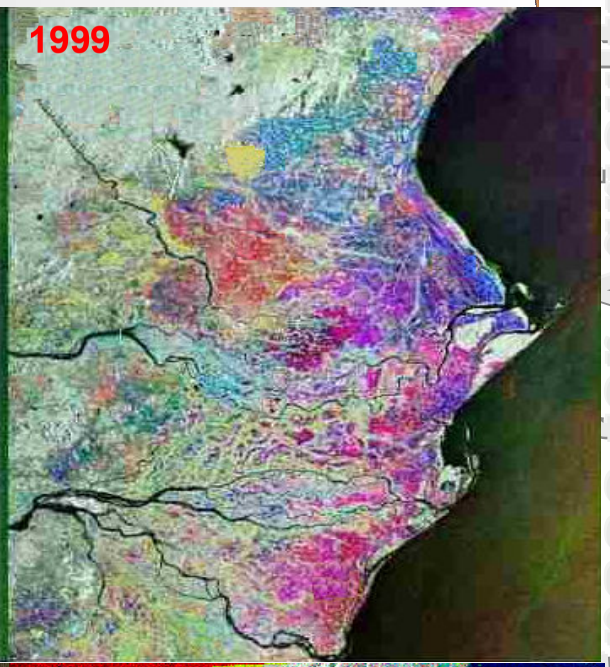
*Forecast (March 21, 2007)

Space for Agriculture

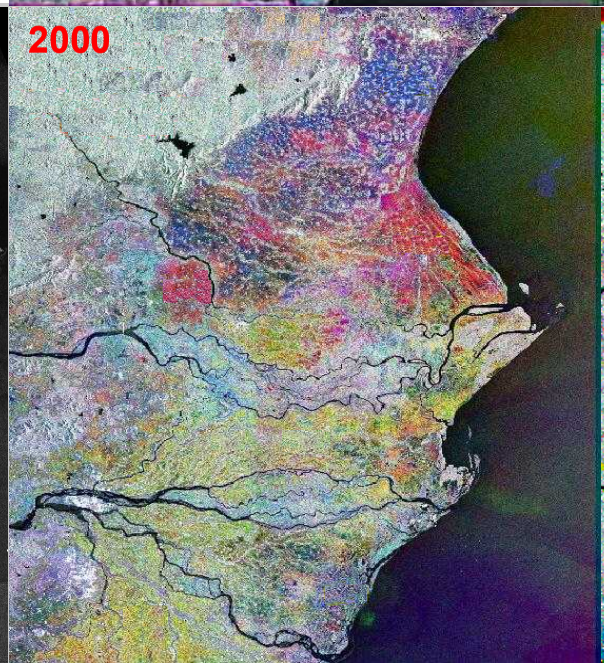
Kharif Rice assessment using multidate SAR data

