

GEOSPATIAL TECHNOLOGY AND APPLICATIONS IN FORESTRY: AN OVERVIEW

S.P.S. Kushwaha
Professor & Head



FORESTRY AND ECOLOGY DEPARTMENT
Indian Institute of Remote Sensing

ISRO, Dept. of Space, Govt. of India
Dehradun 248001, U.K.

spskushwaha@gmail.com

Launch Vehicle Family





**IRS-1C (1995) LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)**



**IRS-1D (1997) LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)**



2003
RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 57 M; 4-XS



IRS-P2 (1994)
LISS-2

IRS-P3 (1996)
WiFS MOS X-Ray,



IRS-P4 (1999)
OCEANSAT OCM, MSMR



2003
CARTOSAT - 1
PAN - 2.5M, 30 KM,
F/A



**IRS-1A & 1B (1988 & 91) LISS-1&2 (72/36M,
4 BANDS: VIS & NIR)**



2004
CARTOSAT-2
PAN - 1M



2005
MEGHA-TROPIQUES
SAPHIR
SCARAB &
MADRAS

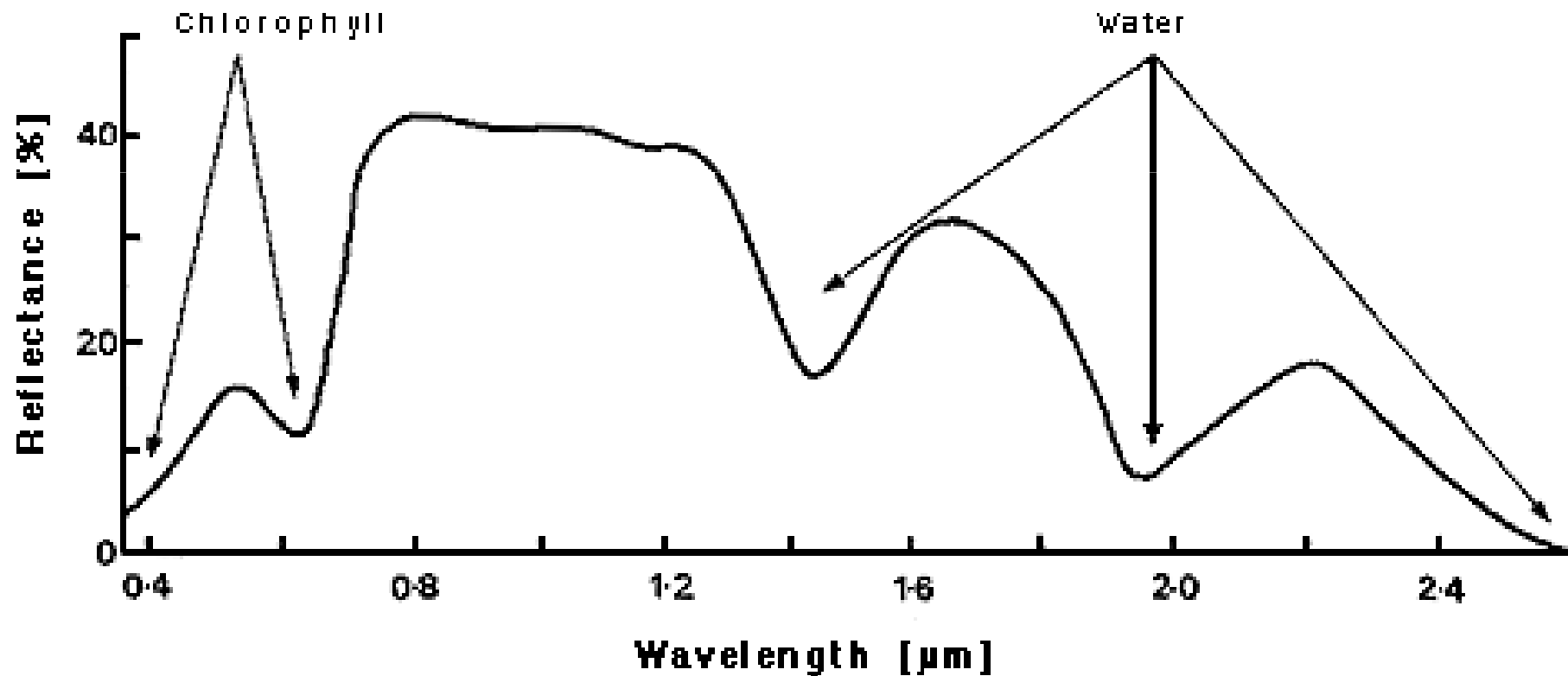
IRS Series of Satellites

Spectral Response of Vegetation

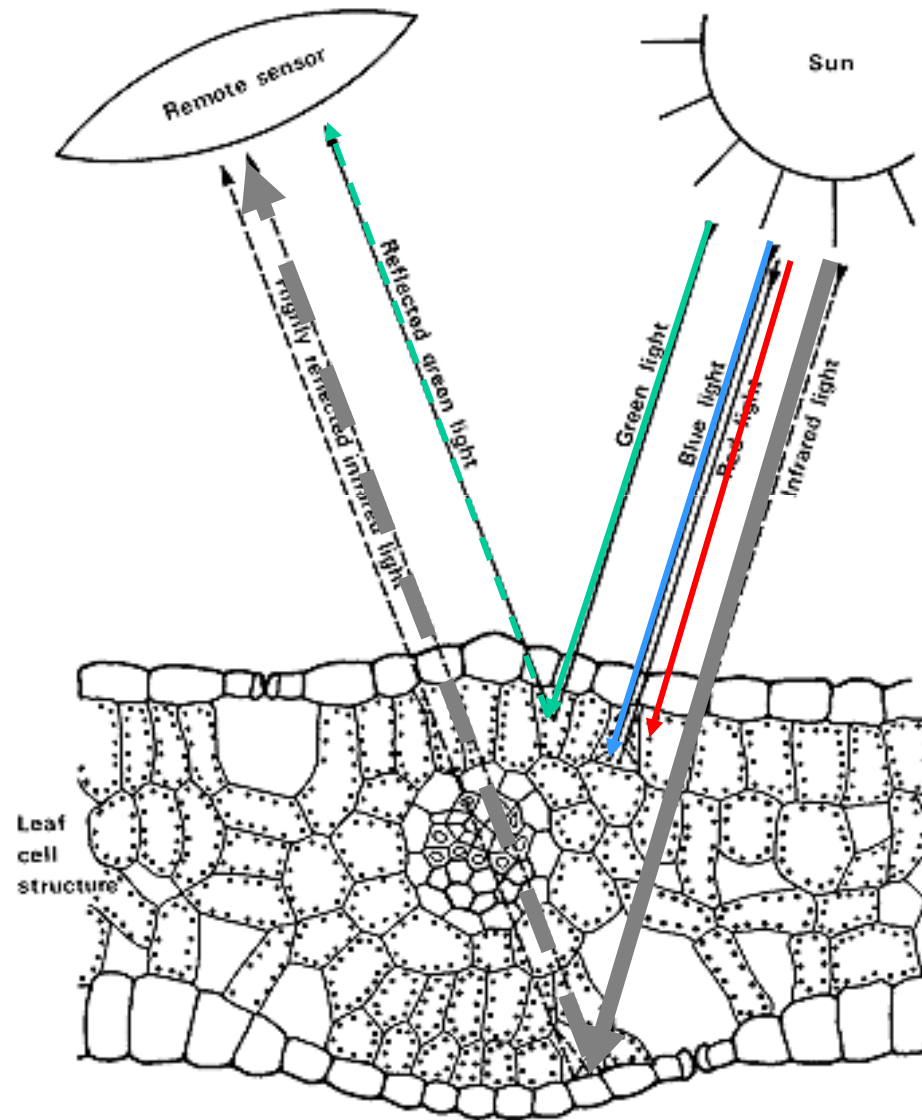
Reflectance due to:

...	Leaf	...	Cell structure	...	Water content	...
...	pigments

Absorption due to:

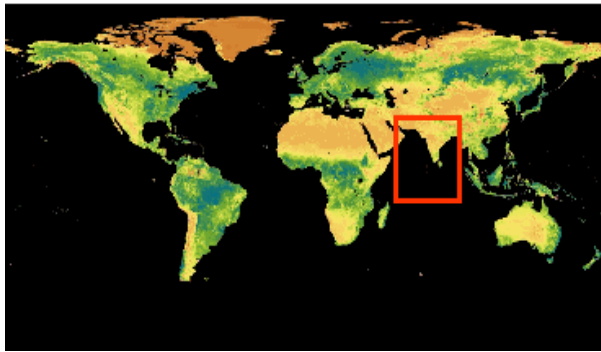


Spectral Properties of Vegetation



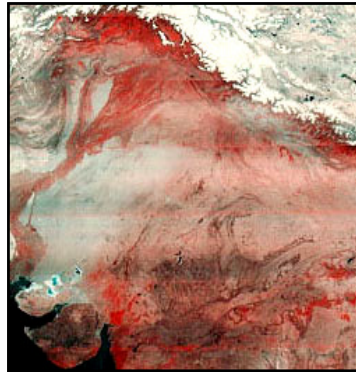
Progress in Imaging Technology

1km



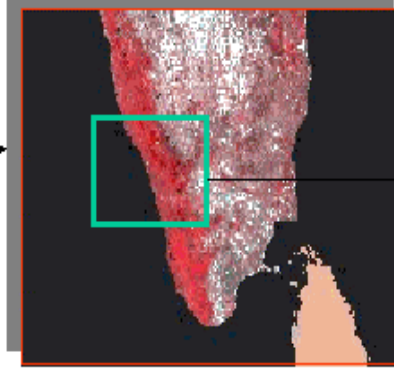
NOAA-AVHRR

360m



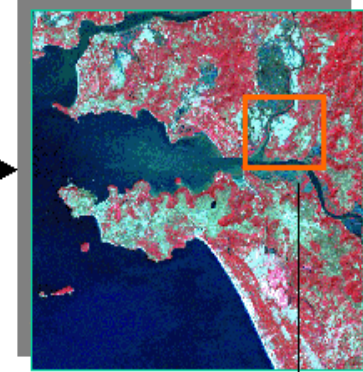
OCM

188m



WiFS

23.5m



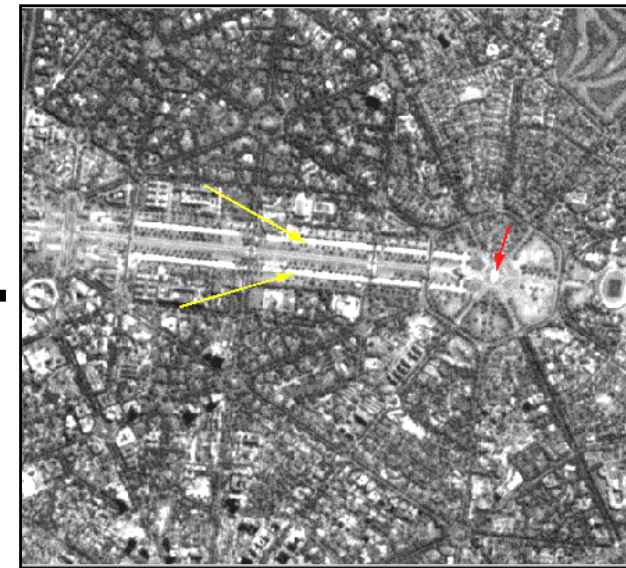
LISS-III

1m



IKONOS

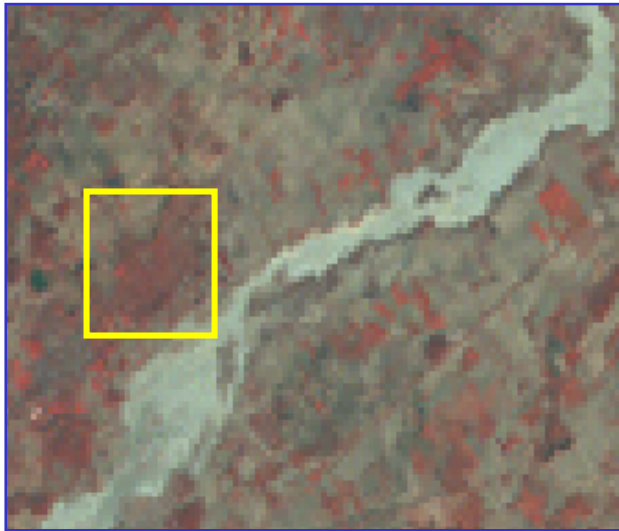
5.8m



IRS 1C/1D PAN

iirs

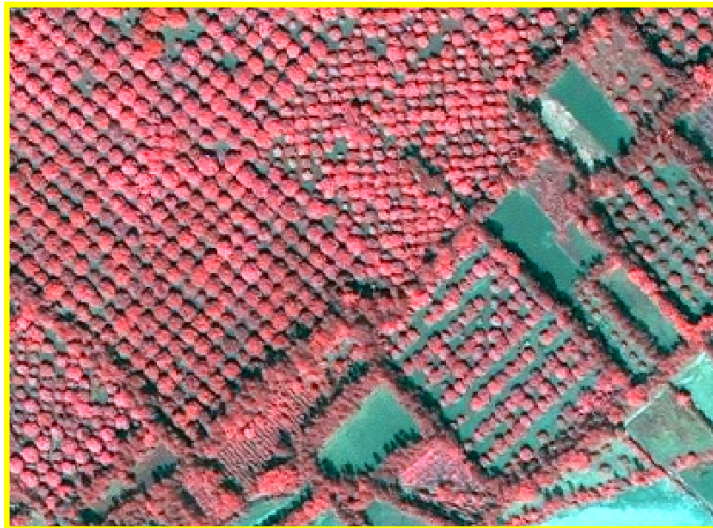
Progress in Imaging Technology....



Landsat-TM



IRS LISS-III



IKONOS MX

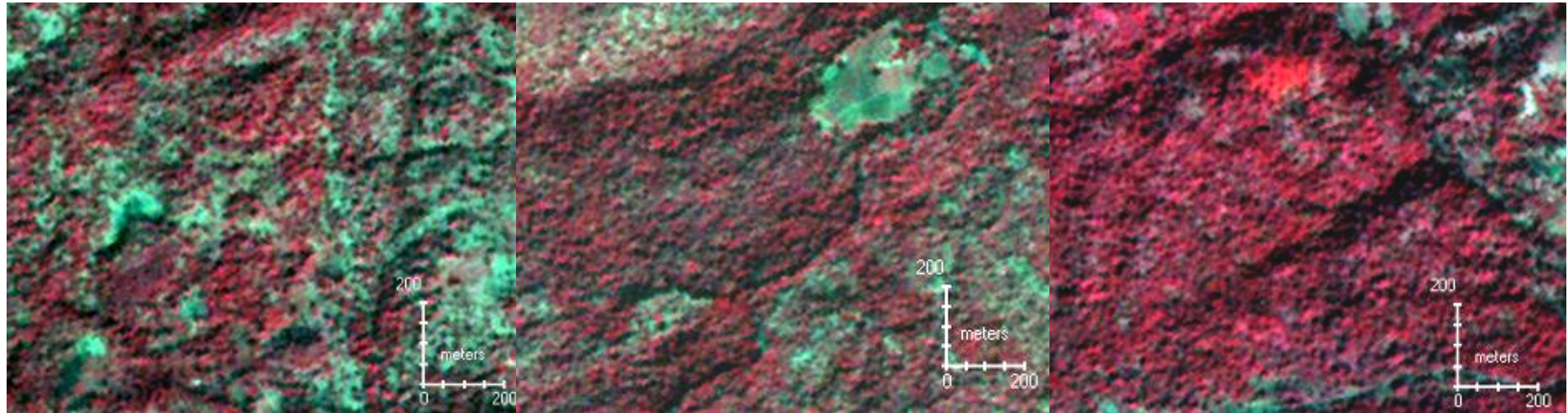


IRS LISS-3+PAN

IKONOS Image of FRI Plantations, Dehradun



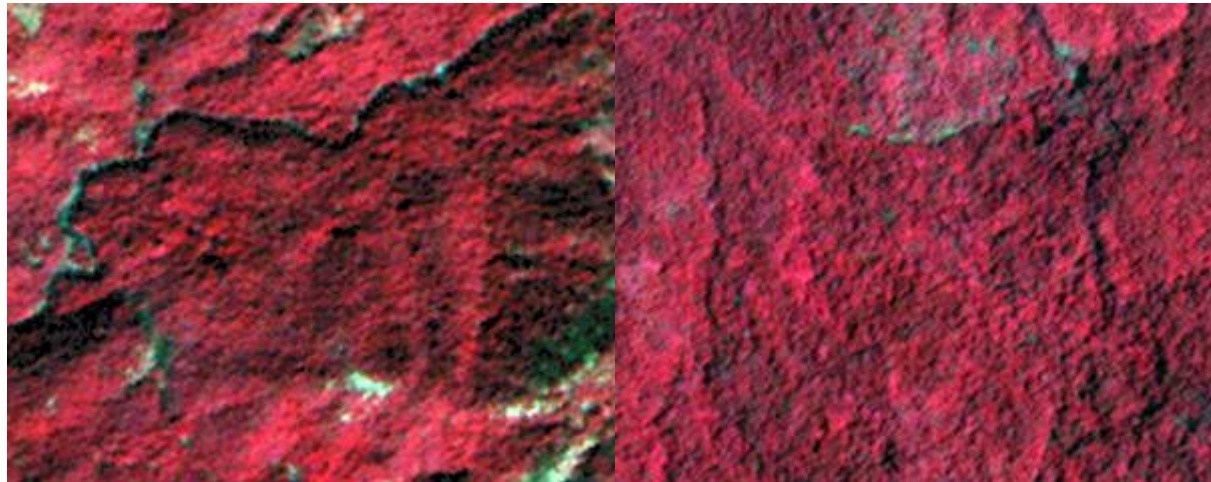
Forest Crown Density Mapping using LISS-4 Data



<20%

20-40%

40-60%

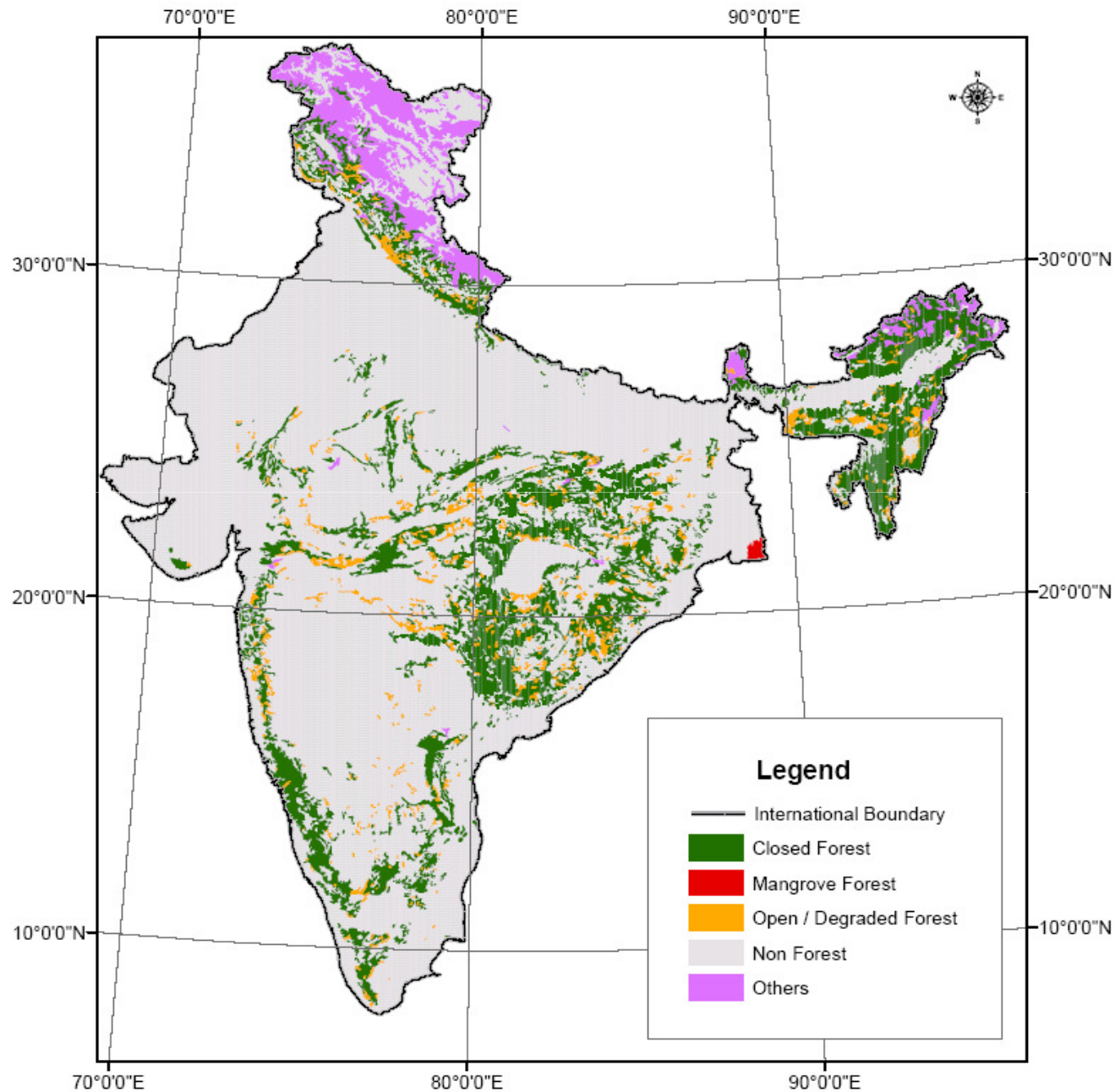


60-80%

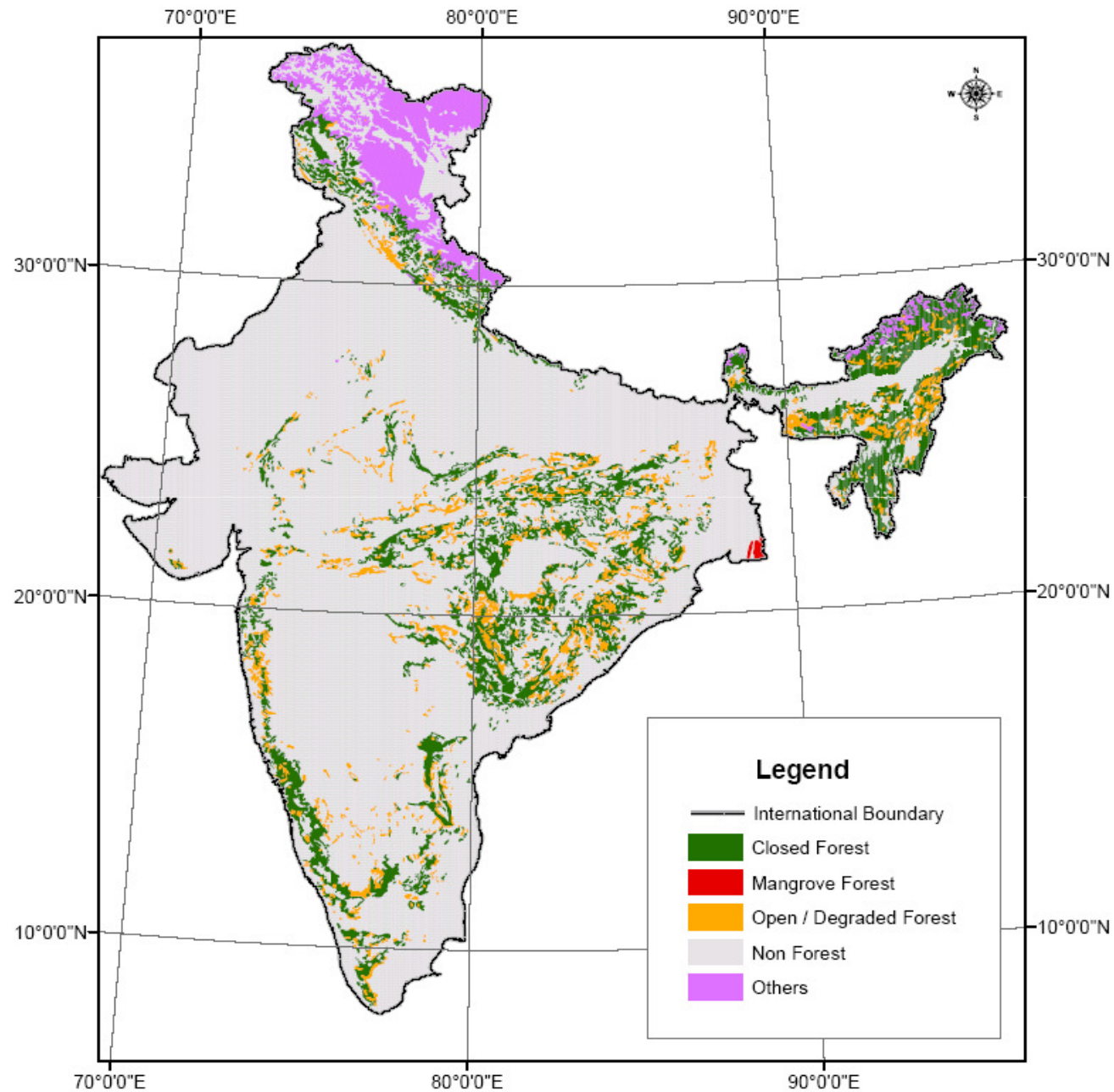
>80%

iirs

Forest Cover in India in 1972-75



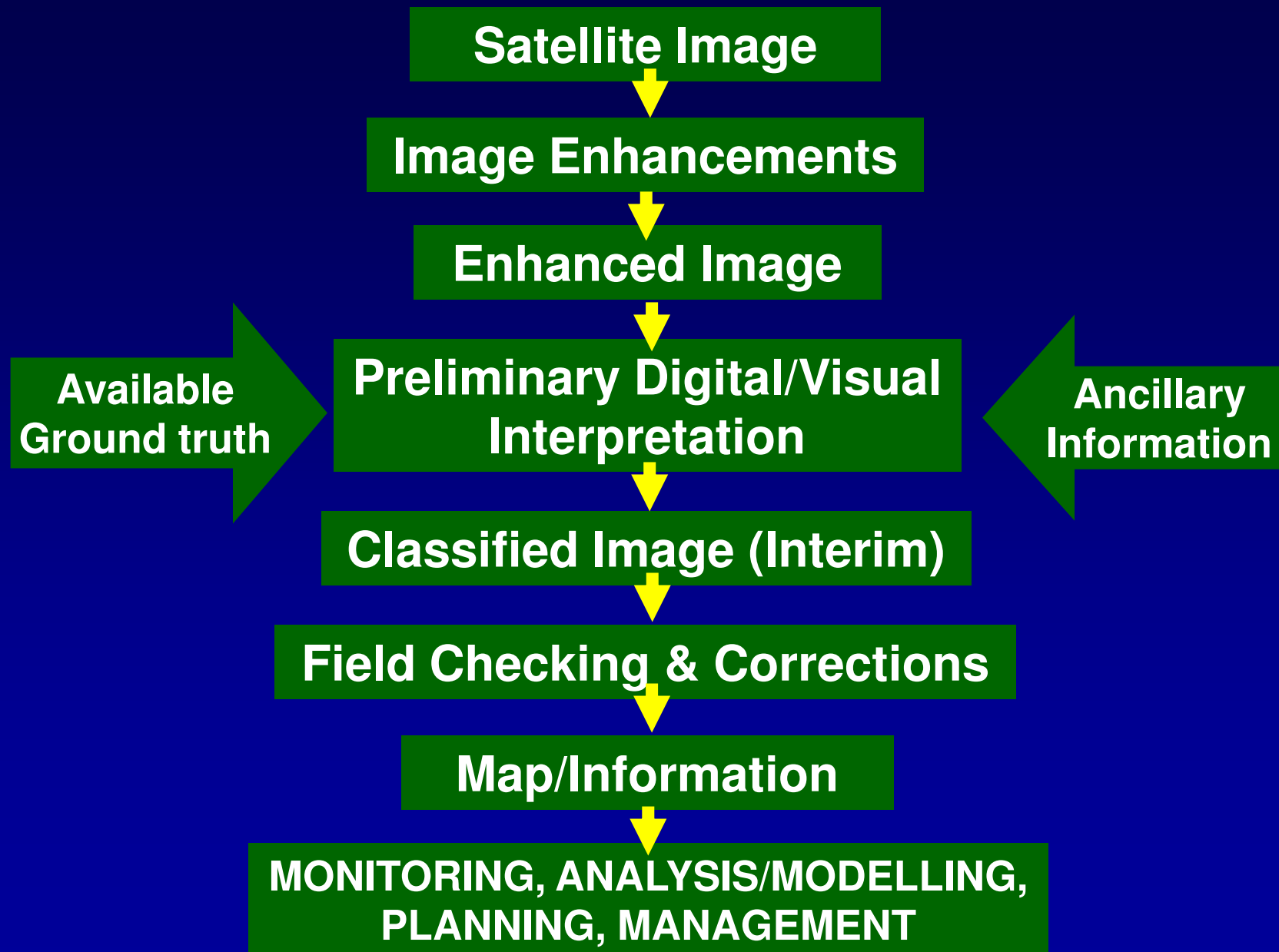
Forest Cover in India in 1980-82



Proper Season of Data for Forest Mapping

Forest Vegetation Type/Region	Season
1. Humid/moist evergreen and semi-evergreen in W. and E. Ghats	Jan – Mar
2. Humid and moist evergreen/semi-evergreen in NER and A & N islands	Feb – Mar
3. Trop. moist deciduous in N. and C. India	Nov – Jan
4. Temp. evergreen in W. Himalayas	Apr – Jun
5. Temp., subalpine/alpine evergreen/deciduous in Jammu and Kashmir	Aug – Oct
6. Dry deciduous/scrub in arid/semi-arid region	Oct – Dec
7. Coastal/mangrove	Jan – Mar (low tide)

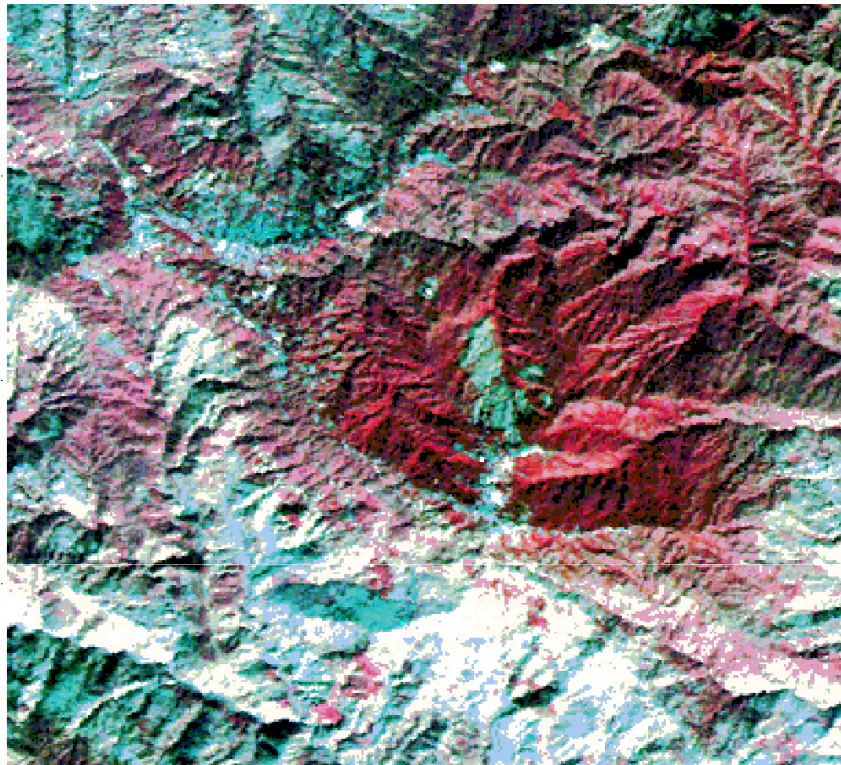
From Data to Information









Interpretation Key

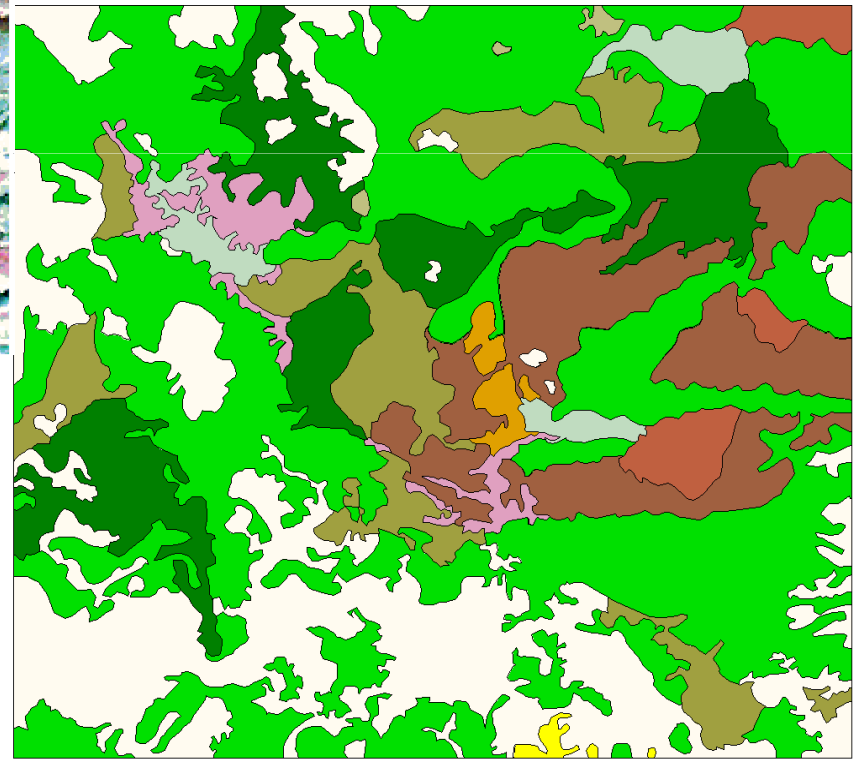
Forest Cover Classes		Tone/ Colour	Size	Shape	Texture	Pattern	Location	Association
1.	Evergreen Forest	B. Red	Large	Irregular	Fine	Irregular	High hills	Surrounded by semi-evergreen forest
2.	Semi-Evergreen	M. Red	Small	- do -	Mottled	Mottled	High to medium elevation	Between evergreen & moist deciduous
3.	Moist Deciduous	B. Red	Large	- do -	Coarse	Irregular	Medium elevation	Between semi-evergreen and moist deciduous
4.	Dry Deciduous	Brown	Small	- do -	- do -	- do -	Lower elevation	Mainly with agriculture land
5.	Degraded	R. Brown	- do -	- do -	Very coarse	- do -	On hills and plains	With plantation, agriculture, etc.
6.	Scrub	L. Red	- do -	- do -	Coarse	Mottled/ patchy	Along sea shore, low hills,	Amidst plantations, dry deciduous forests and agri. areas

Visual Interpretation of Imagery (Ranikhet)



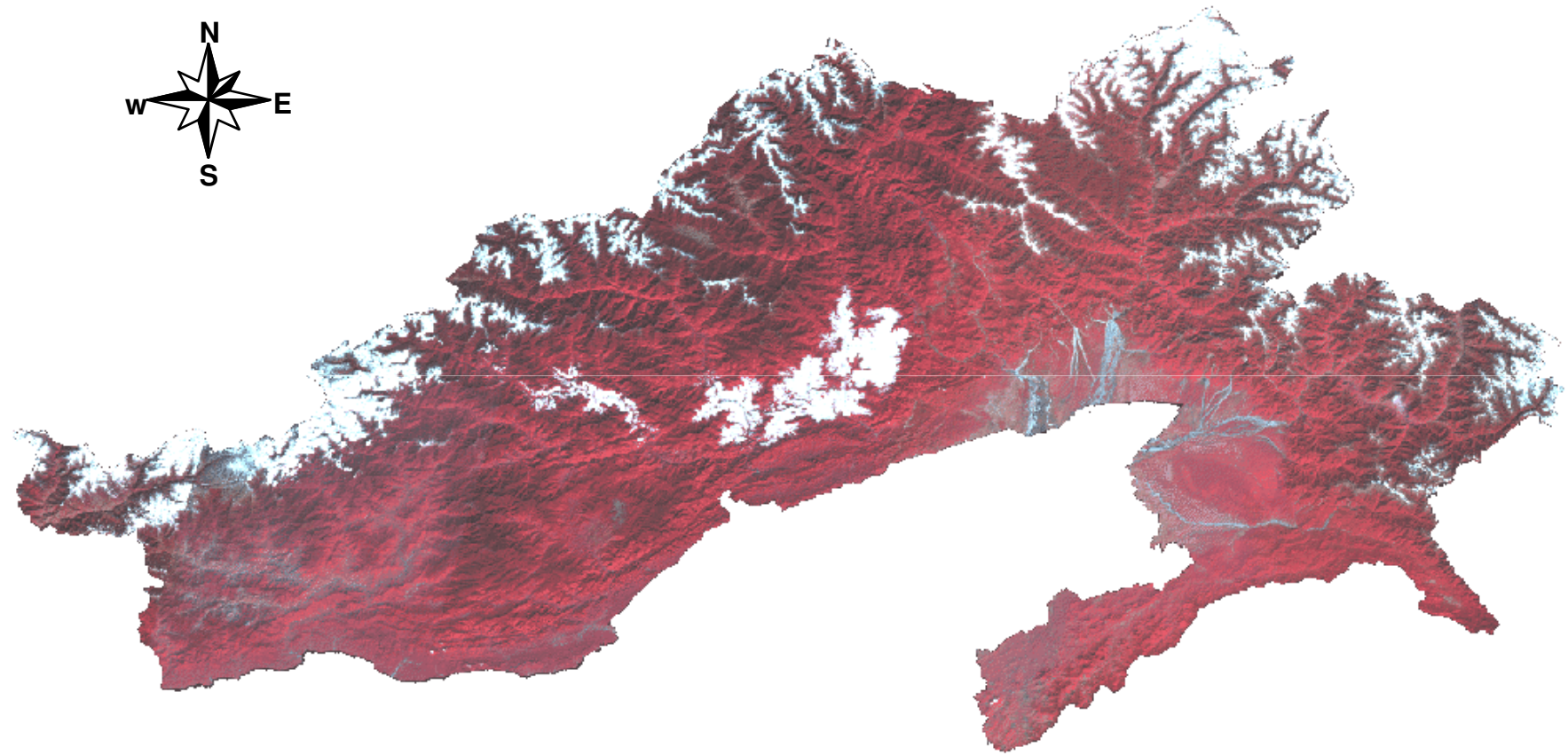
IRS LISS-III

Forest Type	
	Settlement
	Deodar
	Orchard
	Cultivation
	Fallowland
	Bare Ground
	Oak
	Oak - Pine
	Pine - Oak
	Pine
	Mixed Forest



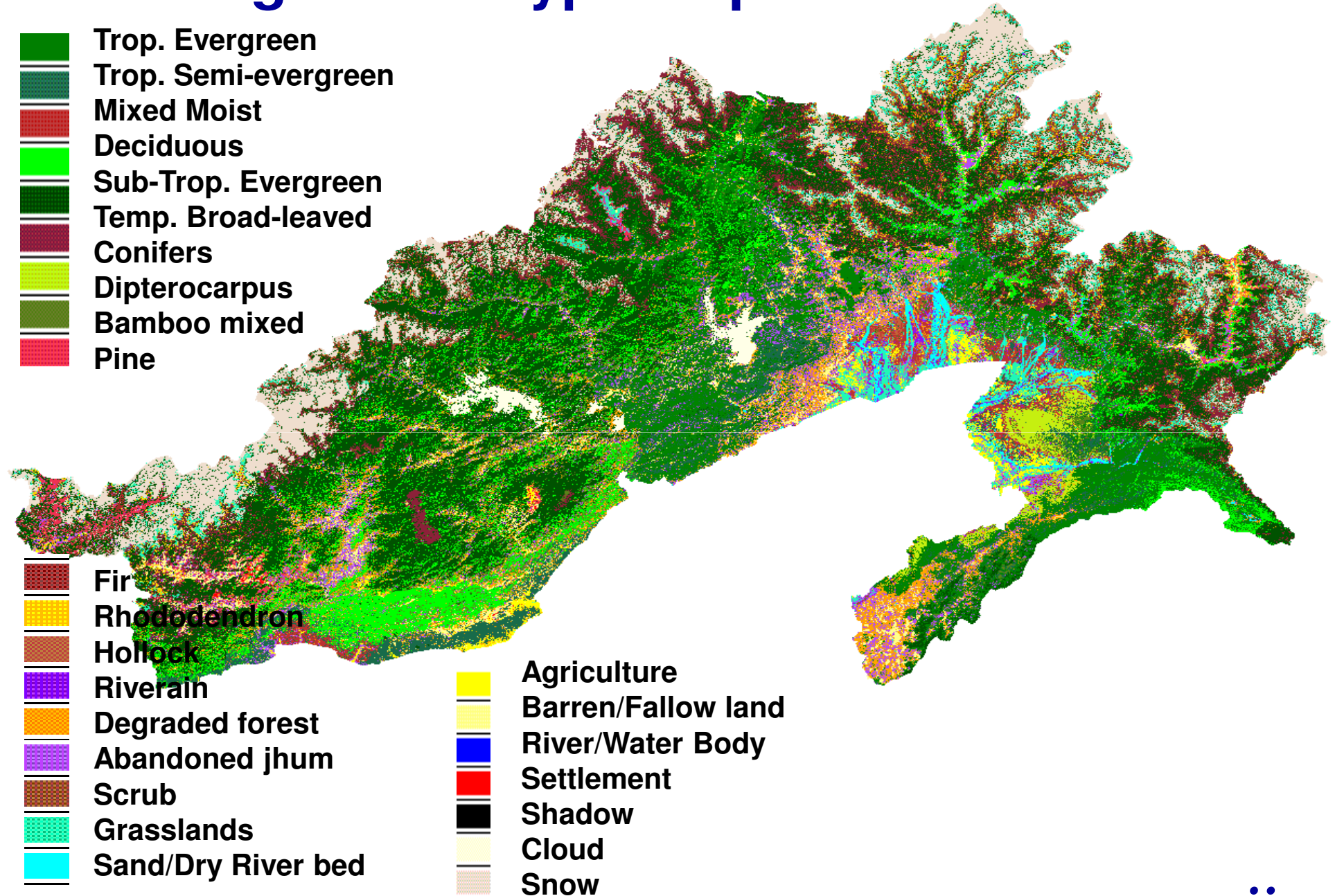
Map

Digital Interpretation of Imagery (Arunachal)