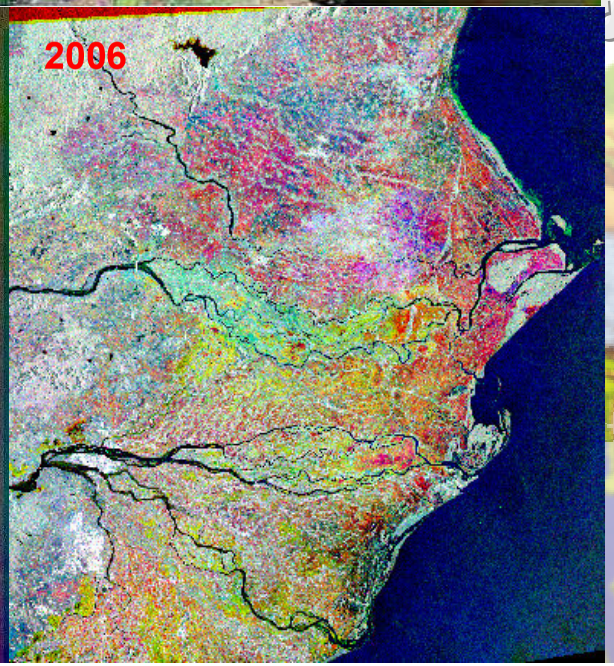






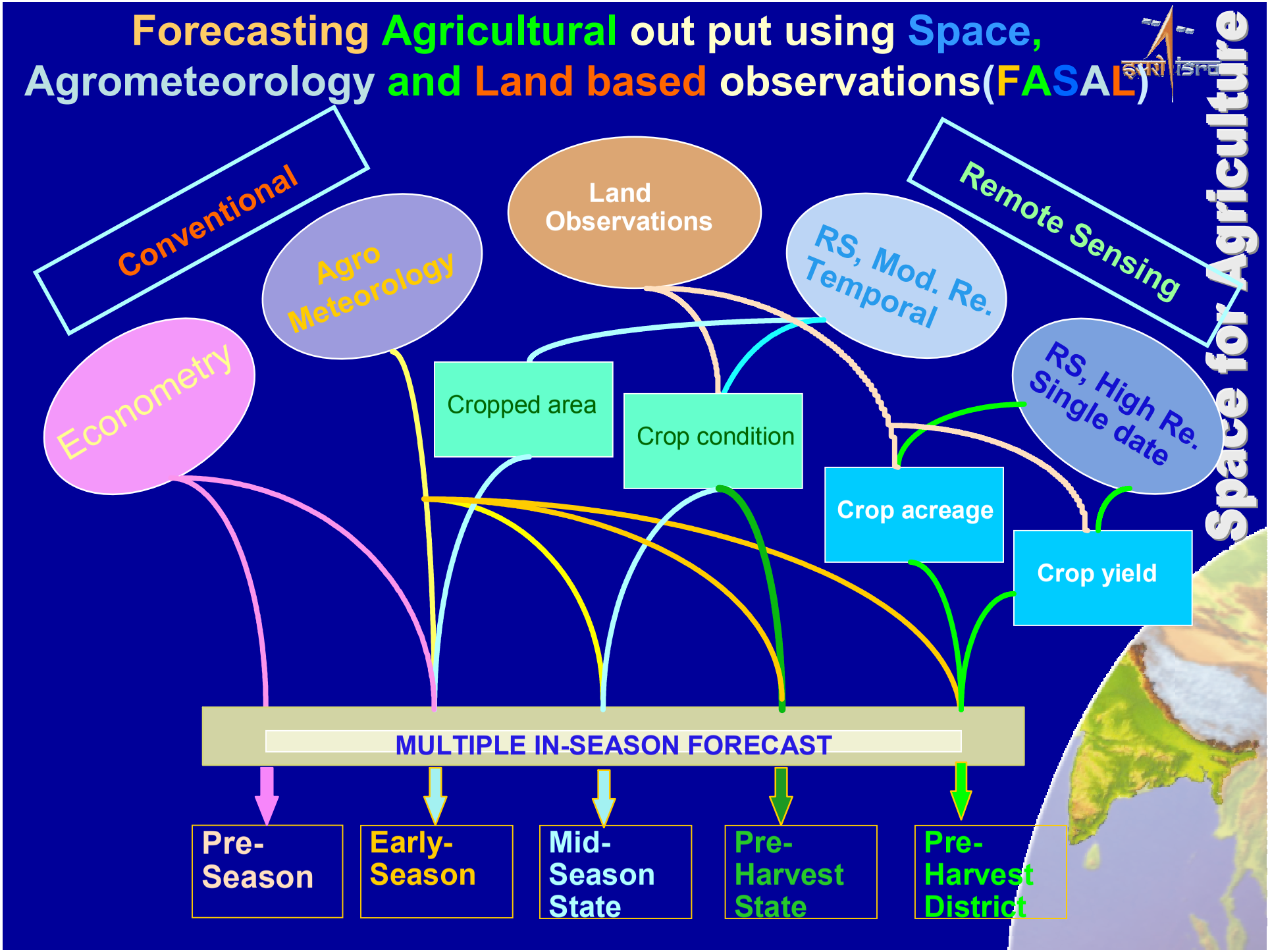






Space for Agriculture

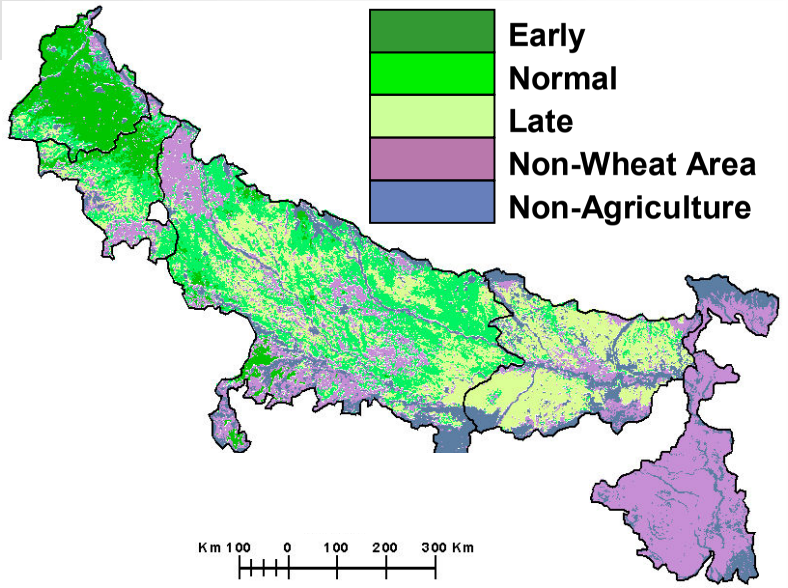
Forecasting Agricultural out put using Space, Agrometeorology and Land based observations(FASAL)