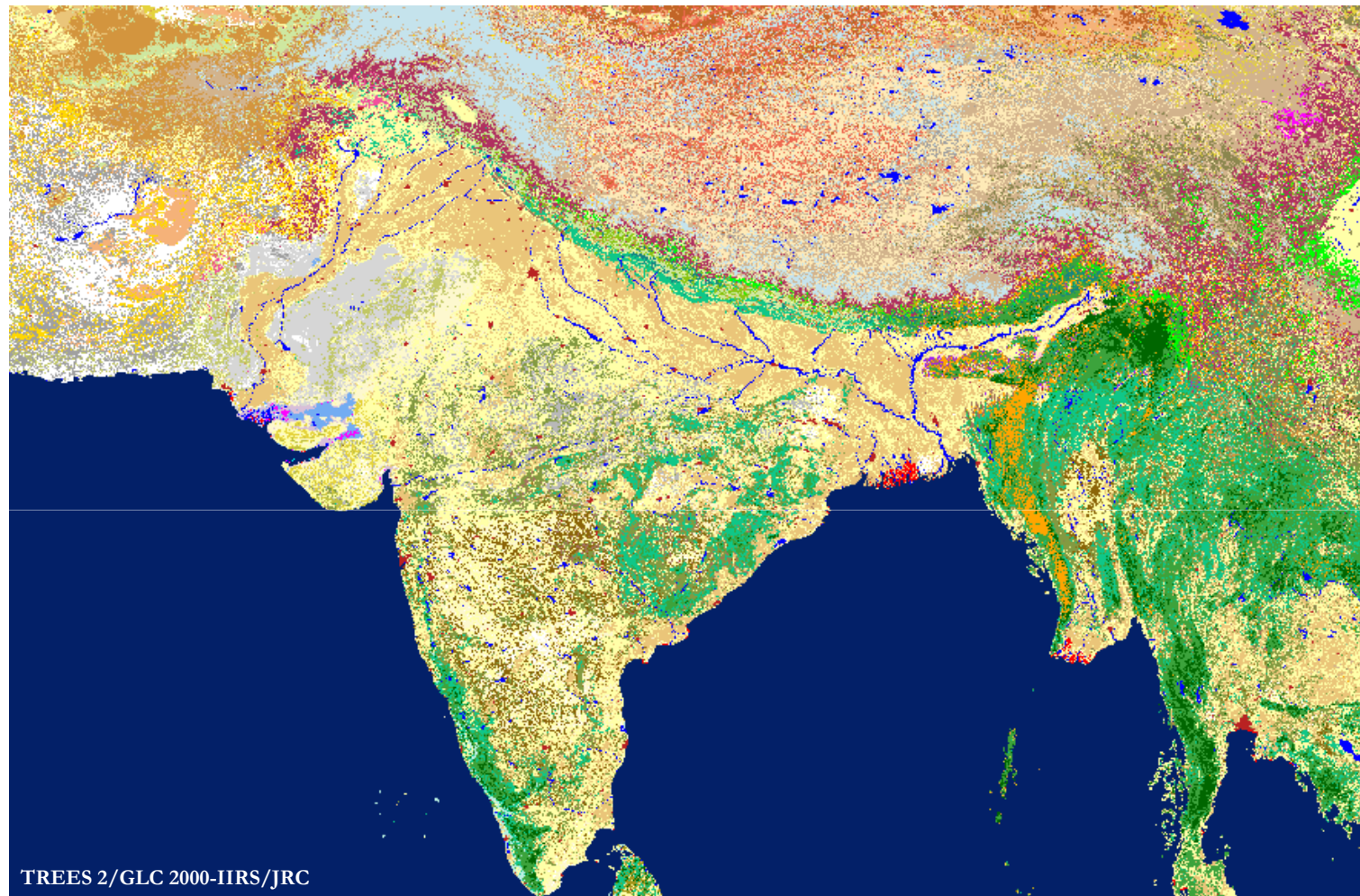


(Mosaic of 21 LISS-III Scenes)

Vegetation Type Map of Arunachal



Large Area Forest Resources Assessment

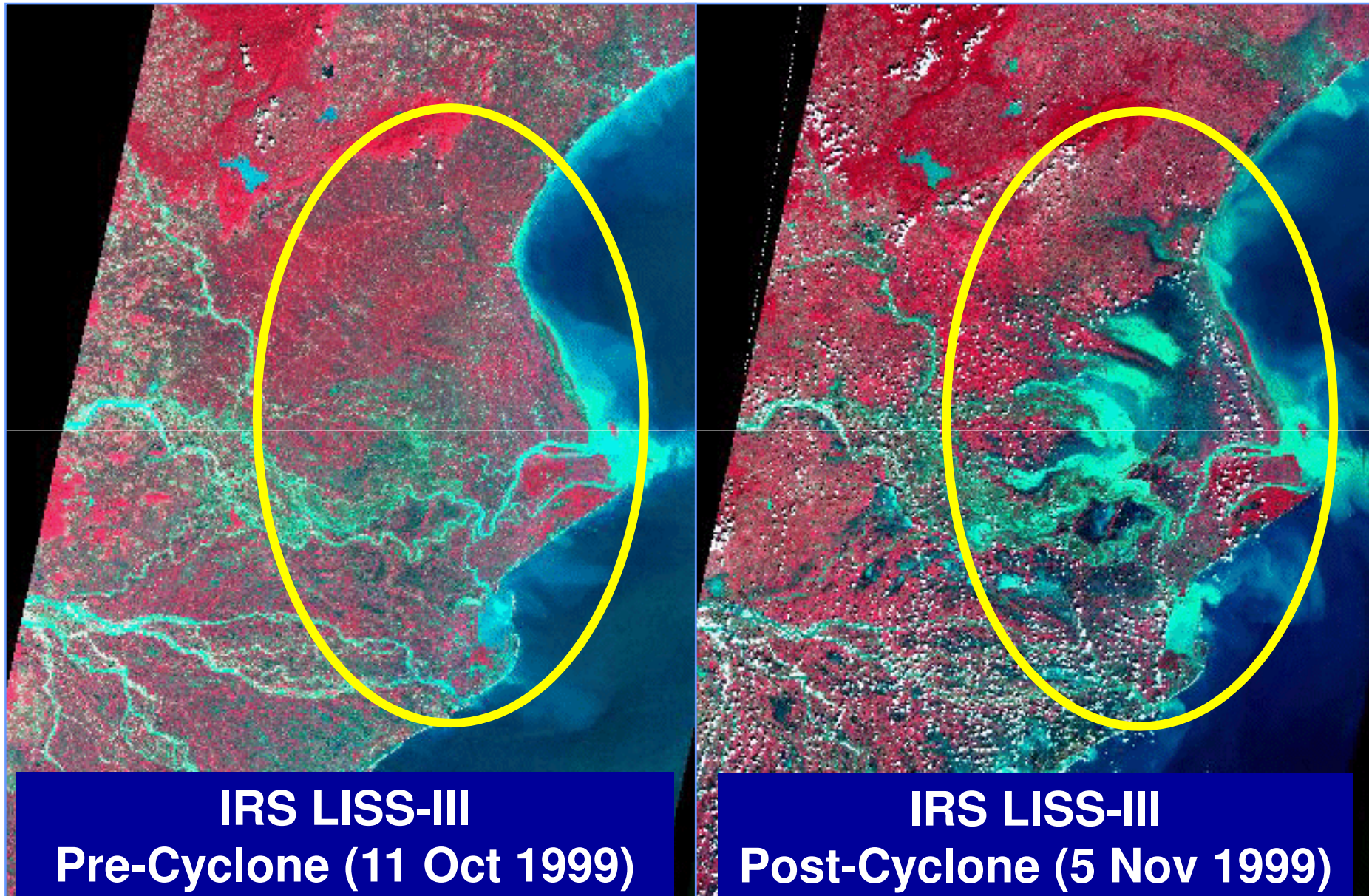


- | | | | | | | |
|--------------------------|---------------------------------|---------------------------------|----------------------------|-----------------------------------|----------------|--------------|
| ■ Tropical Evergreen | ■ Tropical Moist Deciduous | ■ Thorn Forest/Scrub (Southern) | ■ Plain Grasslands | ■ Gobi | ■ Current Jhum | ■ Salt Pans |
| ■ Subtropical Evergreen | ■ Tropical Dry Deciduous | ■ Shrubs | ■ Slope Grasslands | ■ Desert (cold) | ■ Swamp | ■ Mud Flats |
| ■ Temperate Broadleaved | ■ Junipers | ■ Abandoned Jhum | ■ Desert Grasslands | ■ Thorn Scrub / Desert (hot) | ■ Coral reef | ■ Settlement |
| ■ Tropical Montane | ■ Mangroves | ■ Sparse woods | ■ Alpine Meadow | ■ Irrigated Intensive Agriculture | ■ Water Bodies | |
| ■ Tropical Semievergreen | ■ Degraded Forest | ■ Bush | ■ Alpine Grasslands | ■ Irrigated Agriculture | ■ Snow | |
| ■ Temperate Conifer | ■ Dry Woodland | ■ Coastal vegetation | ■ Sparse vegetation (cold) | ■ Slope Agriculture | ■ Barren | |
| ■ Subtropical Conifer | ■ Thorn Forest/Scrub (Northern) | ■ Savannah | ■ Sparse vegetation (hot) | ■ Rainfed Agriculture | ■ Bare Rock | |

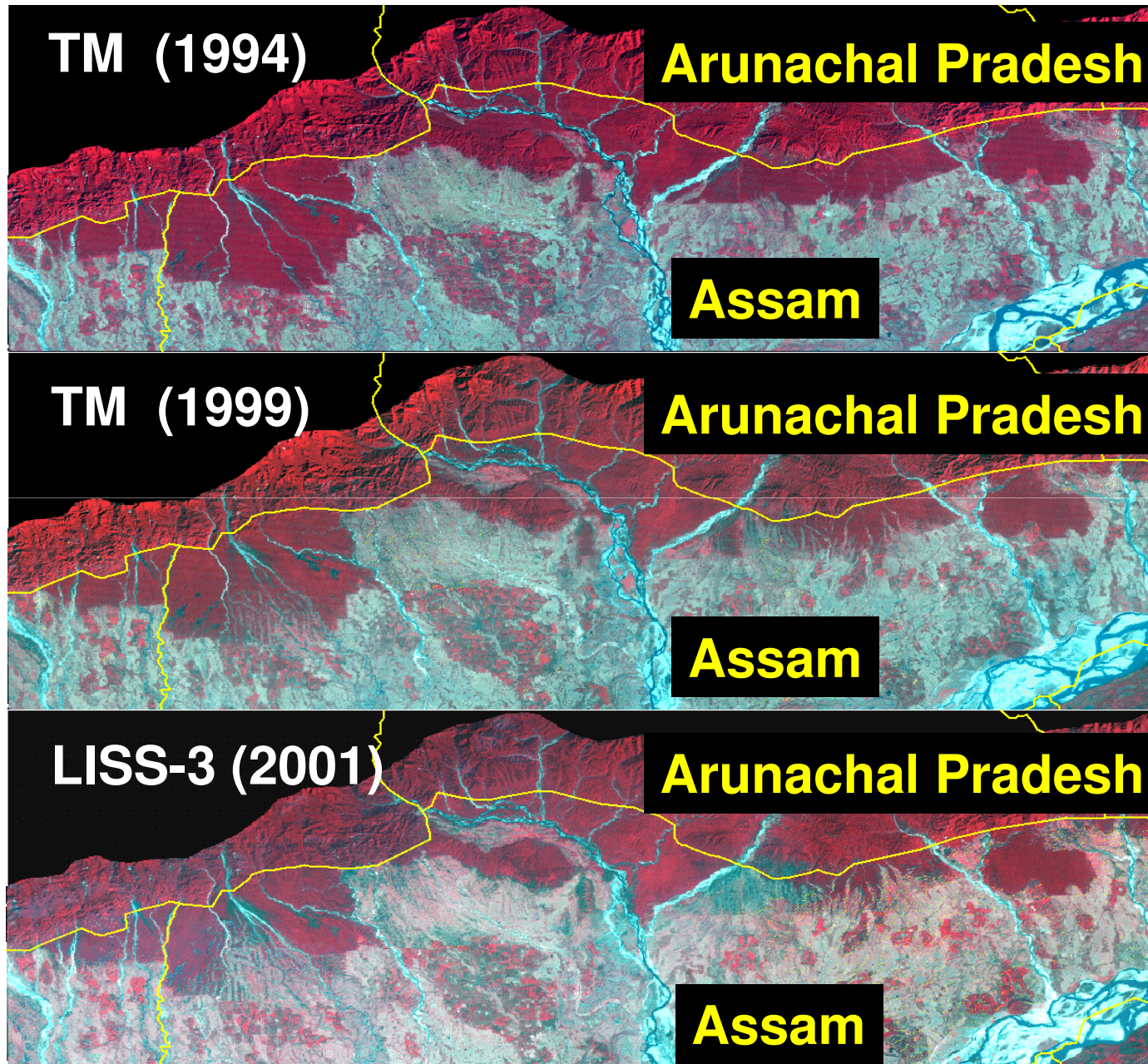
Environmental Monitoring of Mining



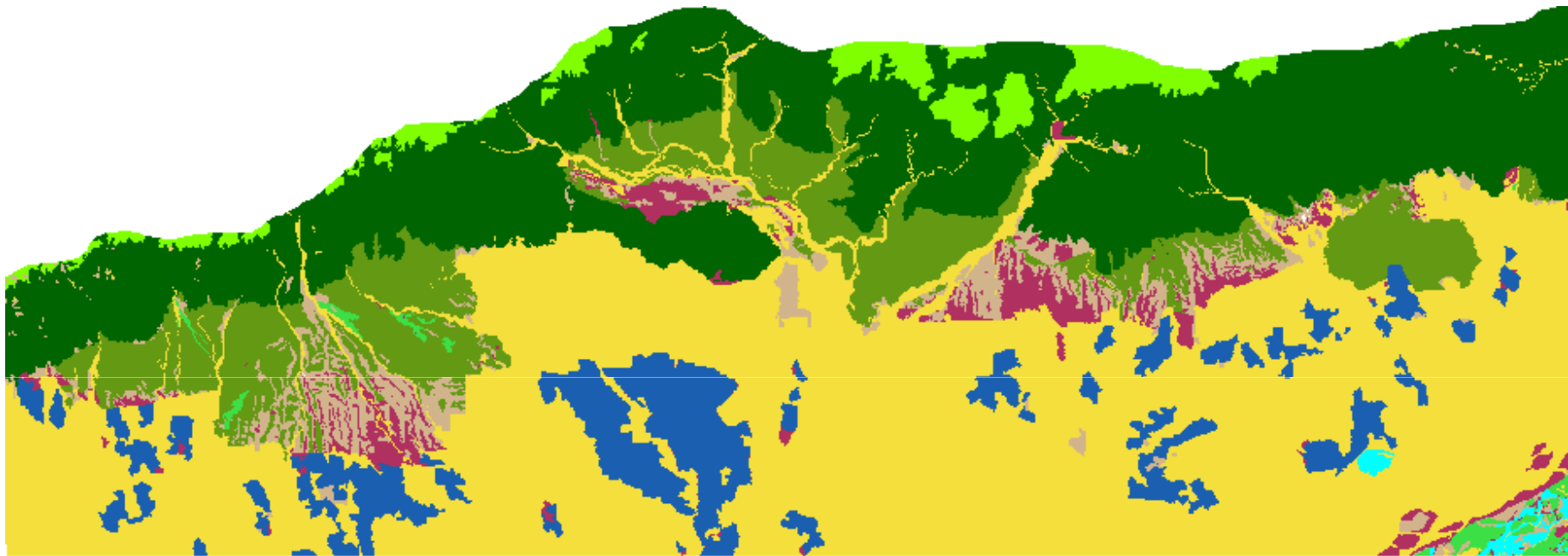
Monitoring Cyclonic Floods



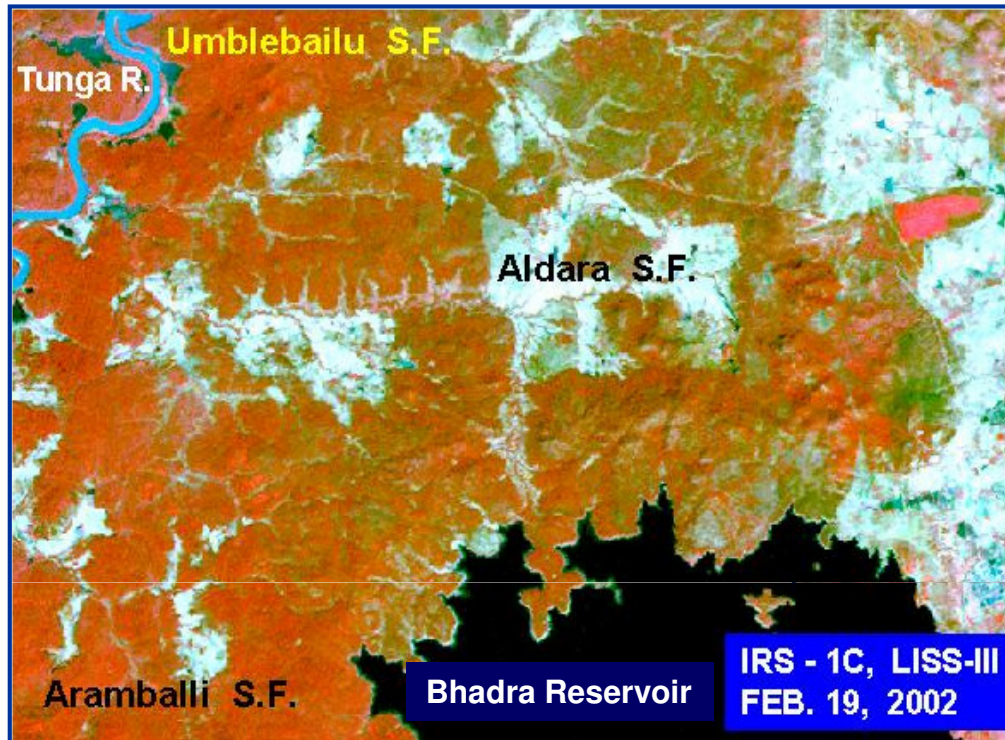
Deforestation Monitoring (Assam)



Total Deforestation in Sonitpur, Assam

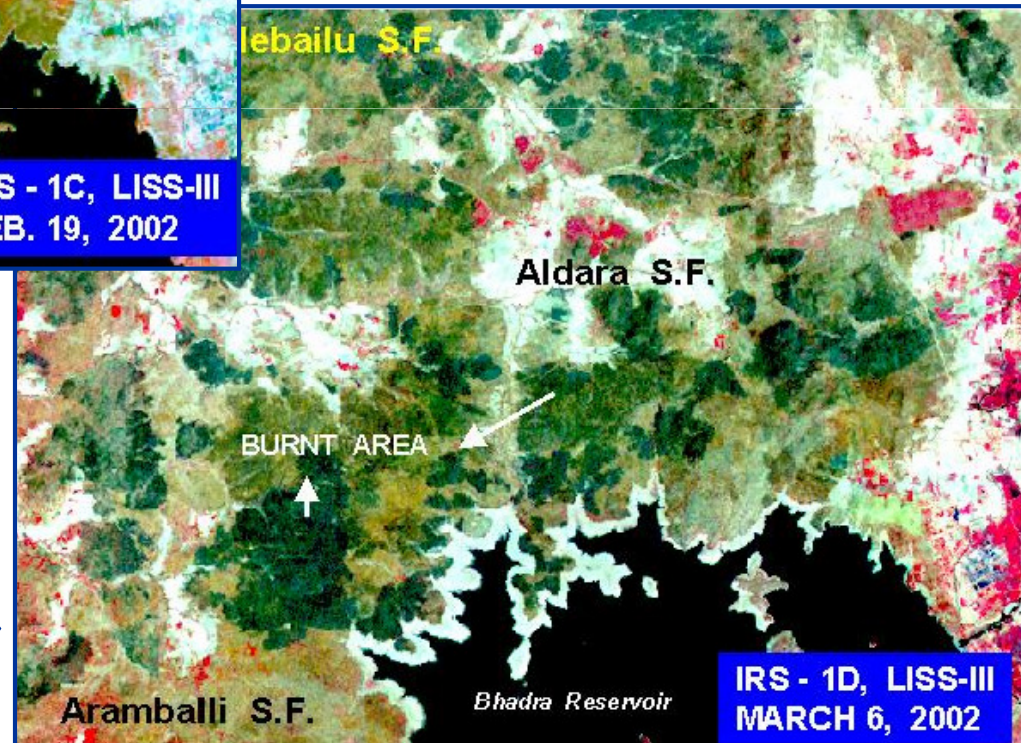


Forest Fire Monitoring (Karnataka)



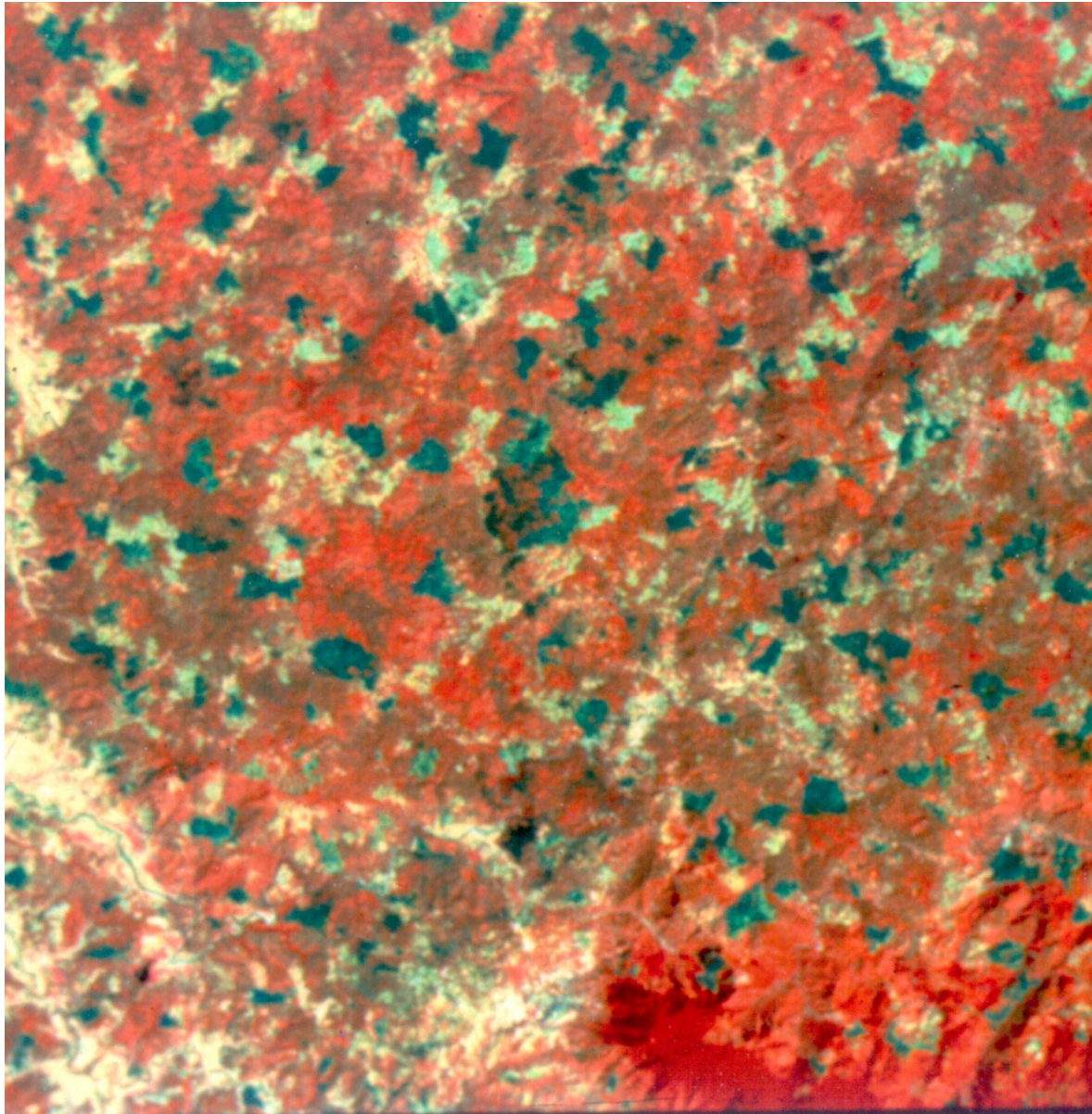
← **No Fire** (Feb 19, 2002)

Fire (Mar. 06, 2002) →

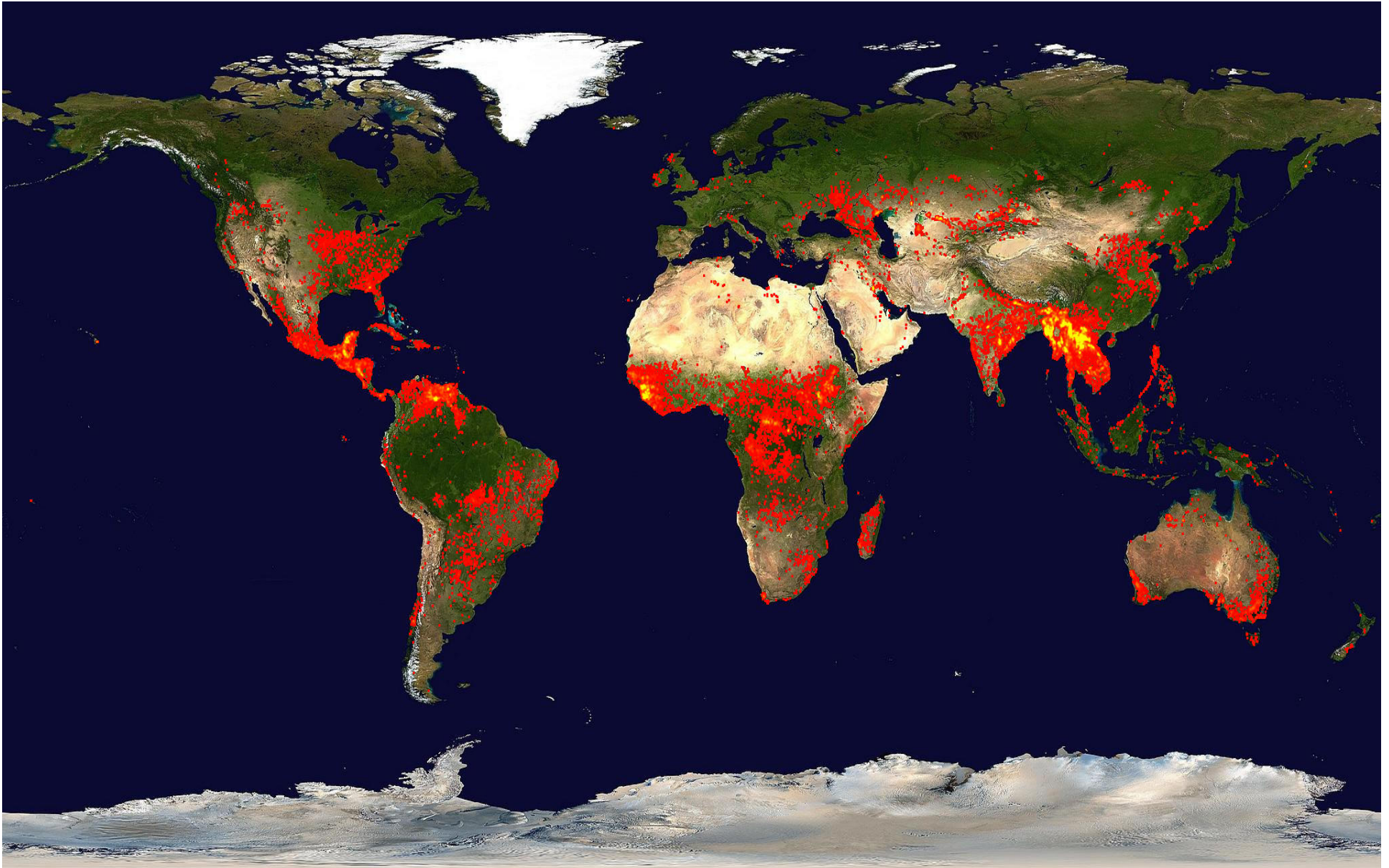


IRS LISS-3 Image of Shifting Cultivation Area

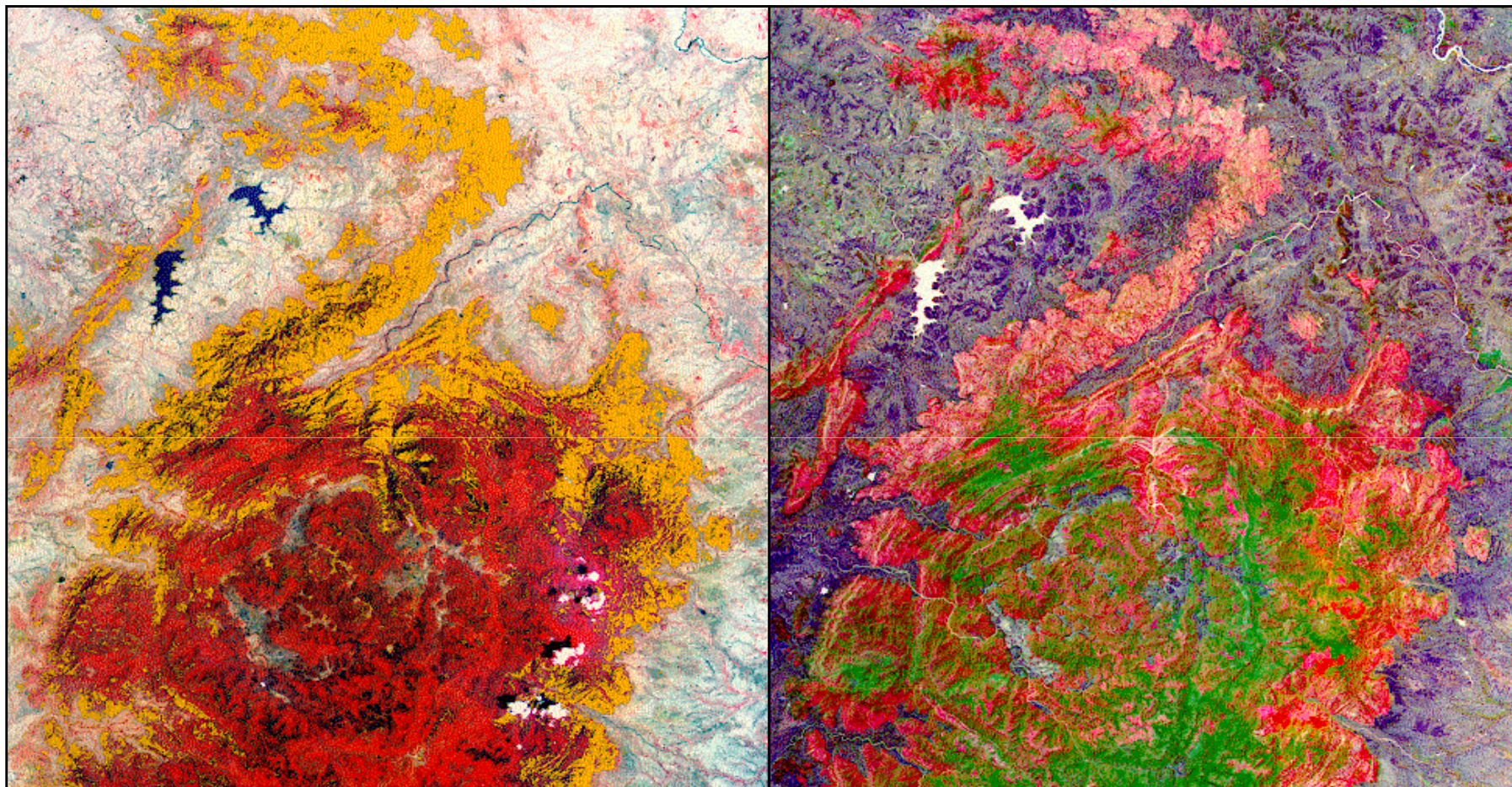
(Garo Hills, Meghalaya)



Global Fires



Forest Fire Monitoring (Simlipal TR)



CLASSIFIED DATA (27-03-94)