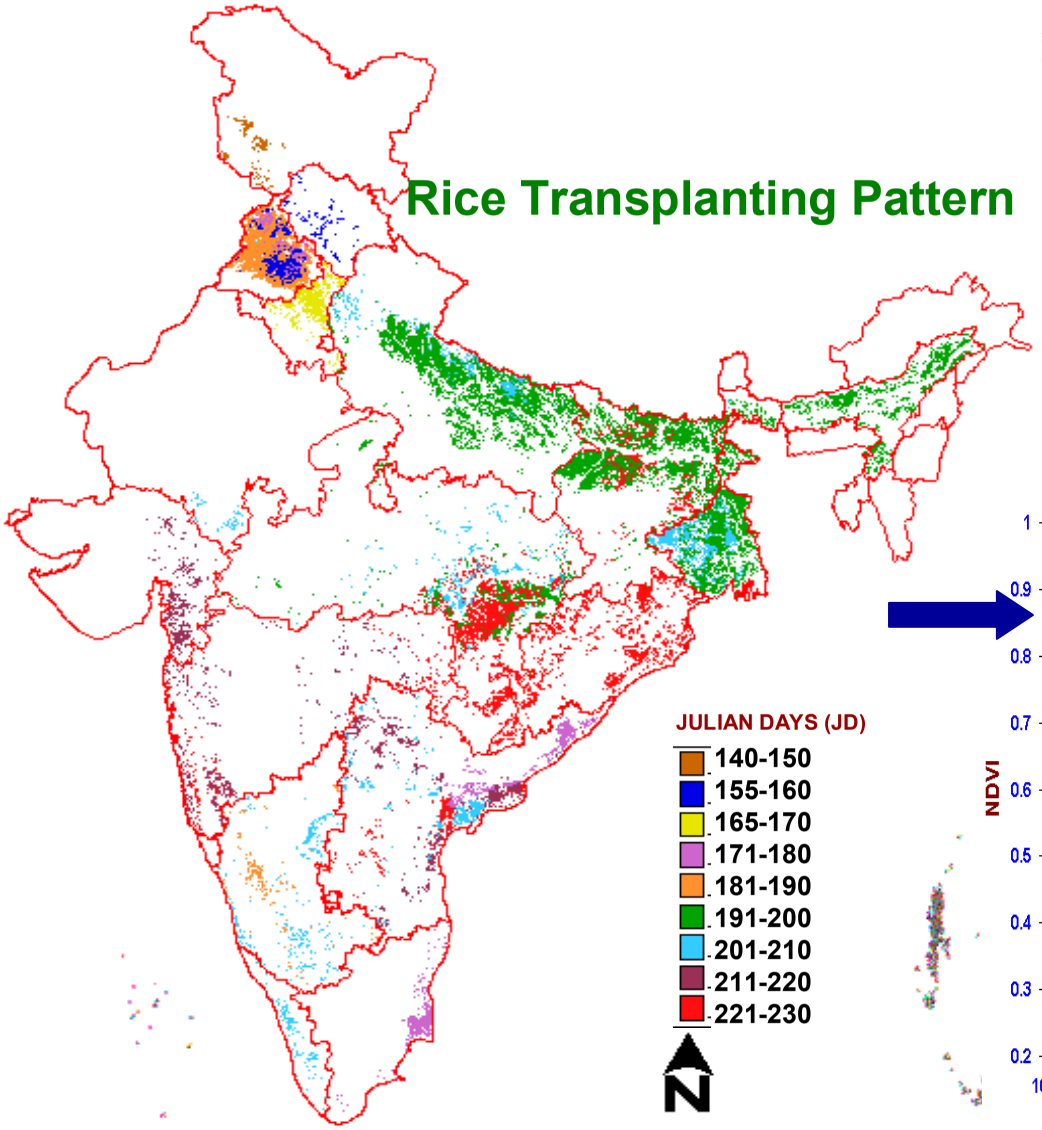
Crop Phenology – Planting/Sowing

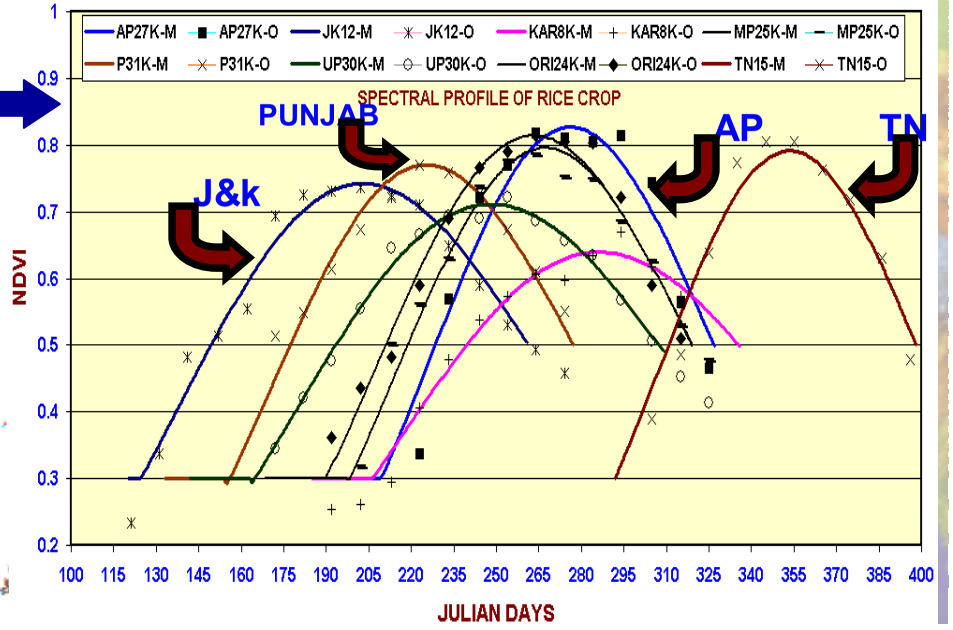
Space for Agriculture

Wheat Sowing Pattern

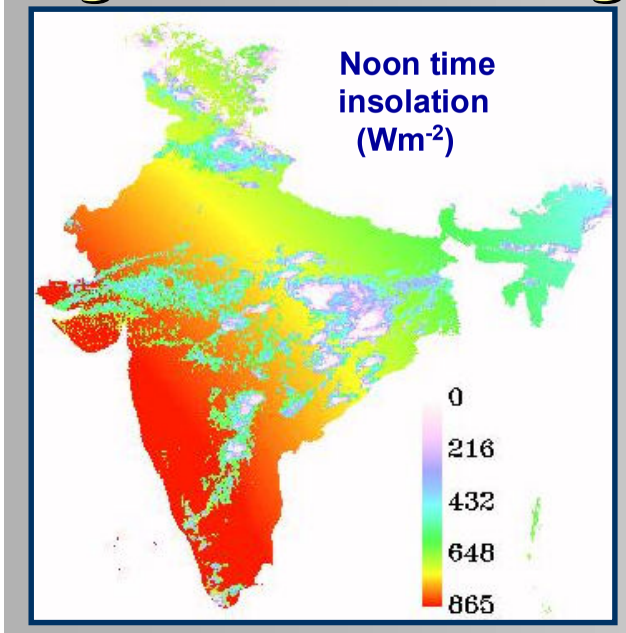


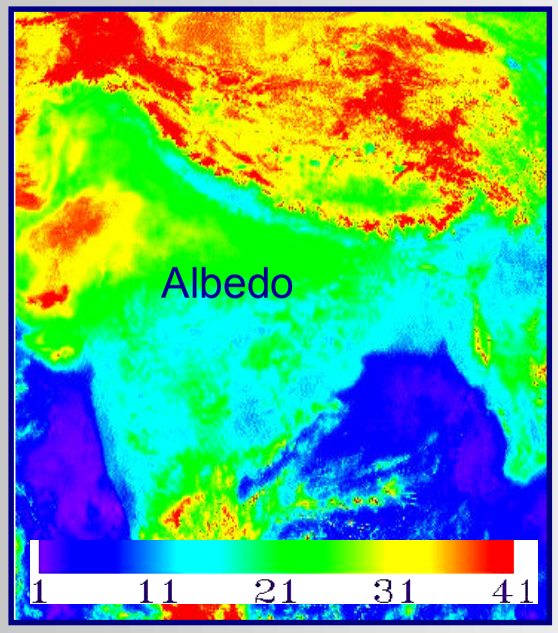
Rice Transplanting Pattern

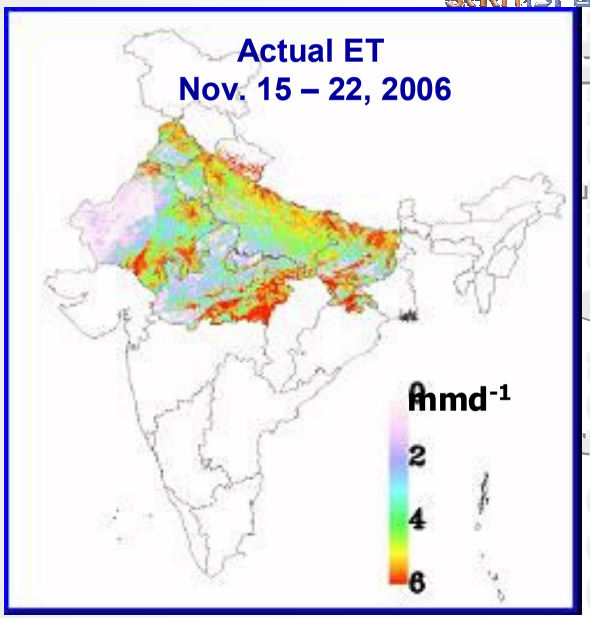


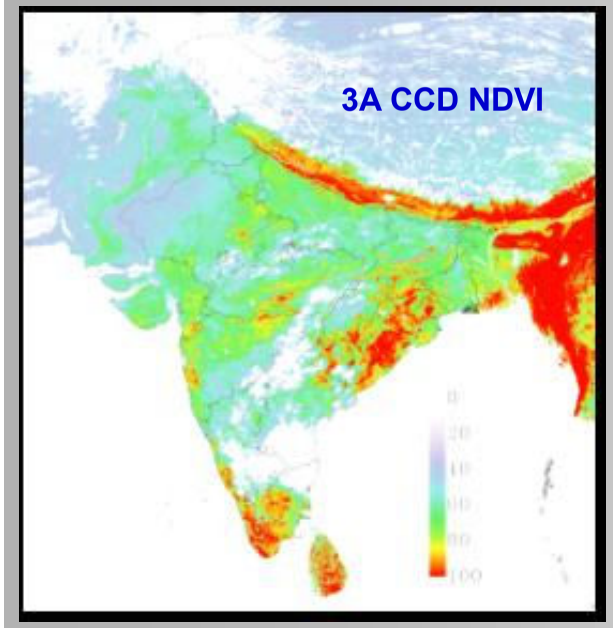


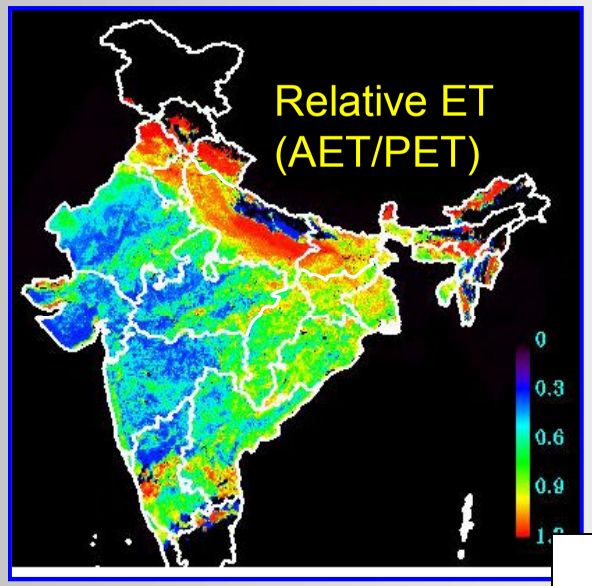
Agro-meteorological Parameters

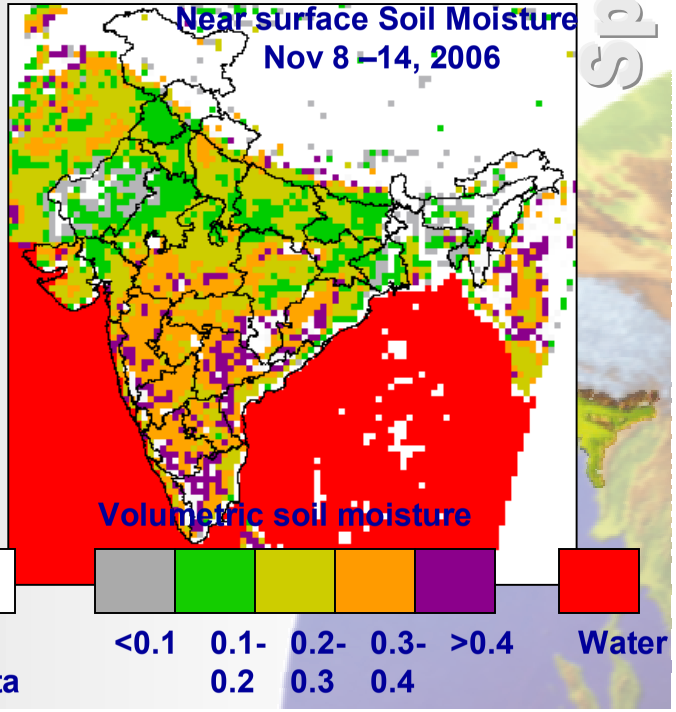








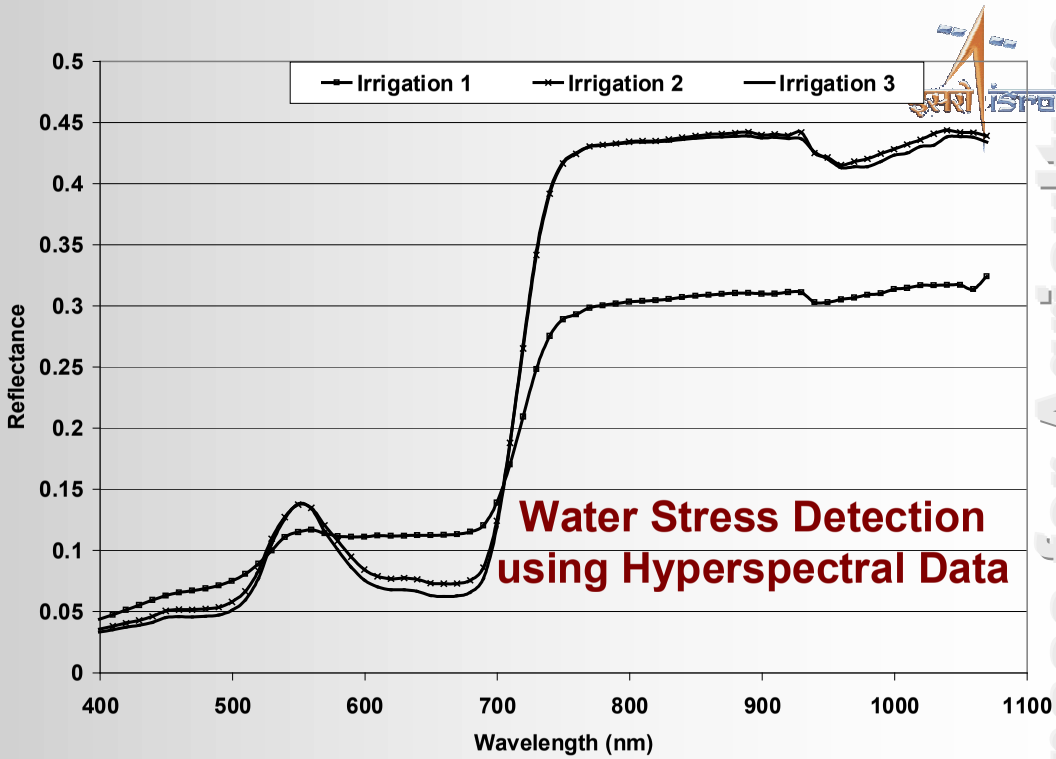


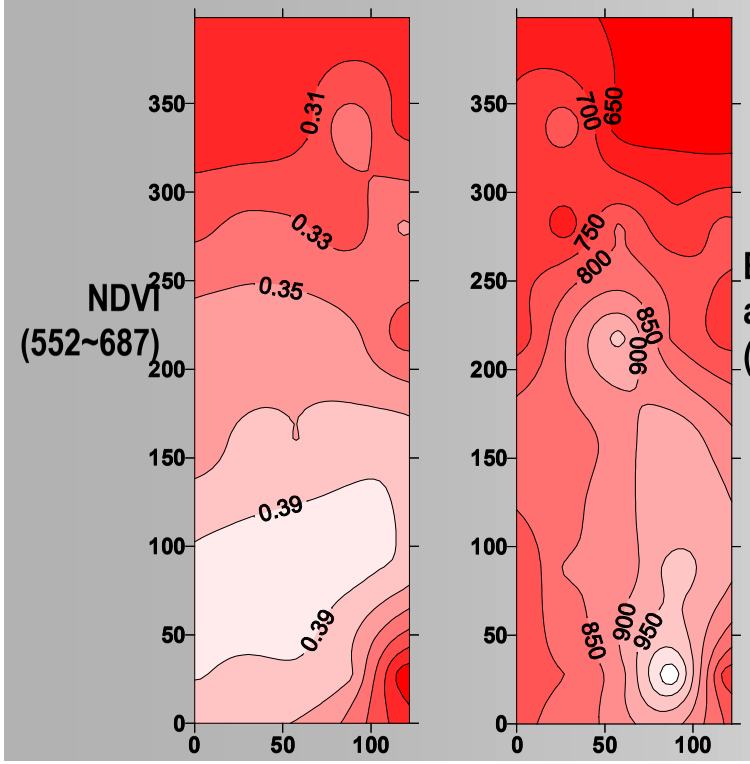


Space for Agriculture

Precision Agriculture

- Within-field variability Mapping
- Yield Mapping
- Management Zone Creation
- Targeted Soil Sampling
- Crop Stress Detection





Nutrient Use Efficiency and economics of fertilization
In Precison Faming(PF) vis-à-vis Recommended Dose (RF)