Yellow - Burnt Areas

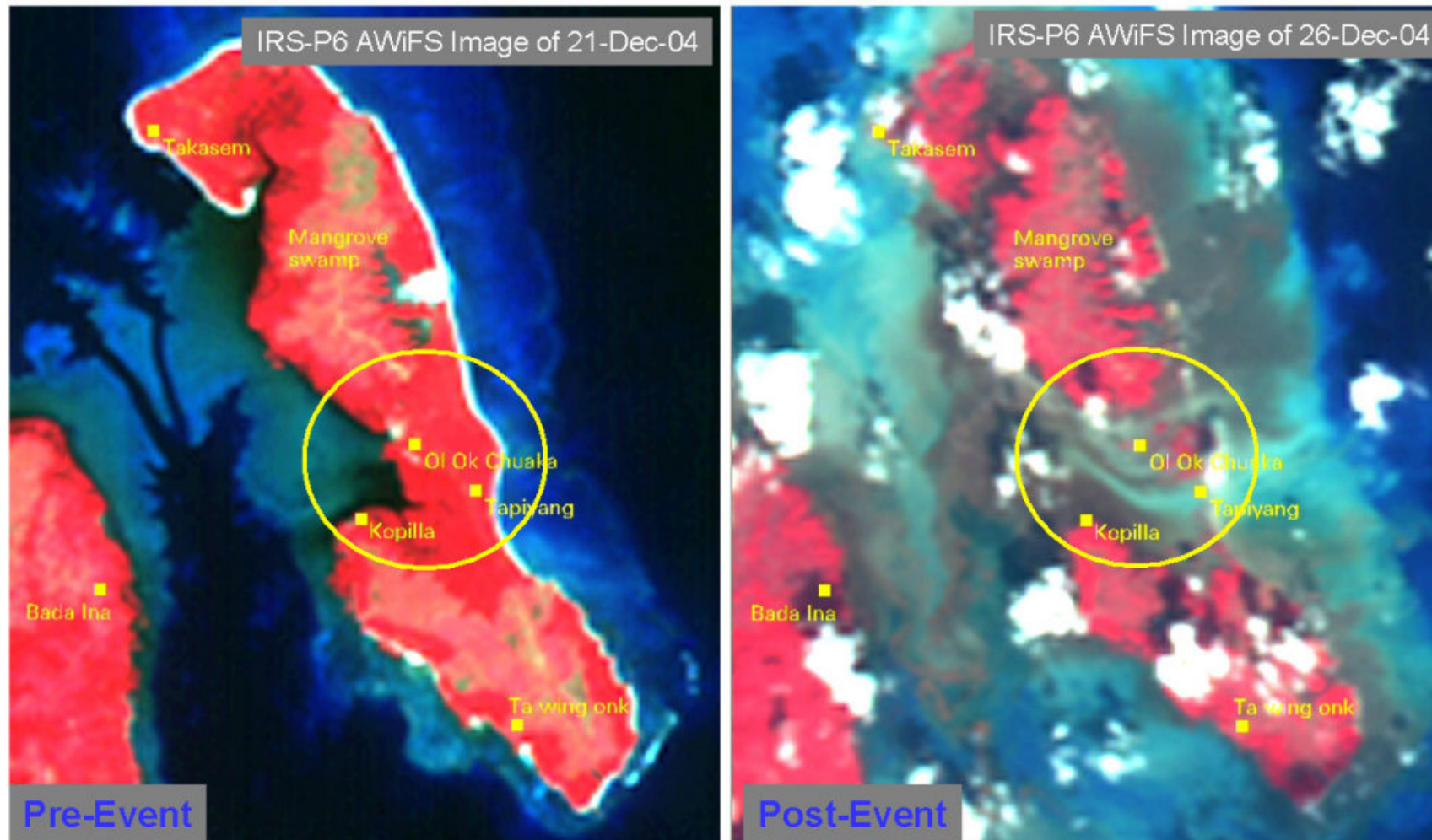
ENHANCED DATA

Dark Pink - Severely Burnt

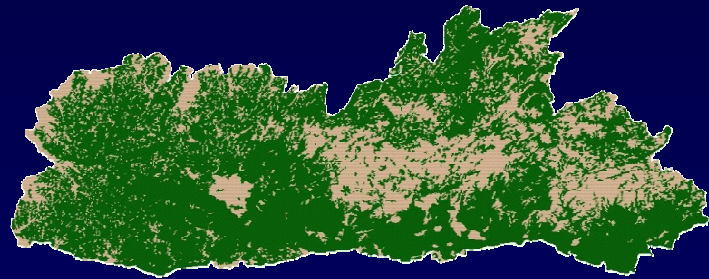
Light Pink - Burnt

iirs

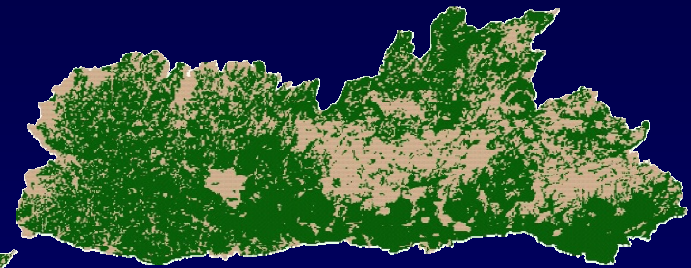
Tsunami Impact Assessment



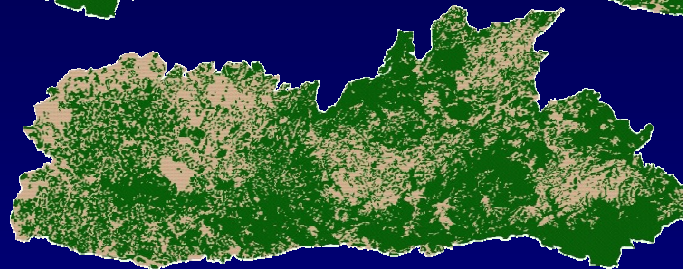
Predictive Modelling of Forest Cover



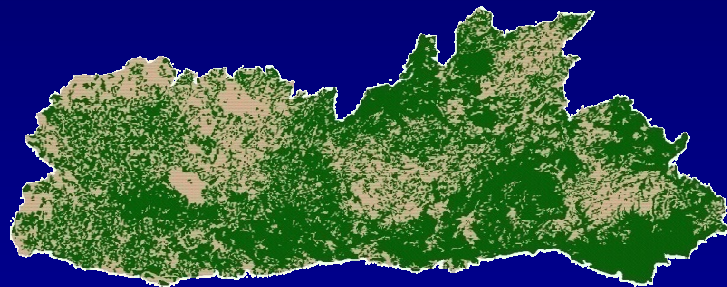
1975



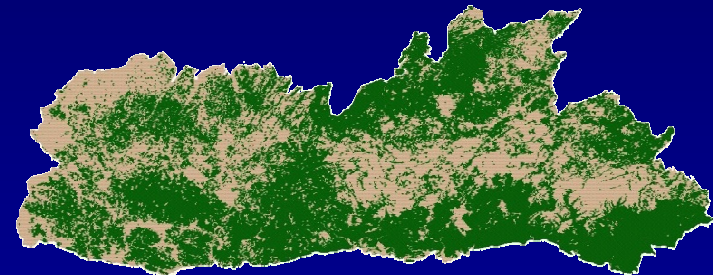
1980



1989

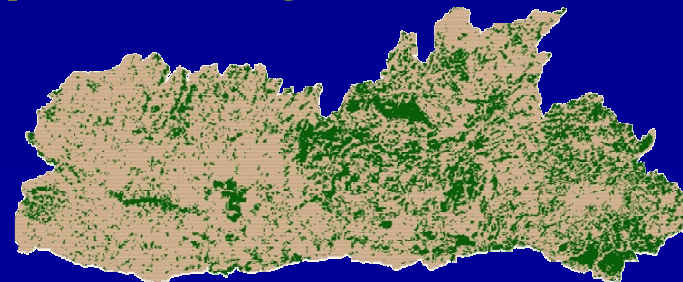


1995



2000

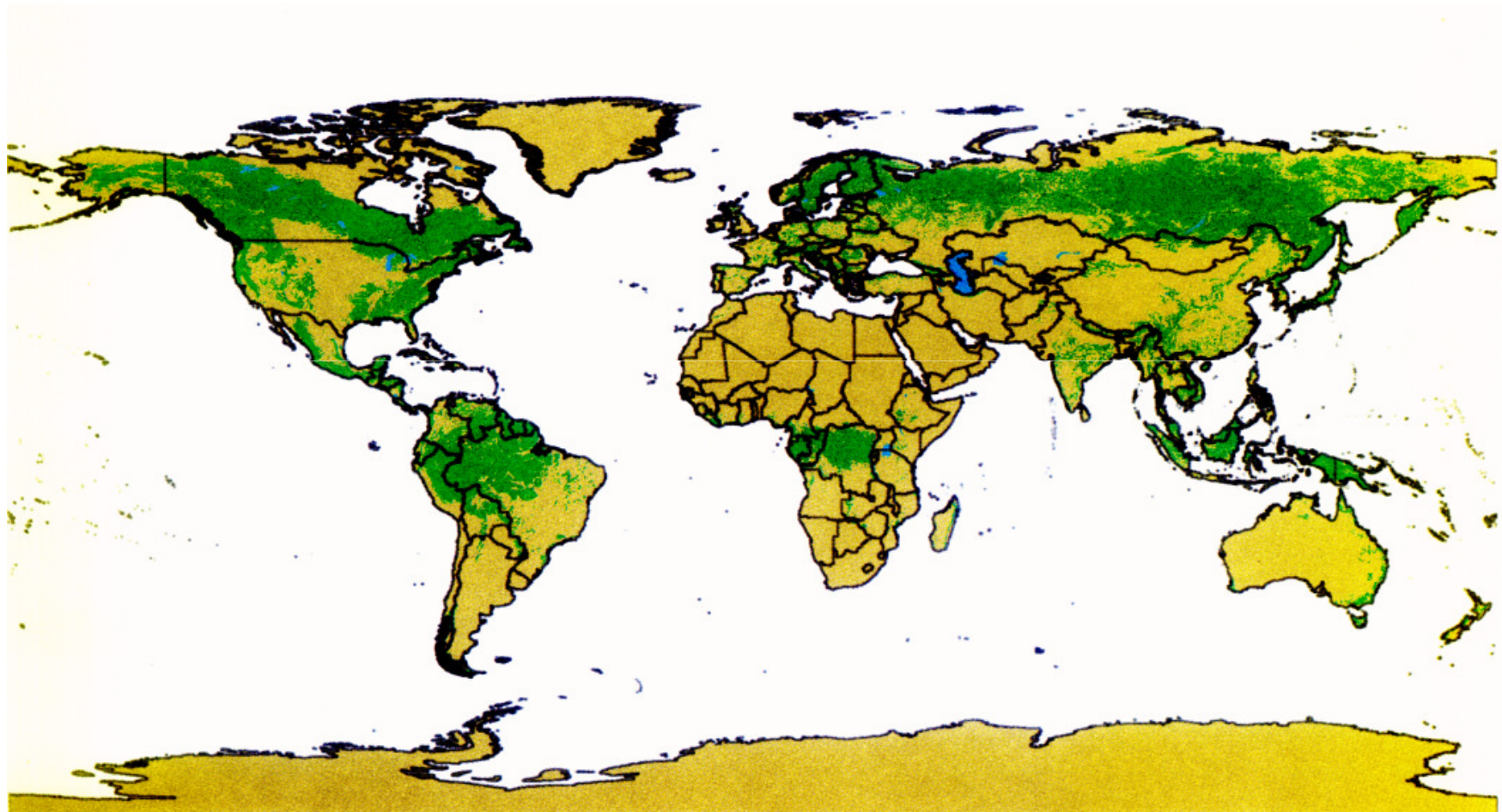
Spatial Regression Model



2050

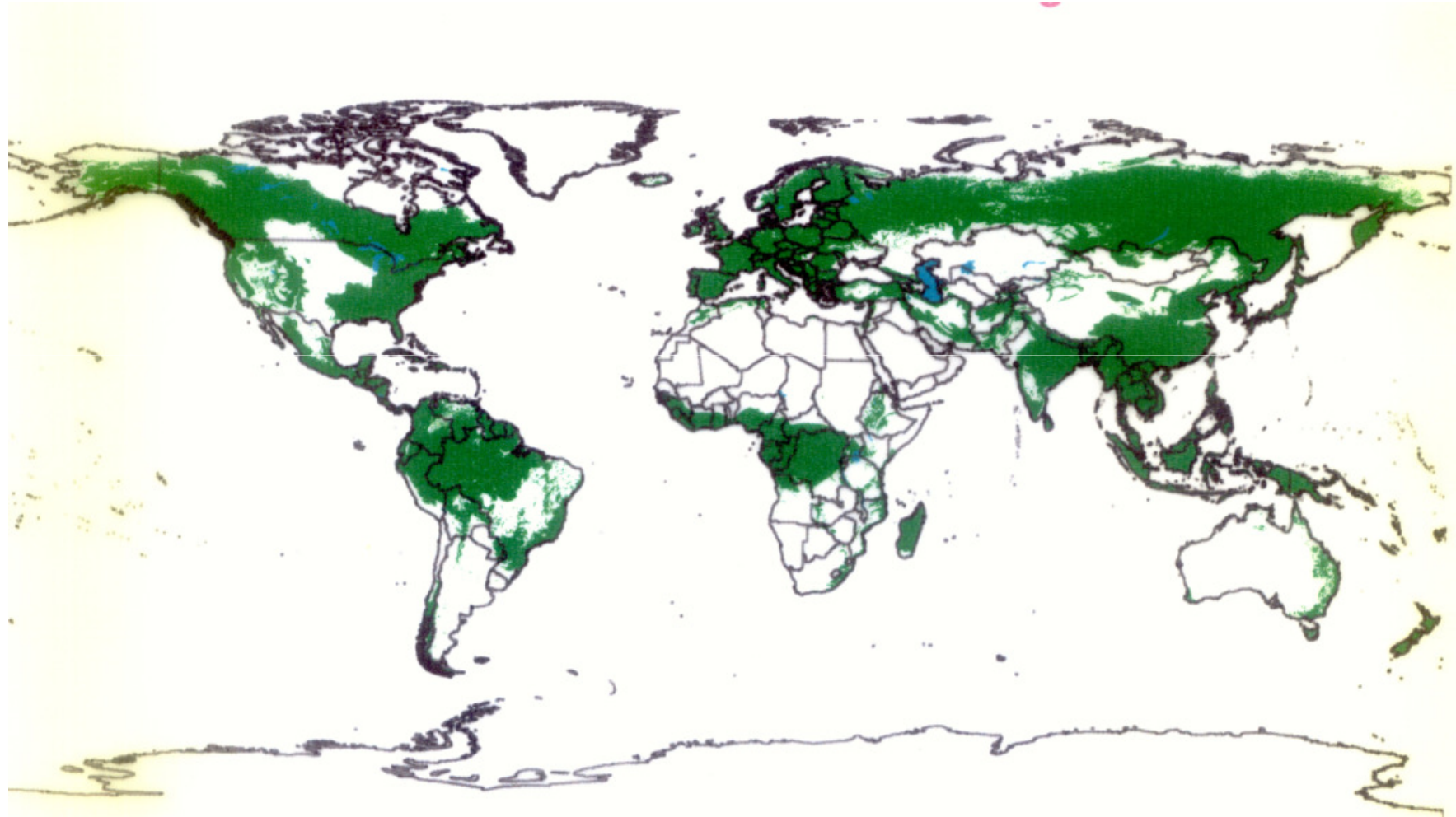
Non-Forest
Forest

Global Forest Cover Today



Global Forest Cover 8000 Years Ago

Backward Modelling



Soil, Vegetation-Atmosphere Carbon Flux Monitoring



Flux Tower

Flux Tower Sites

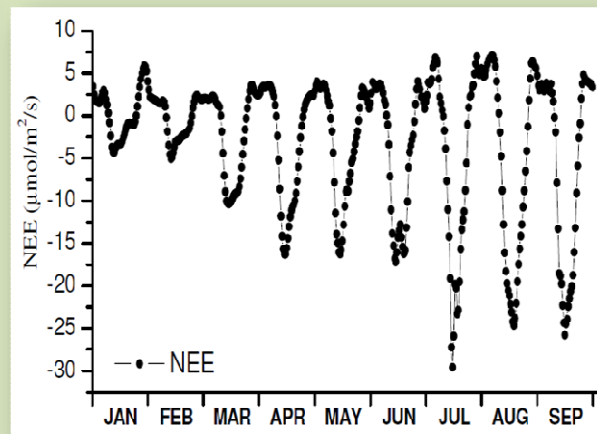


National Carbon Project (ISRO-GBP)

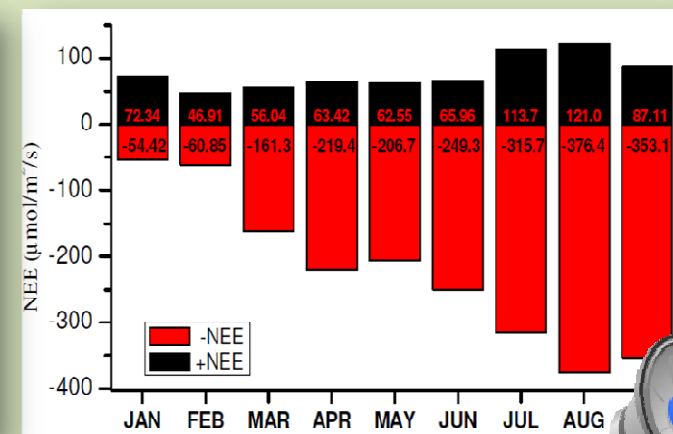
Under the National Carbon Project, the exchange of CO_2 , water and energy between vegetation and atmosphere is being monitored at two flux towers sites located in mixed forest plantation in Haldwani and moist sal forest in Barkot in Doon valley. Results indicate that Haldwani plantation is sink of carbon.

Carbon Flux Monitoring in a Mixed Forest Plantation at Haldwani, Nainital

Mean Monthly Diurnal NEE



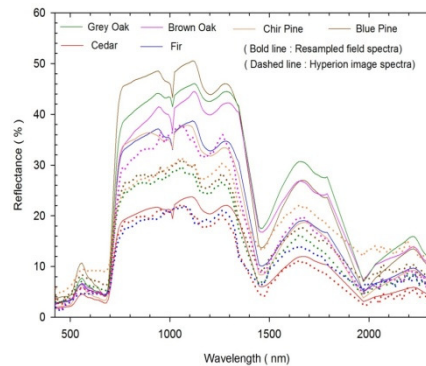
Mean Monthly Diurnal NEE Budget



Hyperspectral Remote Sensing

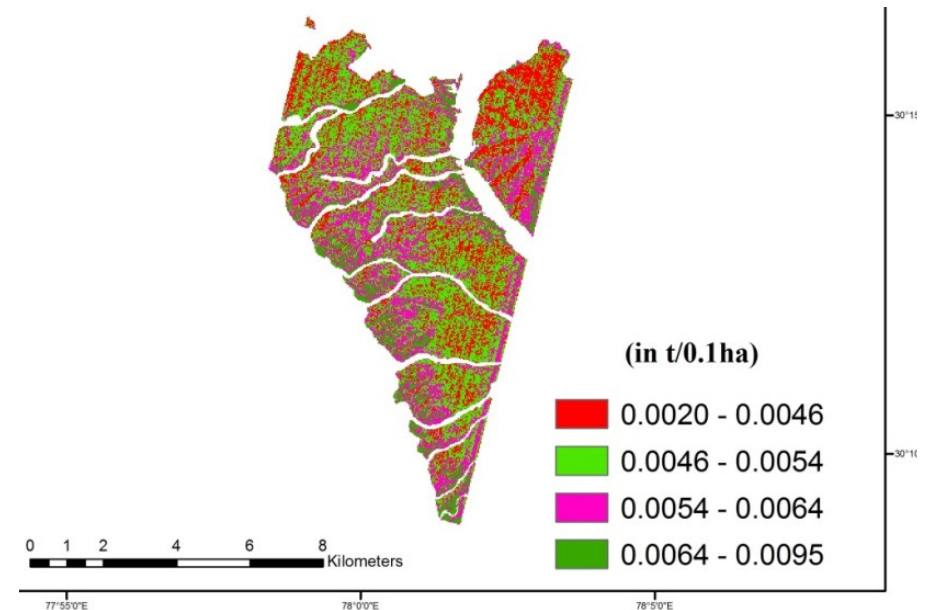
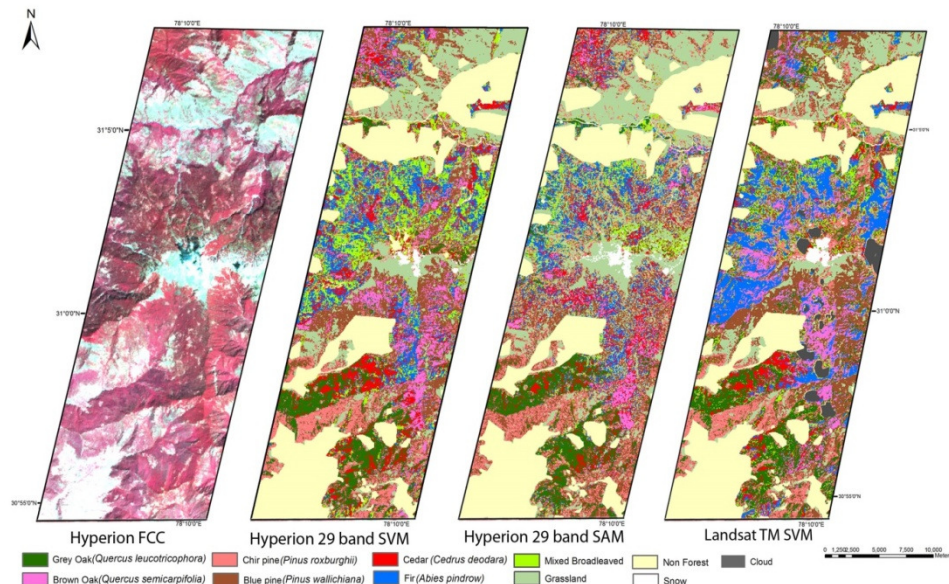
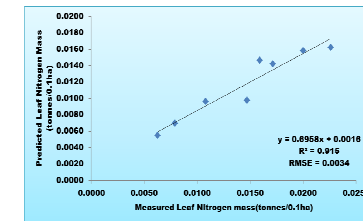
Tree Species Discrimination

Gregarious broadleaved and coniferous forest tree species of western Himalaya were effectively discriminated applying support vector machine (SVM) algorithm (overall accuracy 82.27%) on optimally selected 29 EO-1 Hyperion bands.



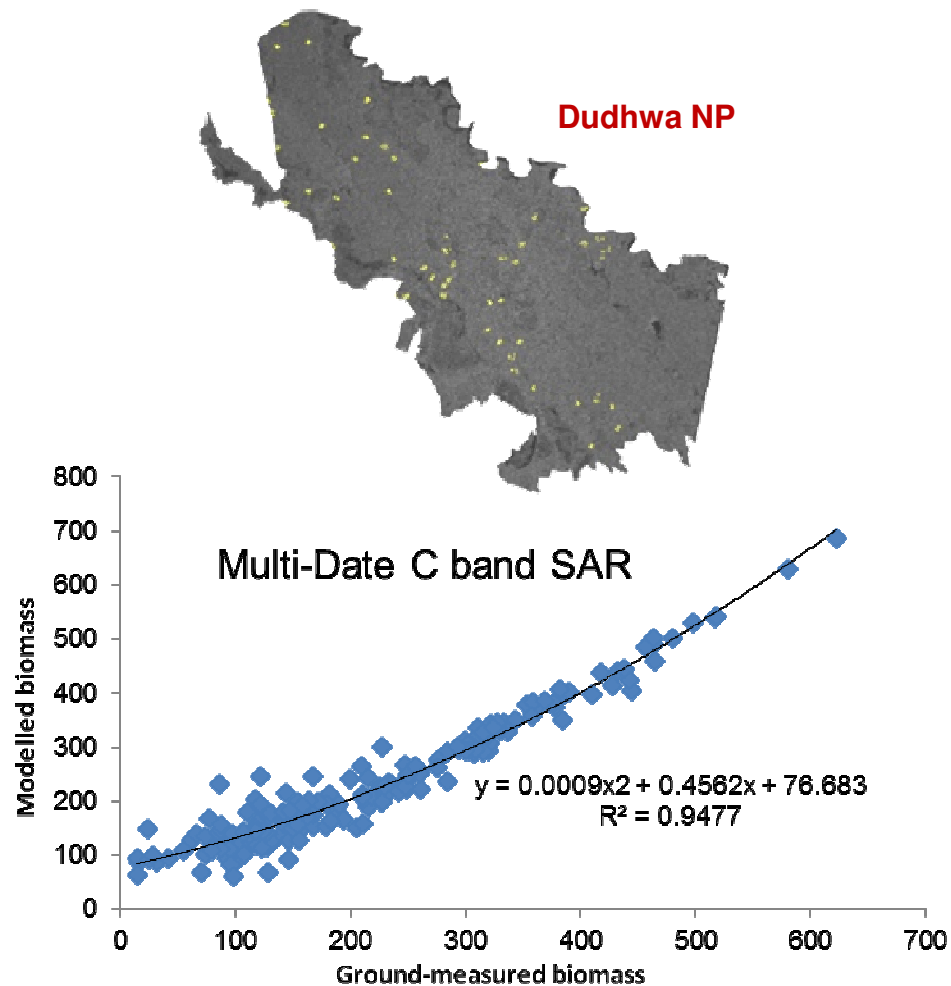
Estimation of Foliar Nitrogen

Estimation of foliar Nitrogen of Moist Sal forest in Doon valley was attempted using Hyperion. 1510nm is associated with Nitrogen absorption. Log Normalized NDNI performed better than other indices.



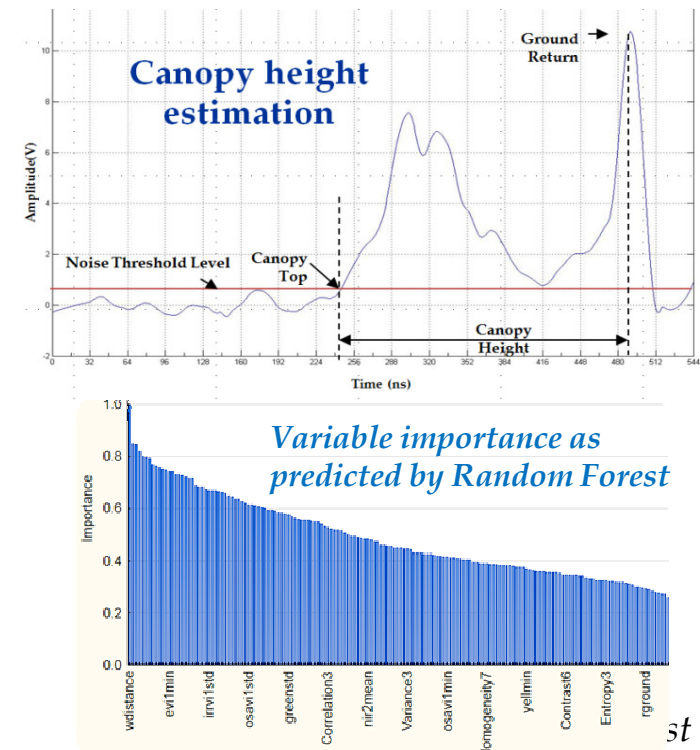
Forest Biomass/Carbon Assessment

Interferometry and Water Cloud Model



High forest biomass density (>200 ton/ha) was effectively modelled using semi-empirical Interferometry & Water Cloud Model (IWCM) in Dudhwa N.P., U.P.