Treatments	Total NPK fertilizer used (kg/ha)	Use Efficiency (kg REY/ kg NPK)	Cost of Cultivation (Rs/ha)	Gross income (Rs/ha)	Benefit: Cost (B:C) Ratio	Net Returns (Rs/ha)
CONTROL	0	-	58055	88977	1.53	30992
RF	890	25.7	67335	123619	1.84	56283
PF	452	50.5	62736	123166	1.96	60430

Space for Agriculture

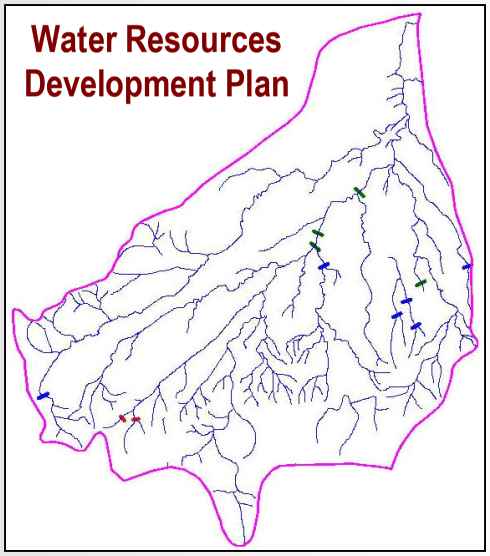
Integrated Watershed Management

Space for Agriculture

Characterisation & Prioritisation



Action Plan Generation



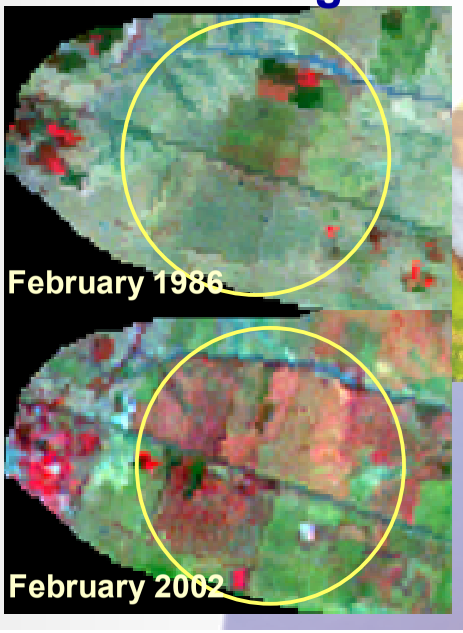
Development



People's Participation



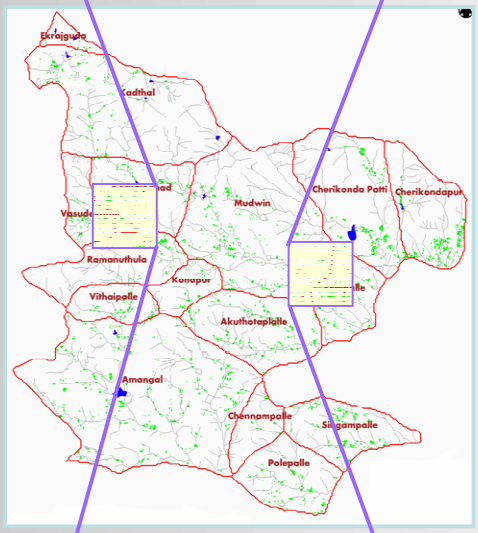
Monitoring



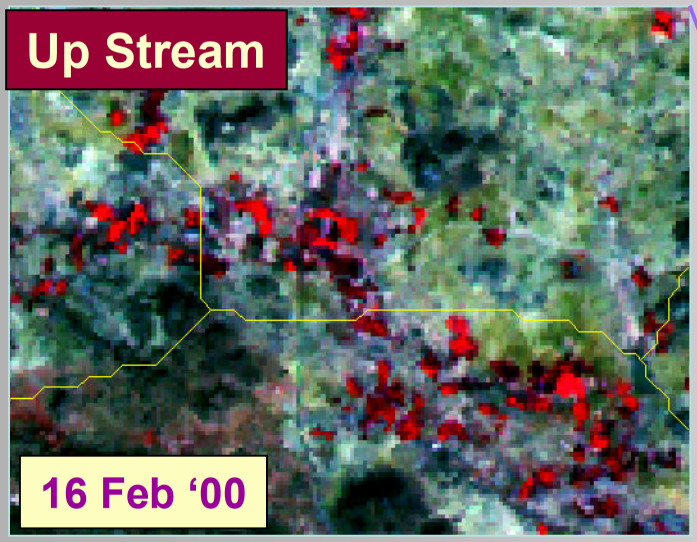
Watershed Development… Monitoring

PRE

Amangal Mandal