Spaceborne LiDAR (ICESat GLAS)



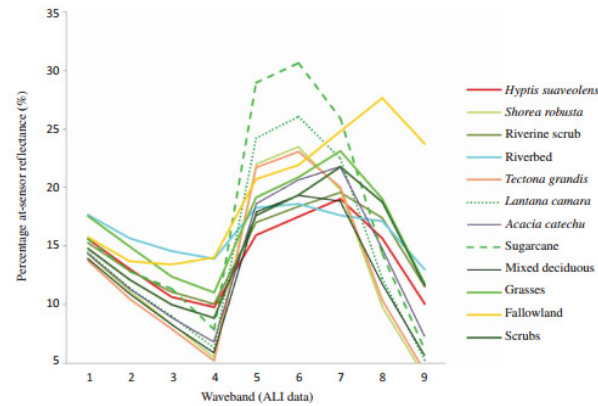
prediction accuracies for forest biomass estimation

Dataset	SVM R ² value	RF R ² value
Lidar (ICESat)	0.699	0.687
WorldView-2 Spectral	0.601	0.594
WorldView-2 Texture	0.515	0.665
Combined	0.887	0.835

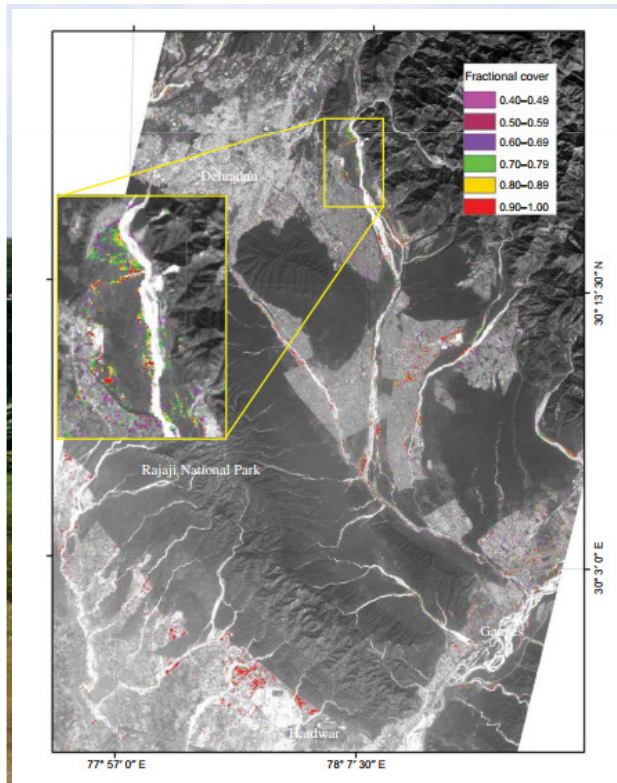
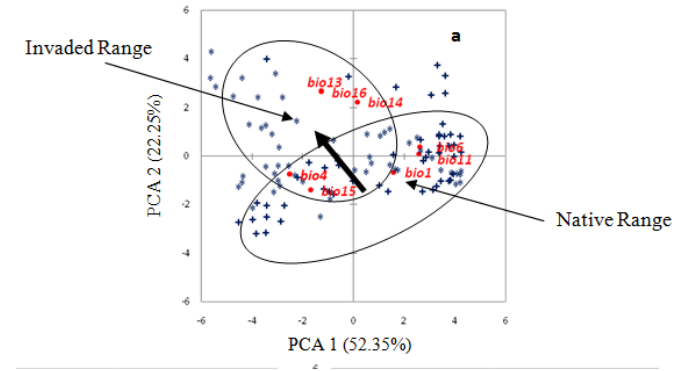
Mapping and Modelling Distribution of Exotic Invasive Weeds



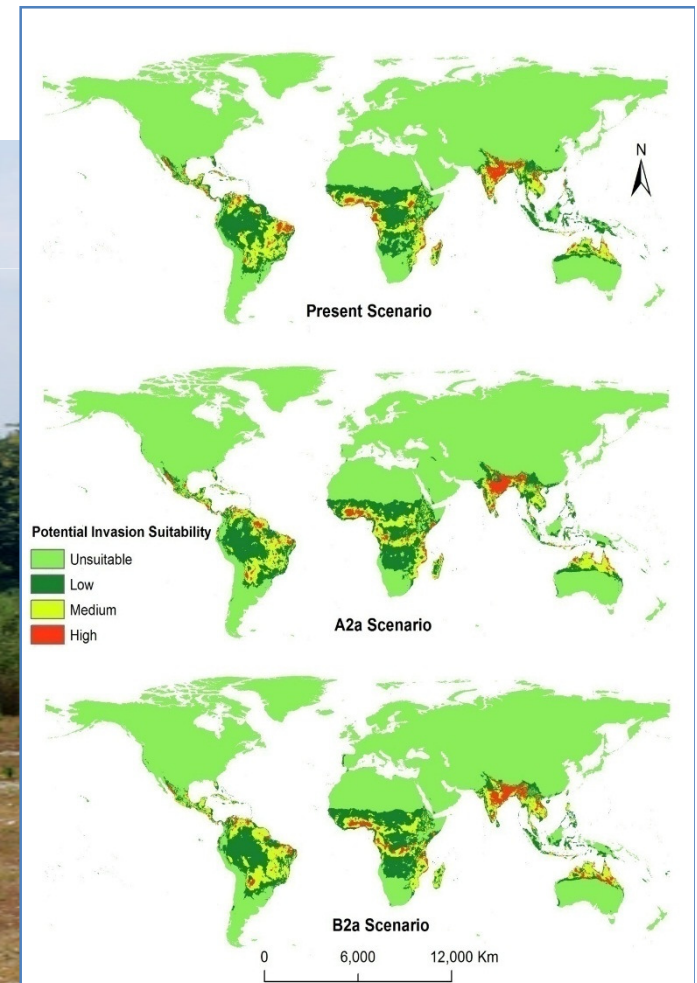
H. Suaveolens (Vilayati Tulsi)



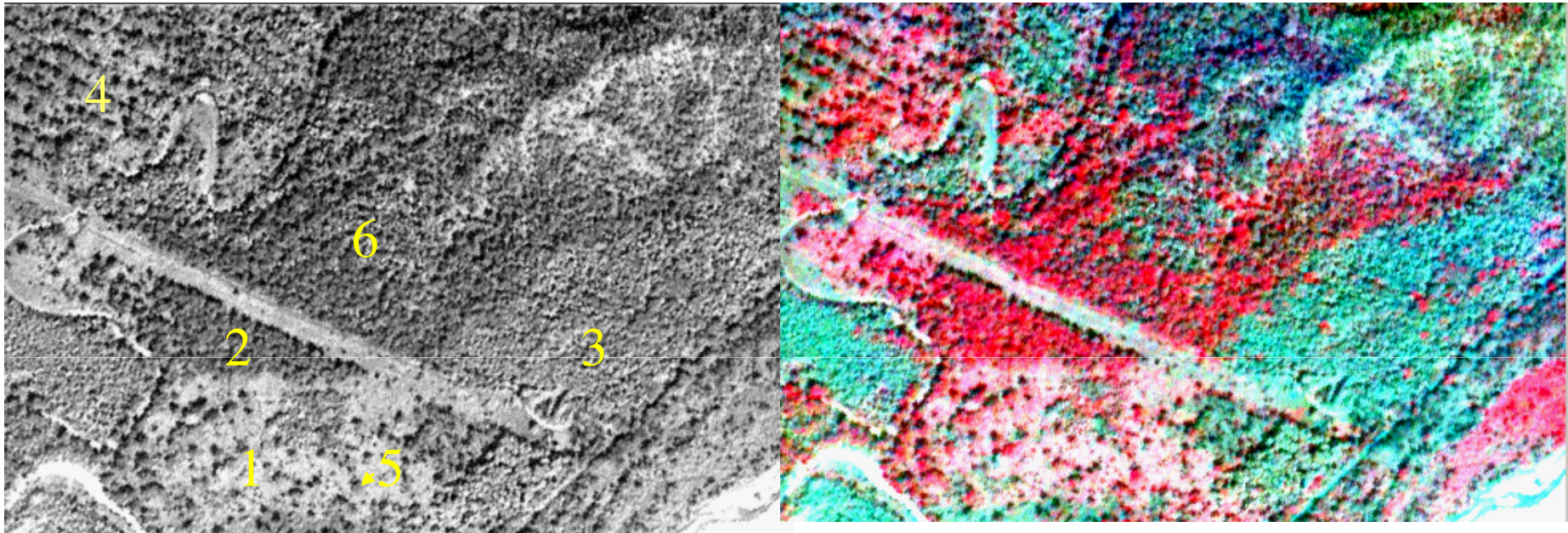
Spectral response in Nov. month



Invasion in part of Doon valley



Monitoring of Lantana in Open and Degraded Forests



**Cartosat-1 Ortho Image
(10.10. 2005)**

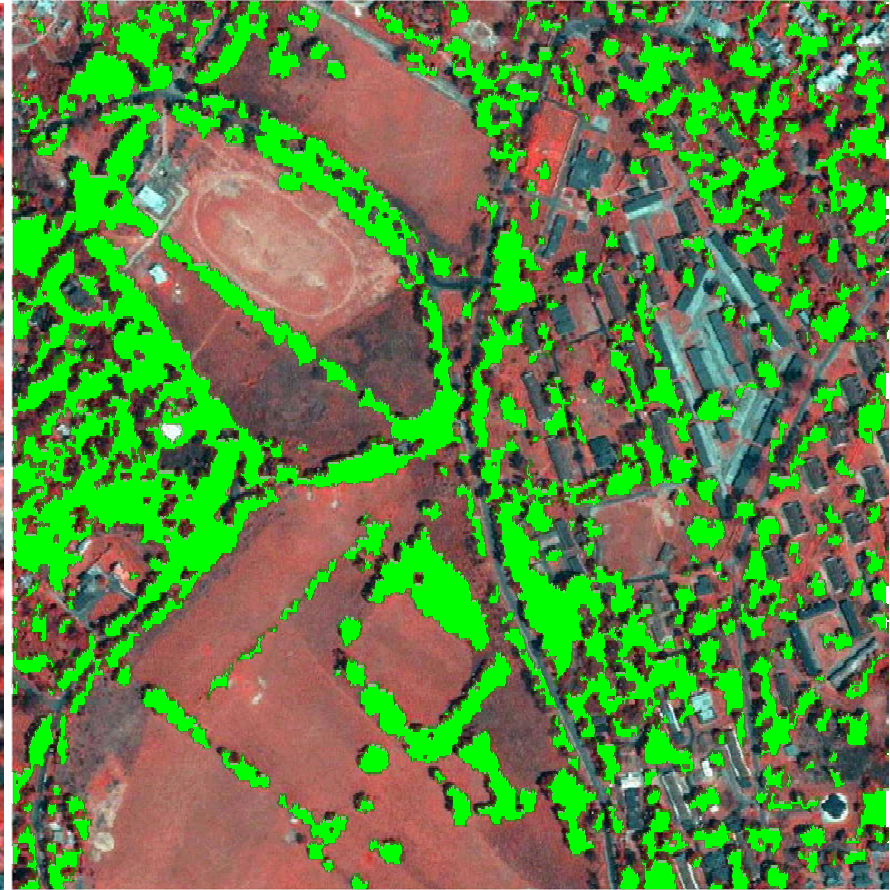
**Cartosat-1+ LISS-IV
Merged (11.04.2004)**

**1. Lantana, 2. Sal, 3. Teak, 4. Forest Depot,
5. Ficus, 6. Sal mixed**

Emerging Remote Sensing Tools

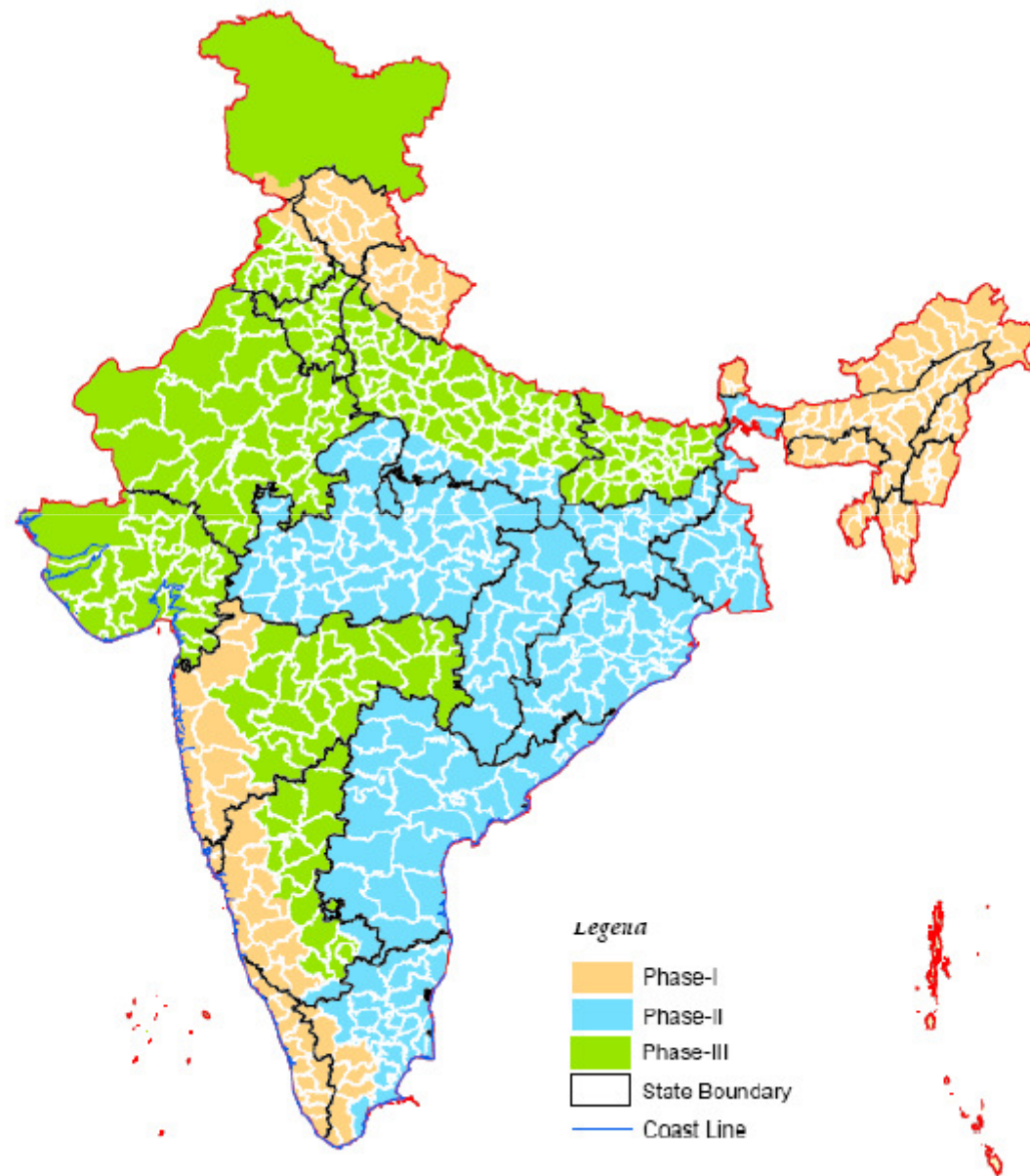


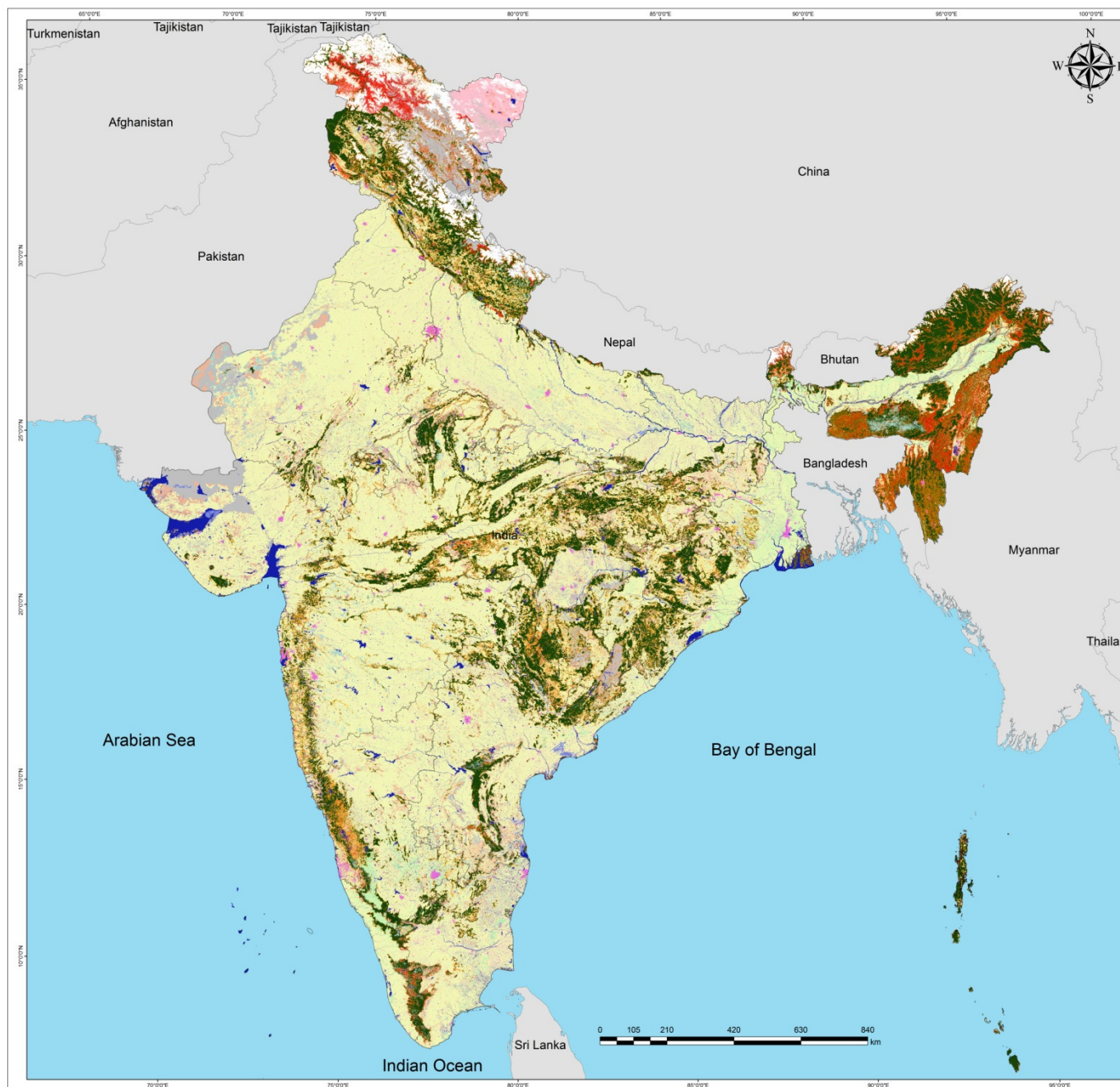
**IKONOS Image of Part
of the Doon Valley**



**Avenue Tree Mapping
using Image Segmentation**

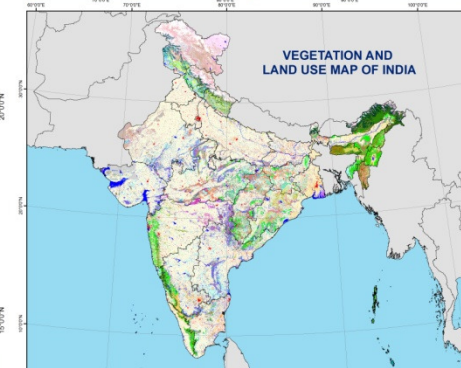
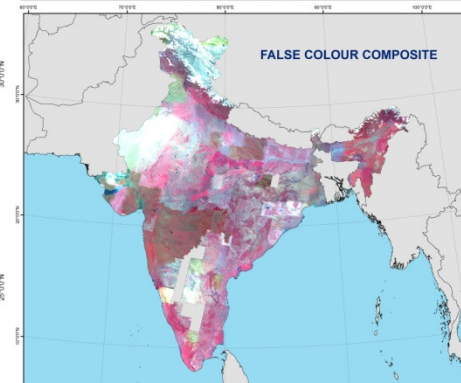
Biodiversity Project in India (1998-2010)





FRAGMENTATION AND LAND USE MAP OF INDIA

Projection - Lambert Conformal Conic
 Spheroid - WGS84
 Datum - WGS84
 Latitude of 1st standard parallel - 35:10:22.096000 N
 Latitude of 2nd standard parallel - 12:28:22.638000 N
 Longitude of central meridian - 80:00:00.00 E
 Latitude of origin of projection - 24:00:00.00 E
 False easting at central meridian - 4000000
 False northing at origin - 4000000



Biodiversity Characterization at Landscape Level

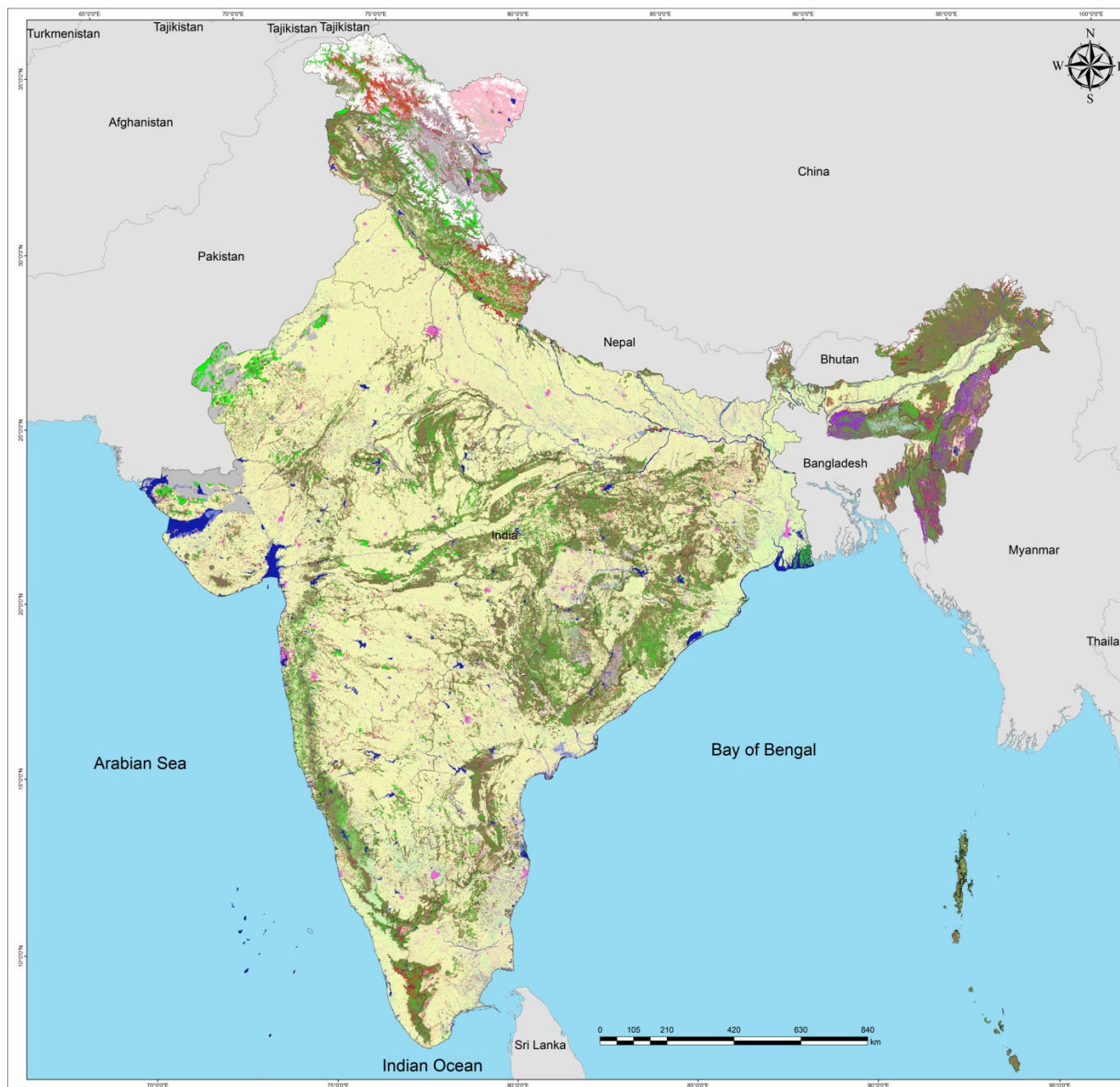
Sponsored by



Indian Institute of Remote Sensing &
 National Remote Sensing Centre
 Indian Space Research Organisation
 Dept. of Space, Govt. of India