Mahaboob Nagar Dist.
Andhra Pradesh



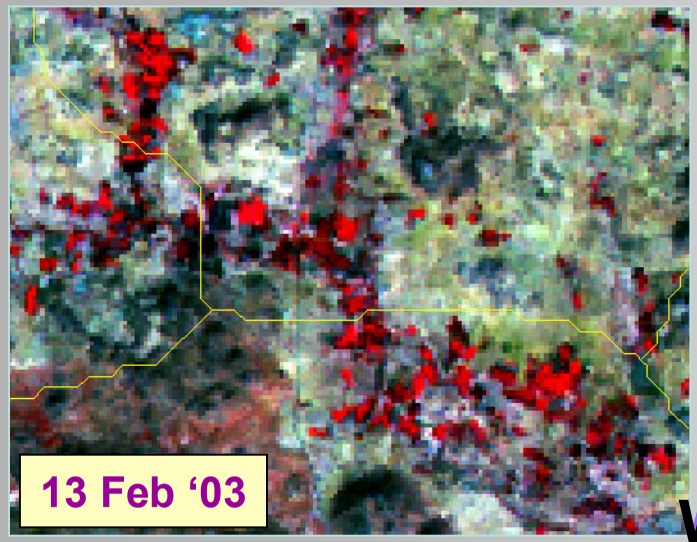
Up Stream

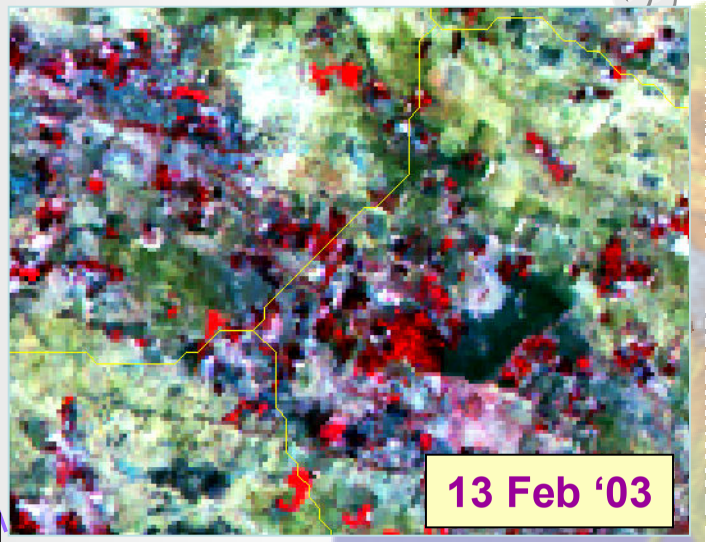


Down Stream



POST



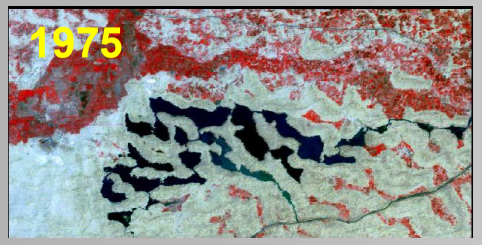


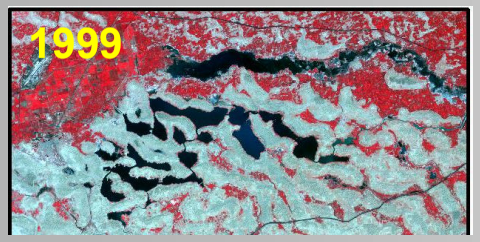
Water harvesting

Impact Assessment on crops

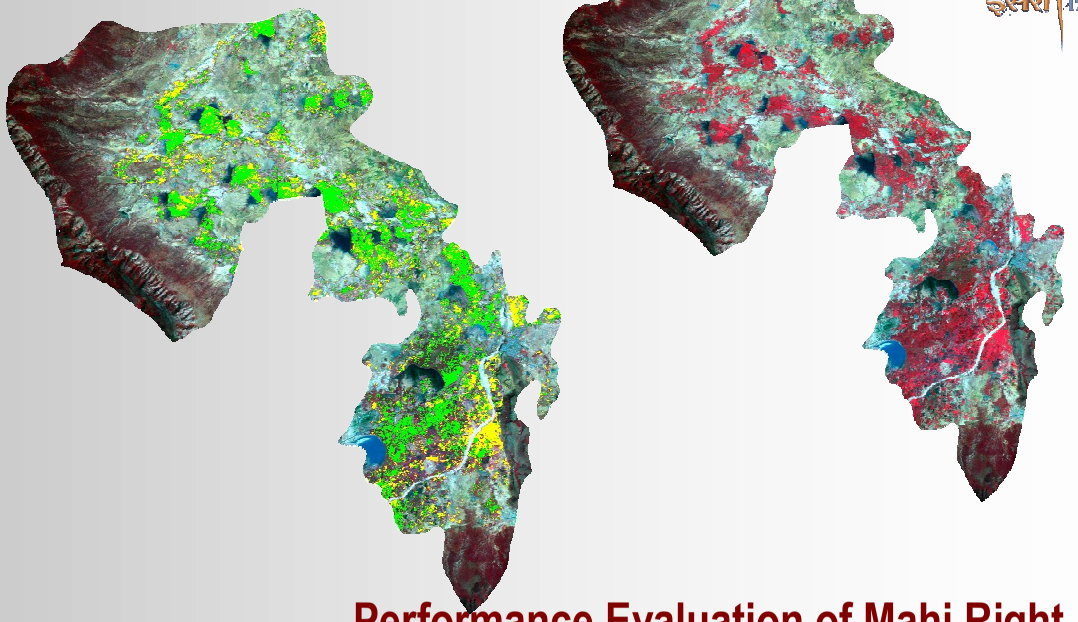
Agricultural Water Management

- Inventory of surface water bodies (tanks, reservoirs)
- Performance evaluation of irrigation commands
- Water logging/salinity

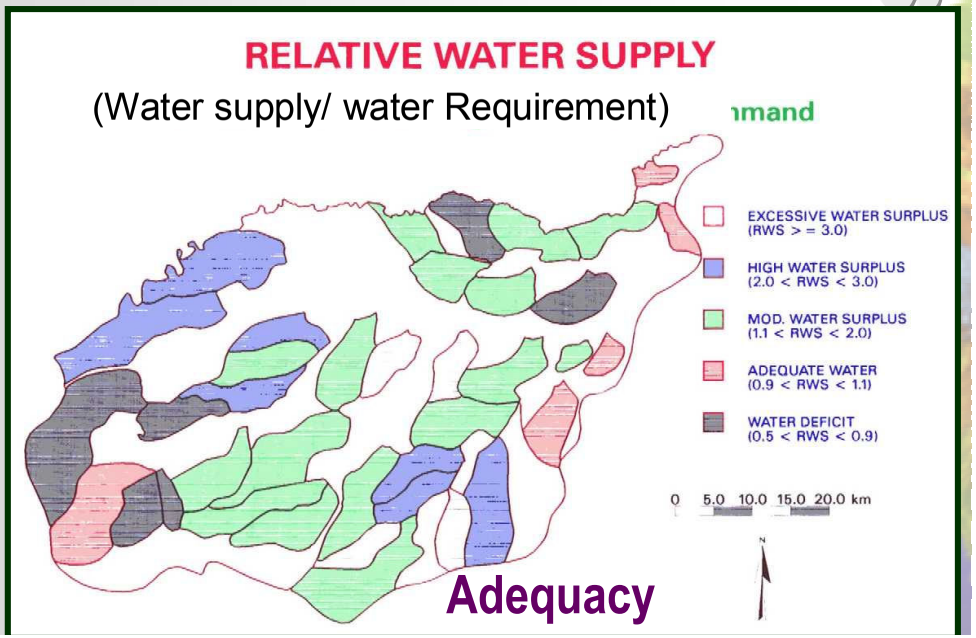




Tank Irrigated Areas

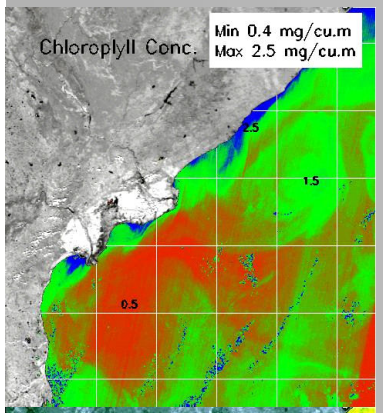


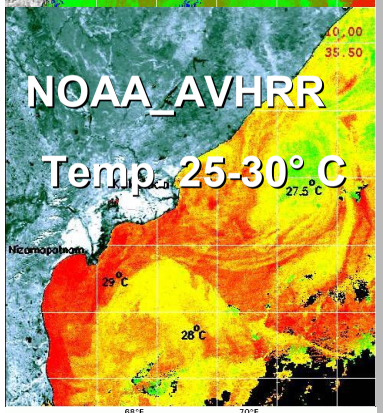
Performance Evaluation of Mahi Right Bank Canal Command

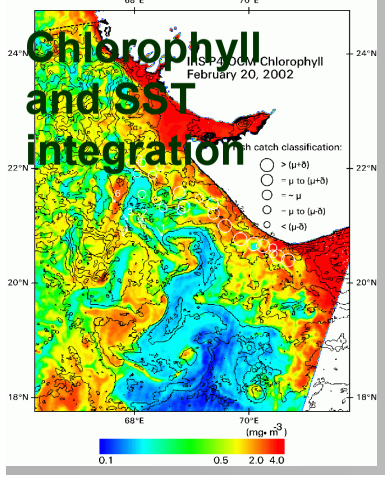


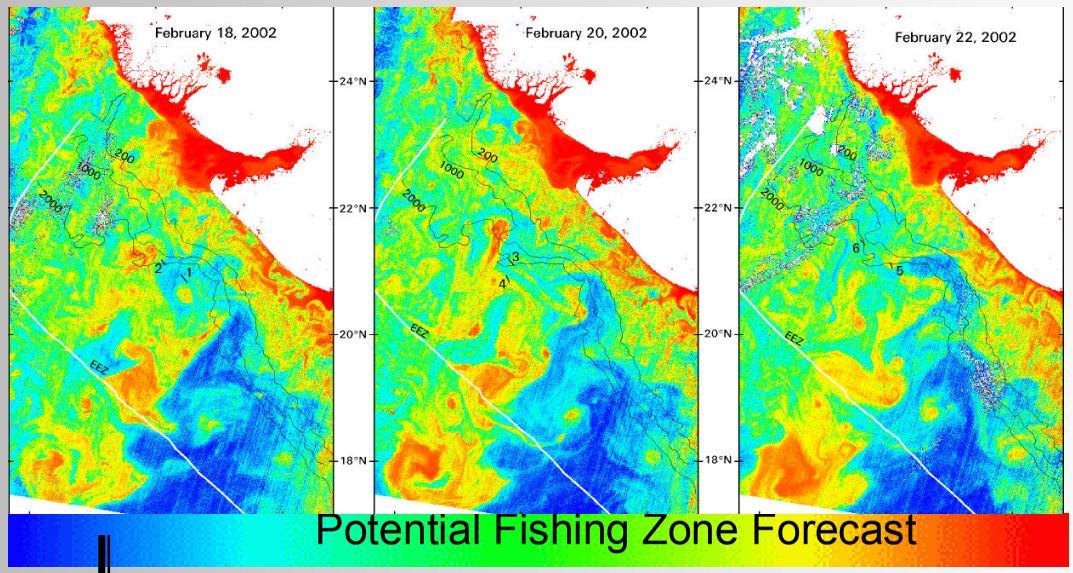
Space for Agriculture

Ocean Biology & Fisheries



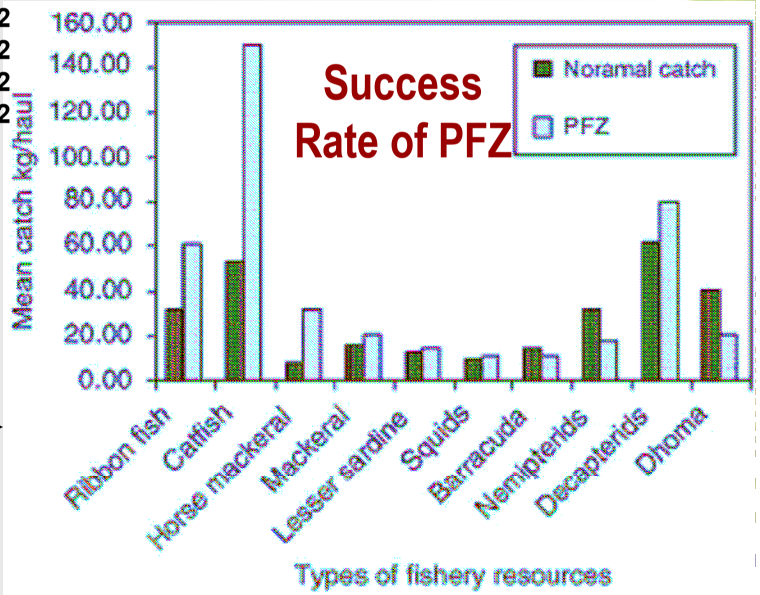






Track No.	Depth(m)	HR (%)	Date
1	2589	3.8	18-02-02
2	1701	1.9	19-02-02
3	1876	1.0	20-02-02
4	2727	1.2	21-02-02
5	1791	2.1	22-02-02
6	1860	1.9	23-02-02