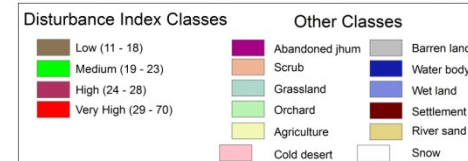
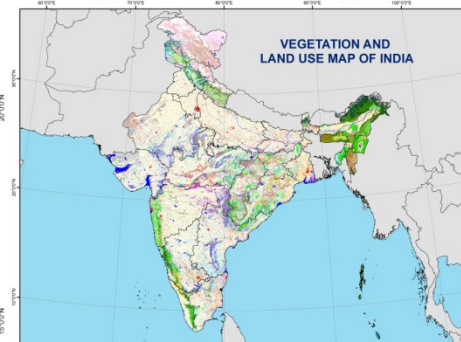
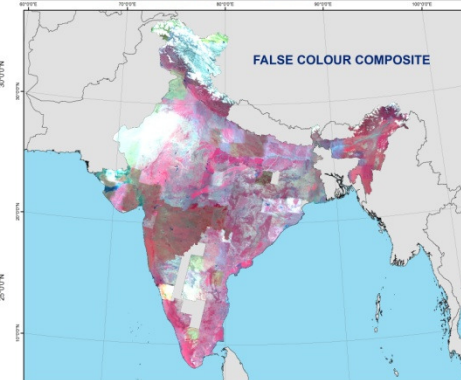


&
 Department of Biotechnology (DBT),
 Govt. of India



DISTURBANCE INDEX AND LAND USE MAP OF INDIA

Projection - Lambert Conformal Conic
 Spheroid - WGS84
 Datum - WGS84
 Latitude of 1st standard parallel - 35:10:22.096000 N
 Latitude of 2nd standard parallel - 12:28:22.638000 N
 Longitude of central meridian - 80:00:00.00 E
 Latitude of origin of projection - 24:00:00.00 E
 False easting at central meridian - 4000000
 False northing at origin - 4000000



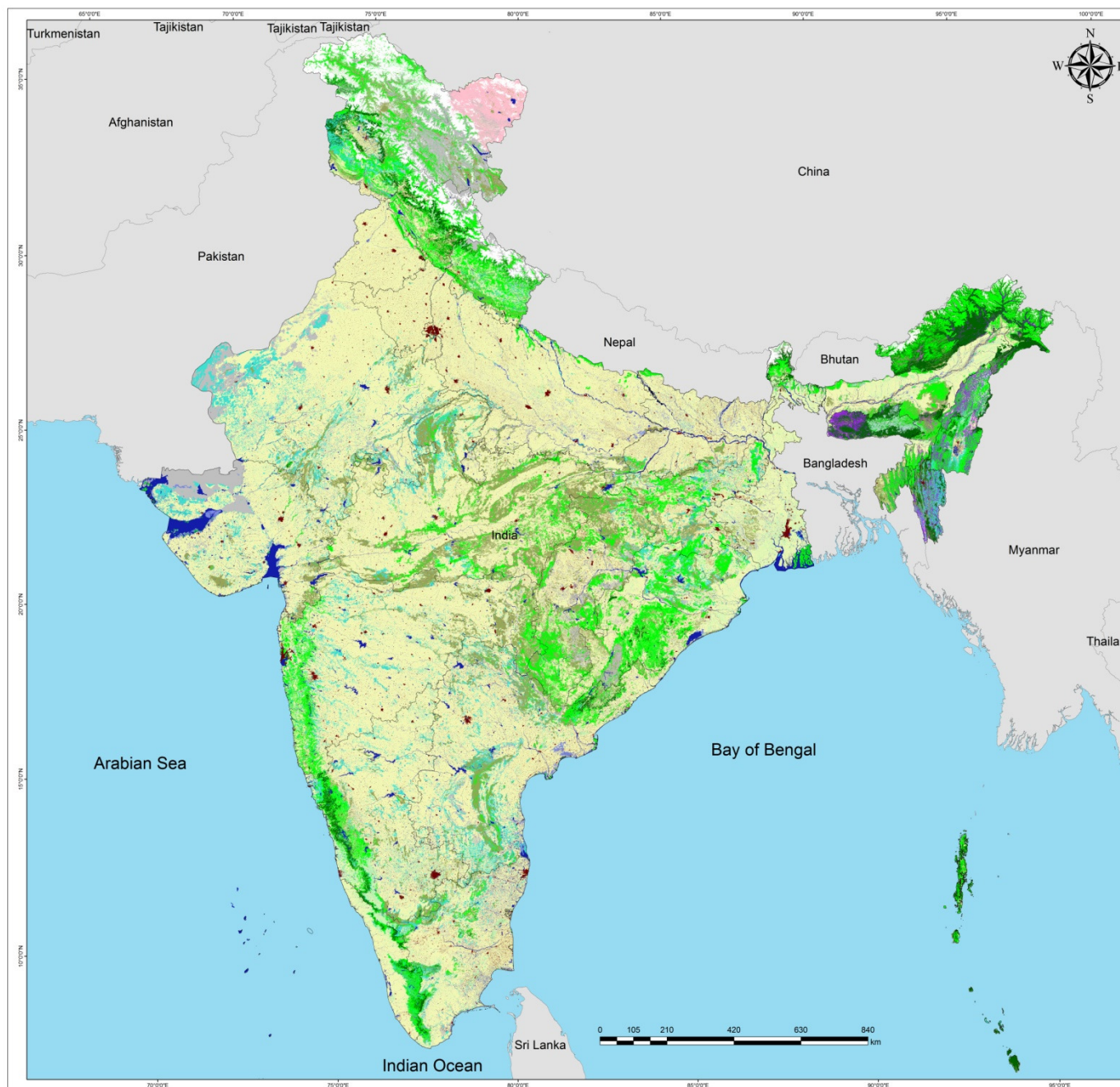
Biodiversity Characterization at Landscape Level

Sponsored by



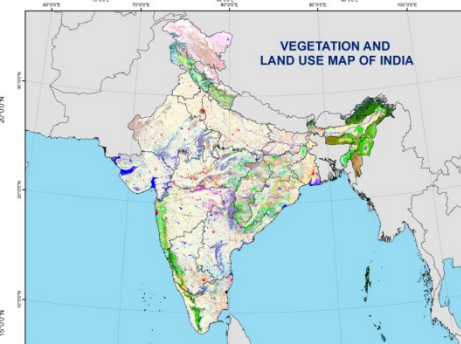
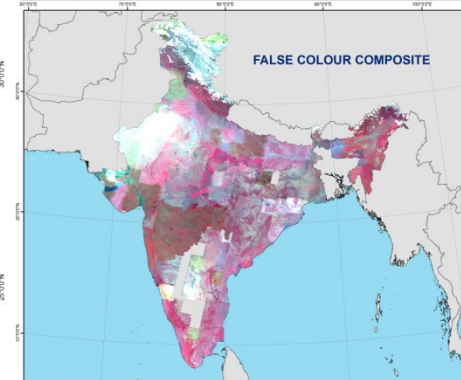
Indian Institute of Remote Sensing &
 National Remote Sensing Centre
 Indian Space Research Organisation
 Dept. of Space, Govt. of India

&
 Department of Biotechnology (DBT),
 Govt. of India



BIOLOGICAL RICHNESS AND LAND USE MAP OF INDIA

Projection - Lambert Conformal Conic
 Spheroid - WGS84
 Datum - WGS84
 Latitude of 1st standard parallel - 35:10:22.096000 N
 Latitude of 2nd standard parallel - 12:28:22.638000 N
 Longitude of central meridian - 80:00:00.00 E
 Latitude of origin of projection - 24:00:00.00 E
 False easting at central meridian - 4000000
 False northing at origin - 4000000



Biological Richness Classes

- Low (17 - 33)
- Medium (34 - 49)
- High (50 - 69)
- Very High (70 - 90)

Other Classes

- Abandoned jhum
- Scrub
- Grassland
- Orchard
- Agriculture
- Cold desert
- Barren land
- Water body
- Wet land
- Settlement
- River sand
- Snow

Biodiversity Characterization at Landscape Level

Sponsored by



Indian Institute of Remote Sensing &
 National Remote Sensing Centre
 Indian Space Research Organisation
 Dept. of Space, Govt. of India



&
 Department of Biotechnology (DBT),
 Govt. of India

Biodiversity Information System (BIS)

BIODIVERSITY INFORMATION SYSTEM SPATIAL QUERY FAQ ABOUT US SEARCH HOME 10:12:12 P.M.

System for Biodiversity Conservation

PROJECT BACKGROUND
An effort to characterise vegetation cover, fragmentation, disturbance and biological richness across the landscape is organised in the form of Biodiversity Information System (BIS). More...

BIODIVERSITY REVIEW
What is biodiversity? It is the sum of all life on Earth. Just think about the millions of species of animals (including humans!), plants and micro-organisms. More...

BIODIVERSITY LINKS
A repository of website and portal addresses, which render any information regarding Biodiversity and its related streams. More...

phyto sis
species information system

friss
Forest Resource Information System

BioSPATIAL
Spatial Query Shell for Biodiversity Characterisation

biospec
Bioprospecting Query Shell

BioCon SDSS
Biodiversity Conservation Prioritisation

BIS
biodiversity information System

<https://bis.iirs.gov.in>

iirs

Indian Bio-resources Information Network (IBIN)

Welcome to Indian Bioresource Information Network - IBIN - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites RSS Feeds Customize this toolbar Highlight

Search the Web Search Address http://www.ibin.co.in/

Google biospatial.bisindia.org Go RS Bookmarks 192 blocked Check AutoLink AutoFill Send to biospatial

Indian Bioresource Information Network

Home Help Site Map

DBT NBDB DATA MAPS NEWS ARTICLES NODES PT'S PREFERENCES WEB DEVELOPMENT

IBIN DATA

- Browse Spatial Data
- Browse BIOSPEC
- Browse Medicinal Plants
- Browse Fish Species
- Browse Amphibia
- Browse Laboratory Animals
- Browse Plants Species
- How To Browse
- Providers
- Data Policy
- Web Map Services (WMS)


RELATED SYSTEM

- Biodiversity Information System
- BIOSPEC Query Shell
- Jeevsampada
- Sasya Sampada
- Matsya Sampada
- Plants Of India
- Plant Species Information System
- FRIS
- Biocons SDSS

HIGHLIGHTS

- Newsletters
- Mailing Lists
- UDDI Registry
- Standards
- Links

Site search: Search



Welcome to Indian Bioresource Information Network

Department of Biotechnology (DBT), Government of India, launched a national level programme to develop a digital database of the bioresource of the country. IBIN is uniquely placed as a single portal data provider on India's bioresource - plant, animal, marine, spatial data and microbial resources. The data sets collated here are the result of the research of over four hundred scientists, working in over 150 institutions for the first time ever, an electronic database was developed using an indigenously developed software application for data access and query on spatial data, plant, animal, marine and microbial resources of the country. All the digital databases were developed with a common basic structure such that they could all be eventually compiled on to a single servicing plot form. There arose a need to offer these Non-spatial data (attribute data) sets on a wide network such that they become available to all the potential end users.

India with unique floristic and faunal richness, their vastness, endemism, heterogeneity and also inaccessibility of large areas has necessitated creation of authentic baseline data on biodiversity. Indian Bioresource Information Network (IBIN) is being developed as a distributed national infrastructure intended to serve relevant information on diverse range of issues of bioresources of the country to a range of end users. It's major goal is to network and promote an open ended, co-evolutionary growth among all the digital databases related to biological resources of the country and to add value to the databases by integration. Indian Bioresource Information Network (IBIN) is designed to serve relevant information on bioresources of the country to professionals involved in bio-prospecting, marketing, protecting bio-piracy and the conservation of bioresources. Thus the network would be a valuable asset for the country's research scientists, bio-resource managers, policy makers, common man, and entrepreneurs and hence is being developed as a one window for information on bioresources of the country.

[Click to read more](#)

IBIN Current Nodes

- National Remote Sensing Agency (NRSA), Hyderabad
- Indian Institute Of Remote Sensing (IIRS), Dehradun
- University Of Agricultural Sciences, Bangalore

Bioresource Data Providers

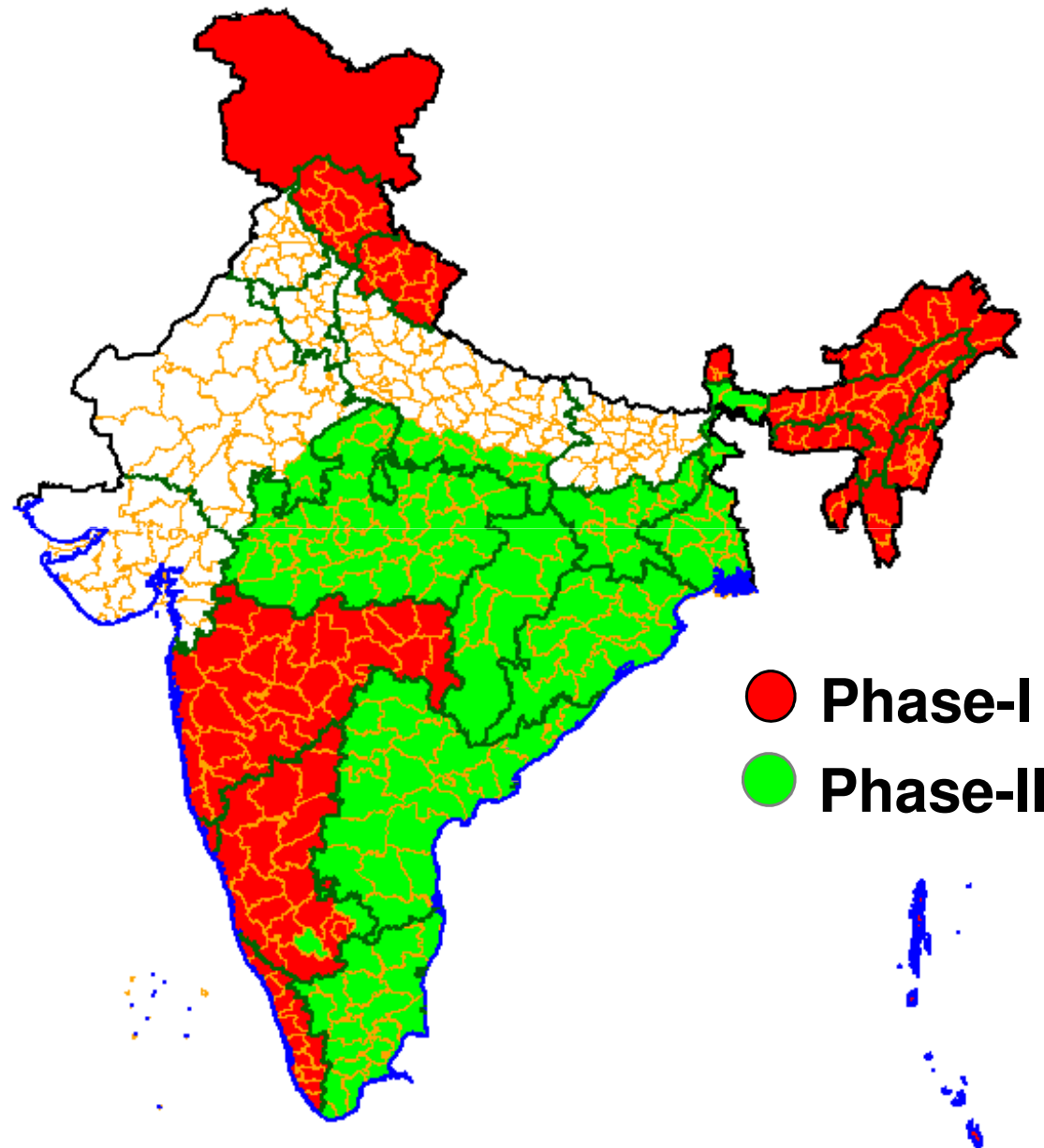
- National Remote Sensing Agency (NRSA), Hyderabad
- Indian Institute Of Remote Sensing (IIRS), Dehradun
- BPMT (DBT Programme) Networking Institutes
- University Of Agricultural Sciences, GKVK, Bangalore
- National Botanical Research Institute (NBRI), Lucknow
- Zoological Survey Of India (ZSI), Kolkata
- Institute Of Microbial Technology (IMTECH), Chandigarh
- Central Marine Fisheries Research Institute (CMFRI), Kochi, Kerala