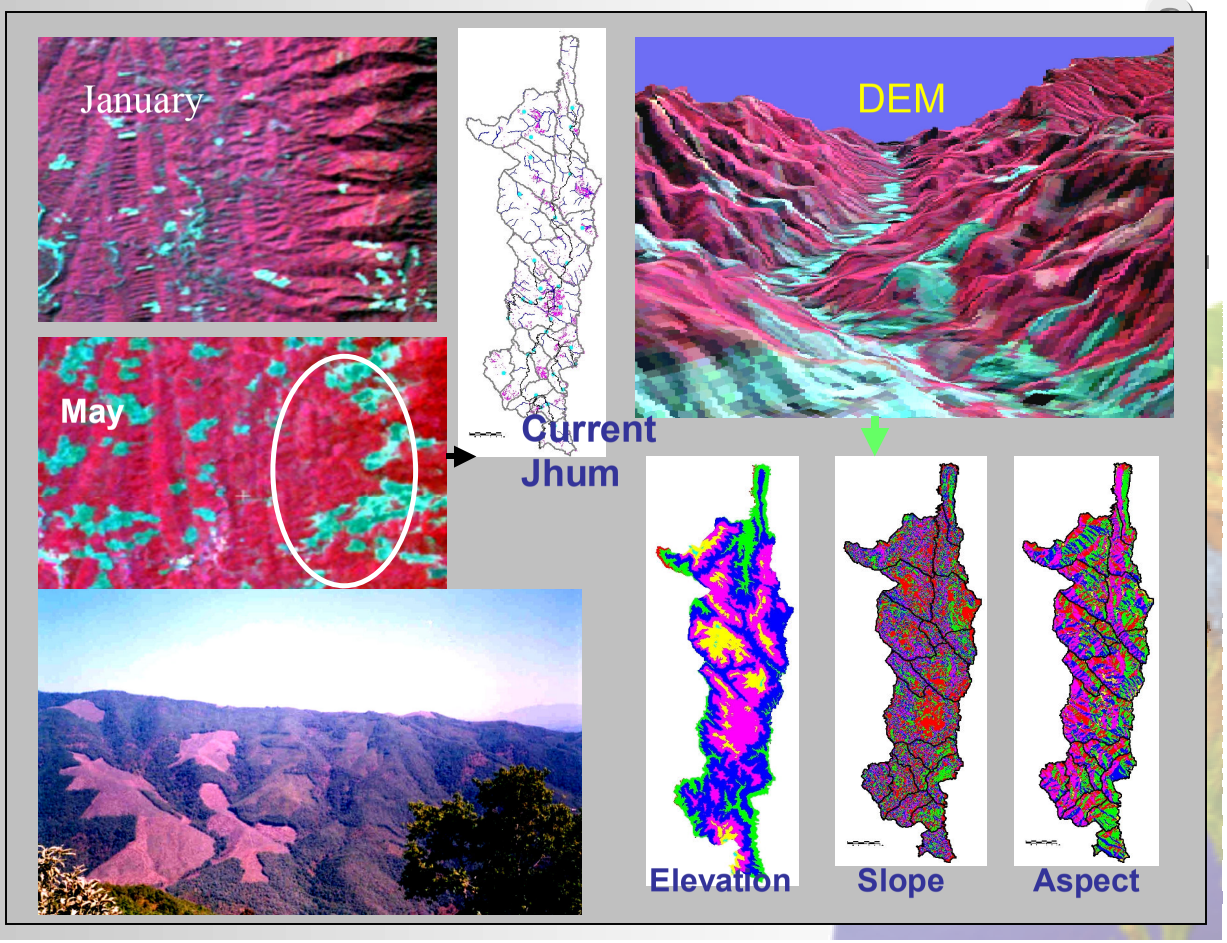
Space for Agriculture

Horticulture Development

- World's 2nd largest producer of fruits (53 MT) and vegetables (108 MT)
- Target: Doubling horticultural production by 2012.
- Centrally Sponsored Scheme on Technology Mission for Integrated Development of Horticulture in NE region including Sikkim, J & K, HP & Uttarakhand
- Initiatives on:
  - National Winter Potato Production Forecasts,
  - Post-harvest infrastructure planning,
  - Site suitability for fruit orchard in NE states & HP

Site suitability maps at village/block level for selected crops in each state

Mizoram	**: Passion fruit,**
Meghalaya	**: Cashew,**
Sikkim	**: Mandarin,**
Manipur & Tripura	**: Pineapple,**
HP	**: Apple**



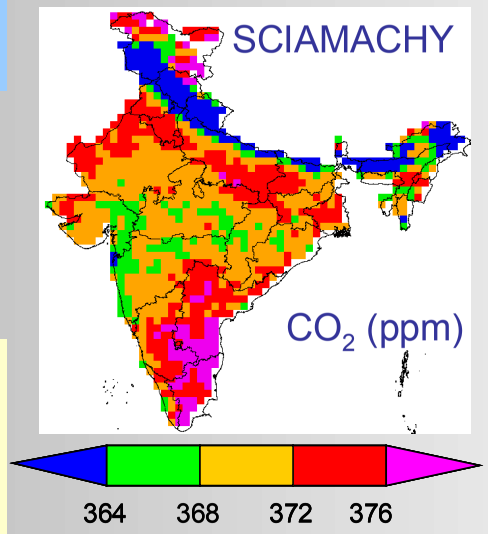
Climate Change: Possible Impacts on Agriculture

Carbon dioxide

Increased photosynthetic capacity; Decreased stomatal conductance; Enhanced water use efficiency; Altered photosynthetic partitioning,

Precipitation

Increase in rainfall lead to increase in yield of Kharif crops (e.g. Rice);High frequency of extreme events will be detrimental



Temperature

Increase in temperature has negative impact on crops yields (especially for the winter season)

Solar Radiation

Solar radiation reduces due to increasing aerosol and foggy situations;Decrease in solar radiation reduce agricultural productivity

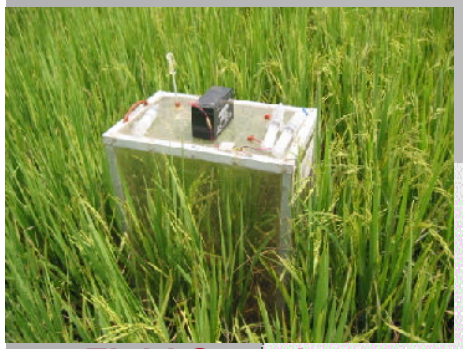
Space for Agriculture



Space input in Climate Change

- **Mapping the Indicators of Climate Change**
- **Monitoring the Drivers of Global Warming**
- **Modeling the Impact of Climate Change**

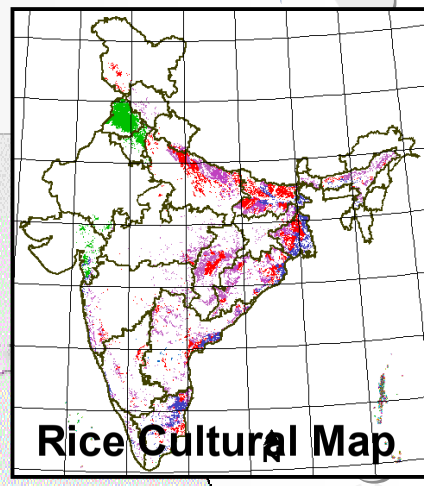
Environmental Impact Assessment of Agriculture

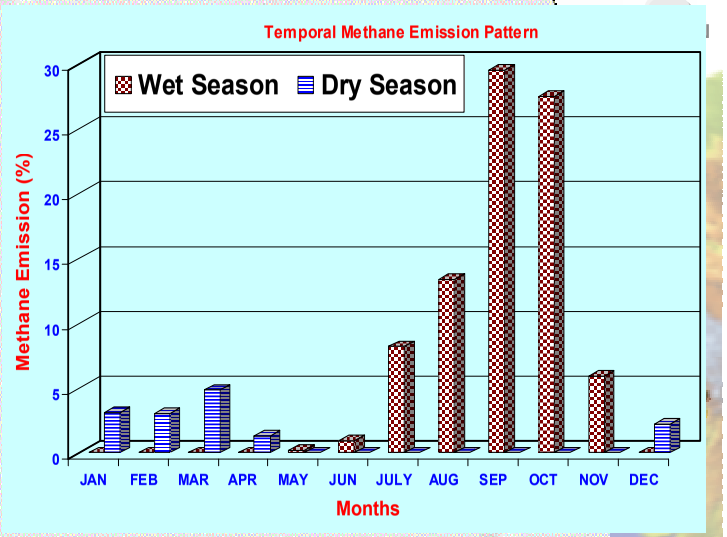


Field Samples collected : 450 (x3)

Methane Emission from Rice Fields

3.43 Tg/yr (35 Tg?)





8 10 12 16 20 28 30 32 36 40 t/ sq.km

Space Applications in Agriculture: the Road Ahead

- **Comprehensive Crop Growth Monitoring System**
  - Multi-stage forecasting
  - Condition Assessment
  - Damage Assessment
- **Agricultural/ Horticultural Development Planning**
  - Site suitability
  - Precision Agriculture
  - Infrastructure Development
  - Rainfed Area Agricultural Management
- **Agricultural Advisories**
  - Crop Insurance
  - Farmer's Advisory through VRC
  - Fisheries Species level forecast
  - Agrometeorology Advisory Services
- **Climate Change and Agriculture**
  - Effect of Agriculture on drivers of Global Warming (CH_4, N_2O..
  - Impact of climate change on agriculture & hydrology
  - Inputs for Adaptation Measures

2009	**Resourcesat-2** (AWiFS, LISS-III, LISS-IV)
2011	**TES: Hyperspectral** (12.5 m & 200 Ch 2.5 m Stereo, 5 m MX)
2009	**RISAT-1** (C-SAR)
2010	**GEO-HR Imager** (50 m VNIR; 250 m SWIR, 1 km IR)
2008	**Oceansat-2** (OCM, Scatterometer ROSA)
2008	**INSAT-3D** (Imager, Sounder)
2009	**Mehga Tropiques** (MADRAS, SAPHIR, ScaRab, GPS Occ)

Thank you.