<https://ibin.gov.in>

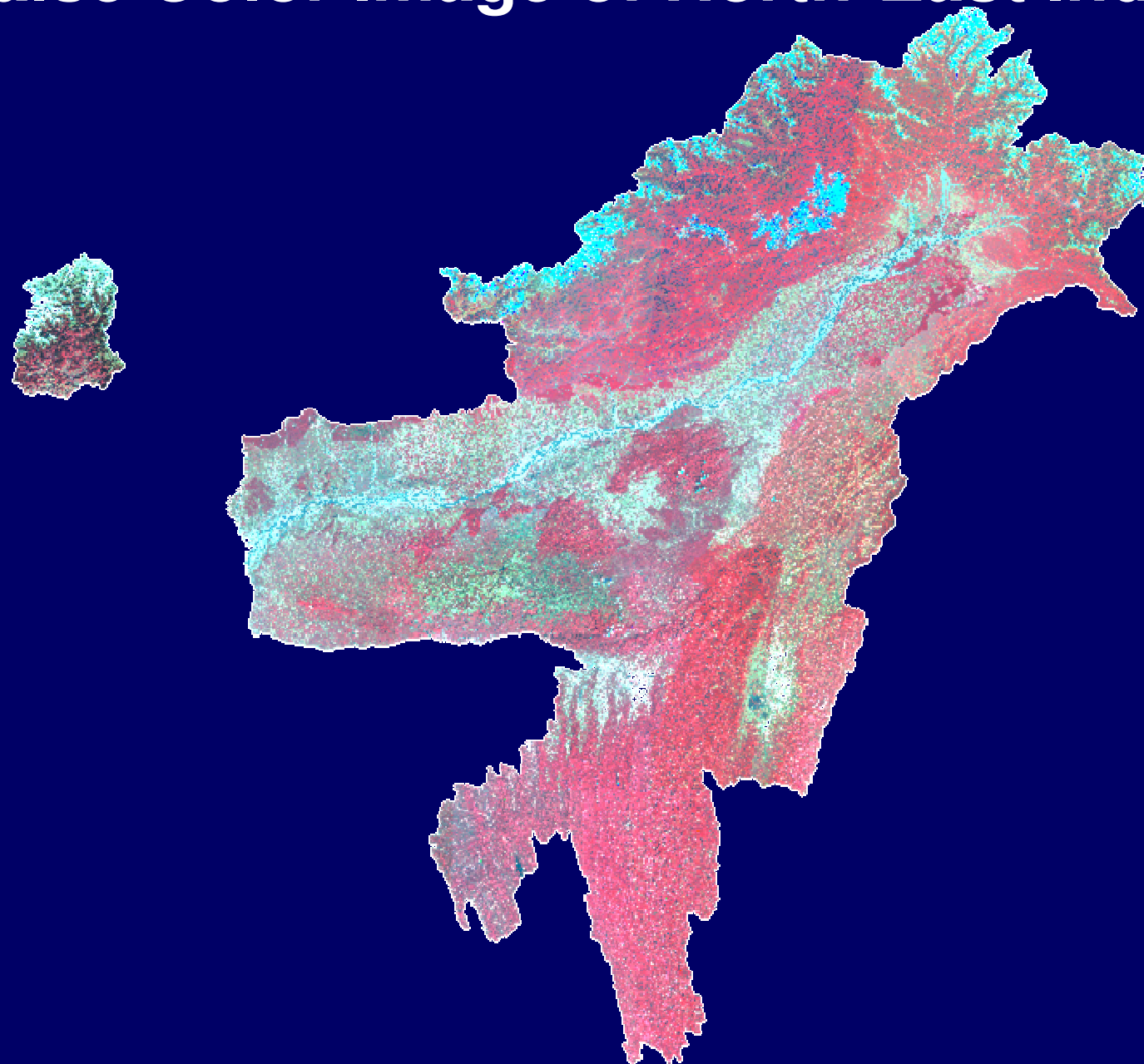
Products and Publications



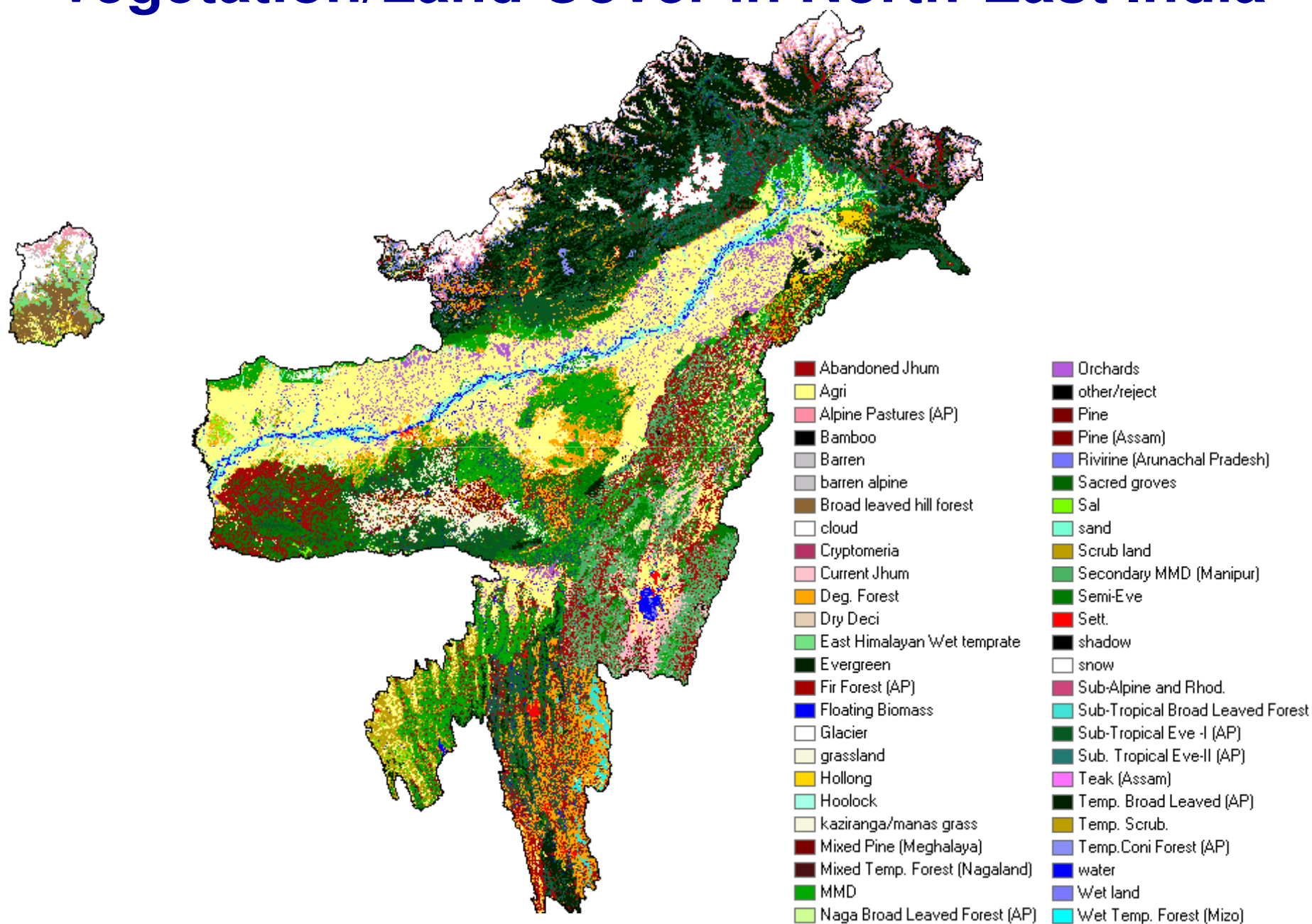
Biodiversity Characterization



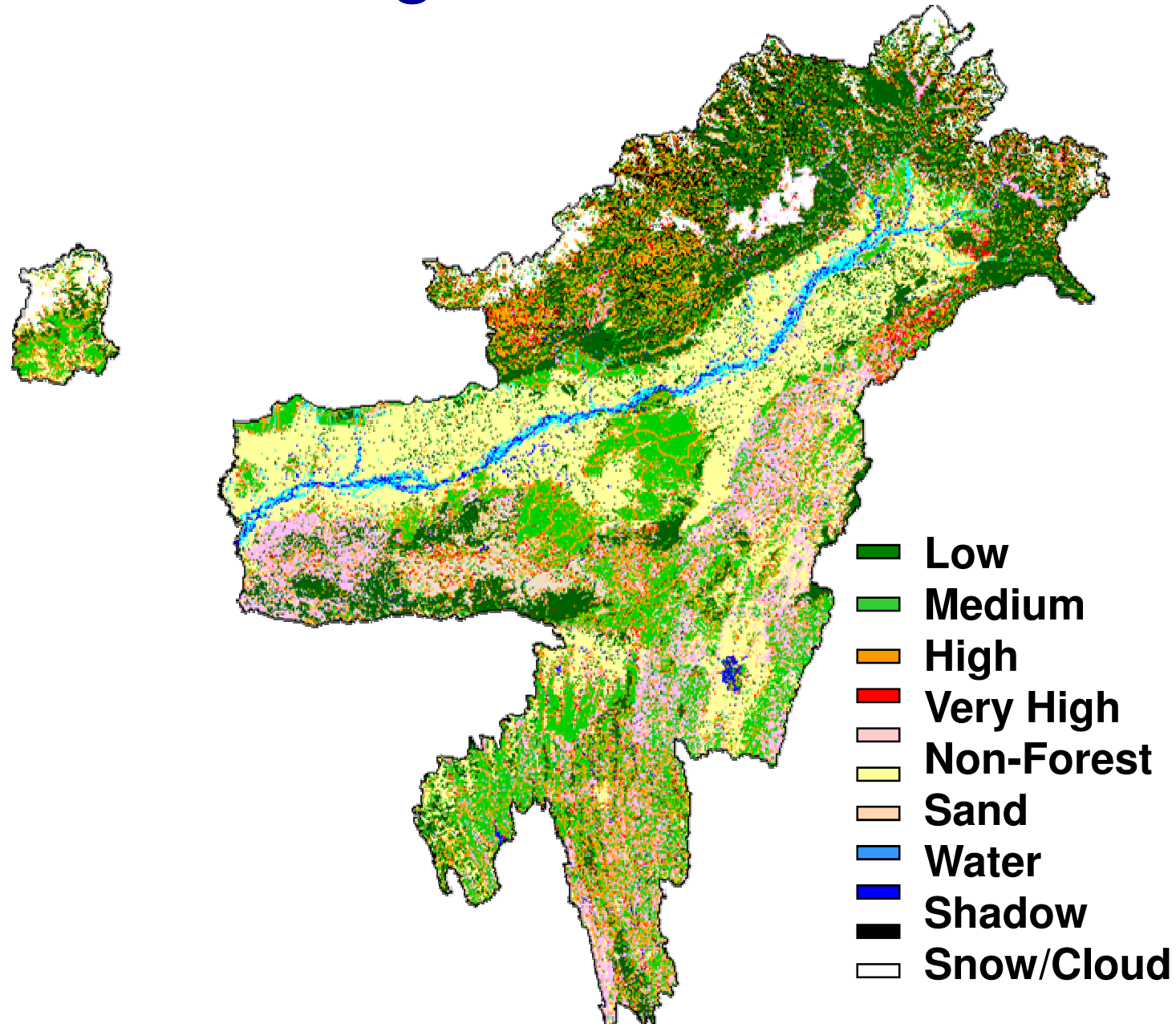
False Color Image of North-East India



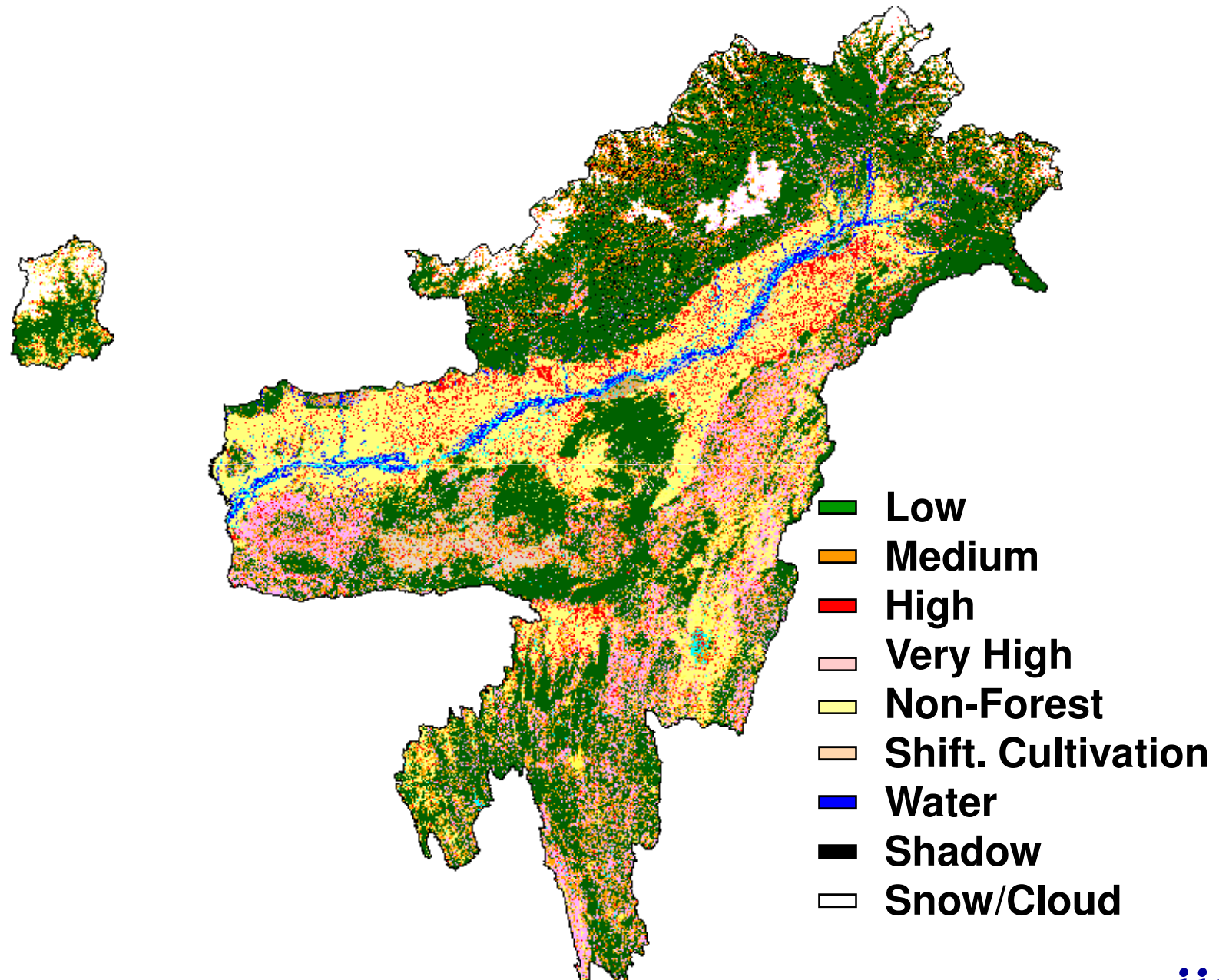
Vegetation/Land Cover in North-East India



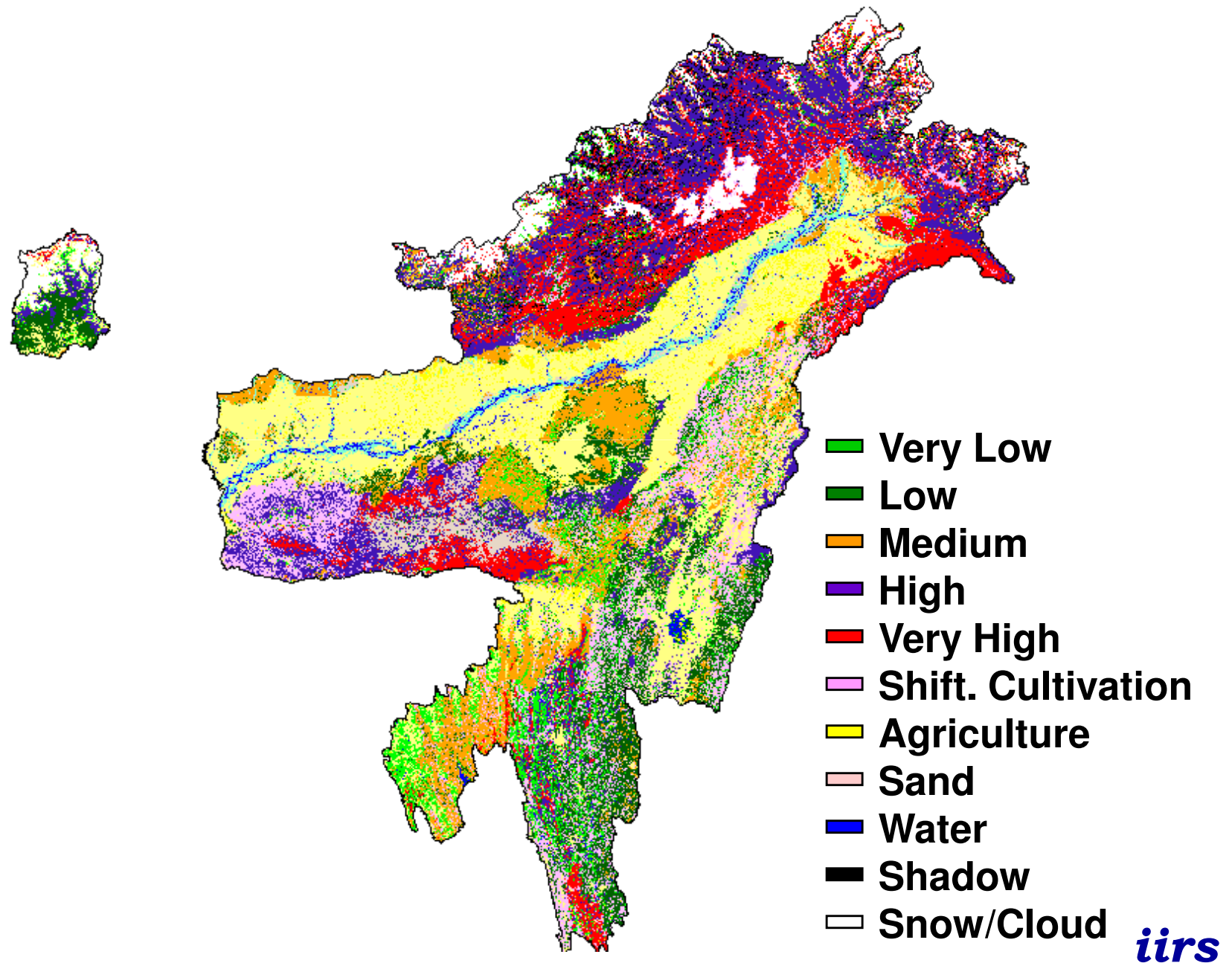
Disturbance Regimes in North-East India



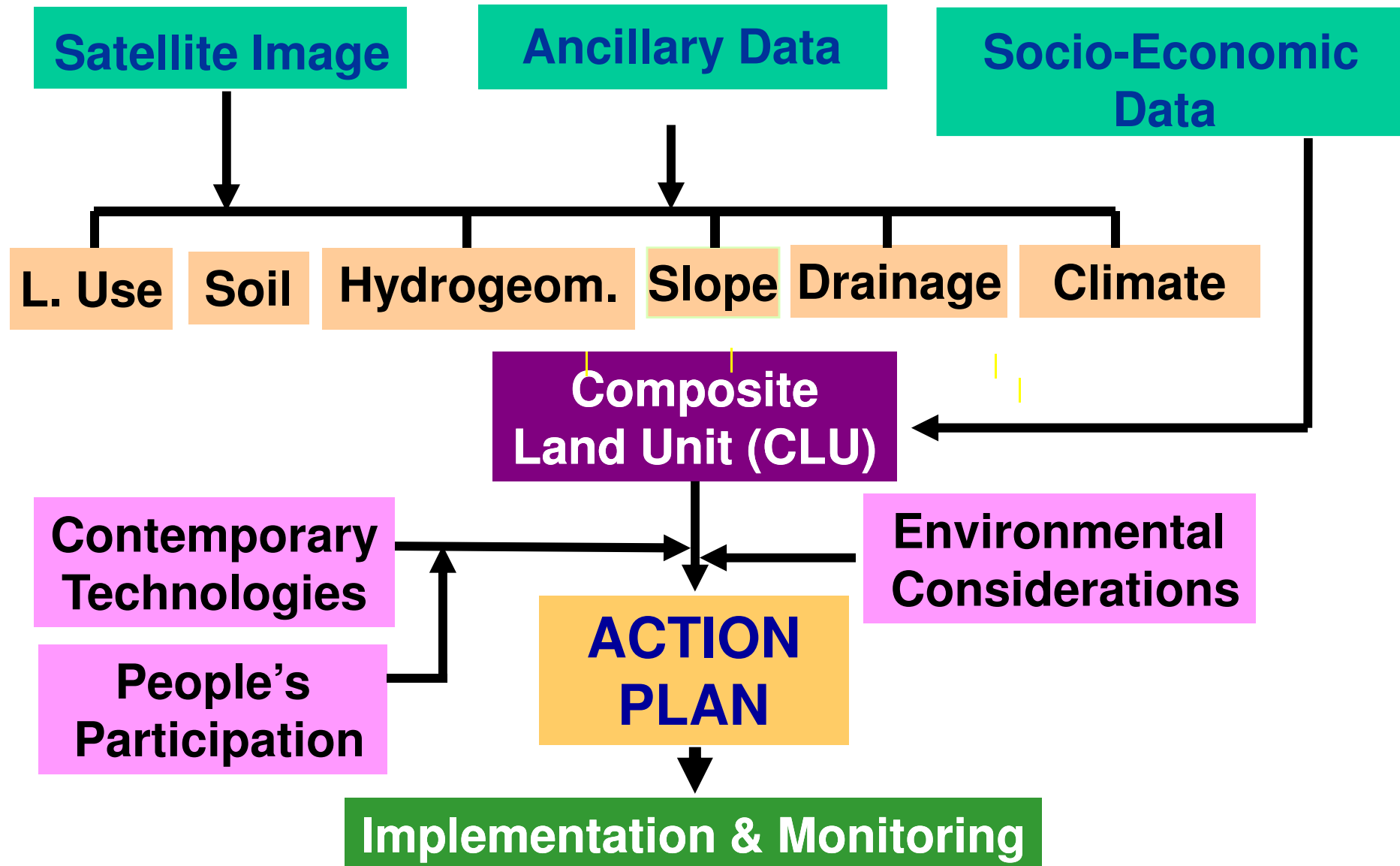
Forest Fragmentation in North-East India



Plant Richness in North-East India

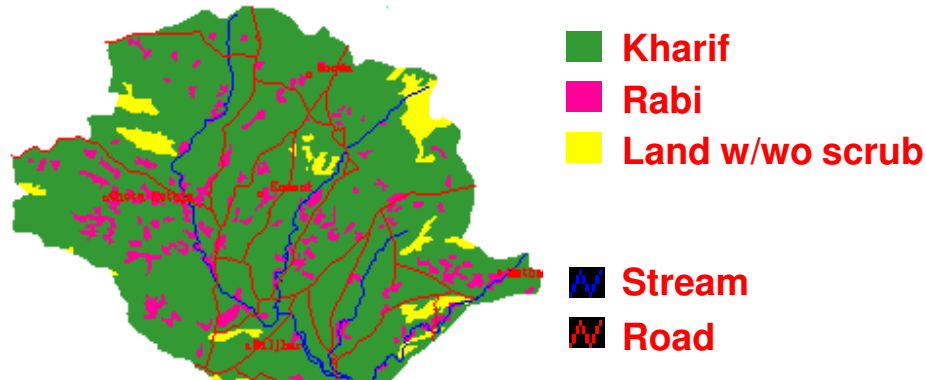


Sustainable Development Planning

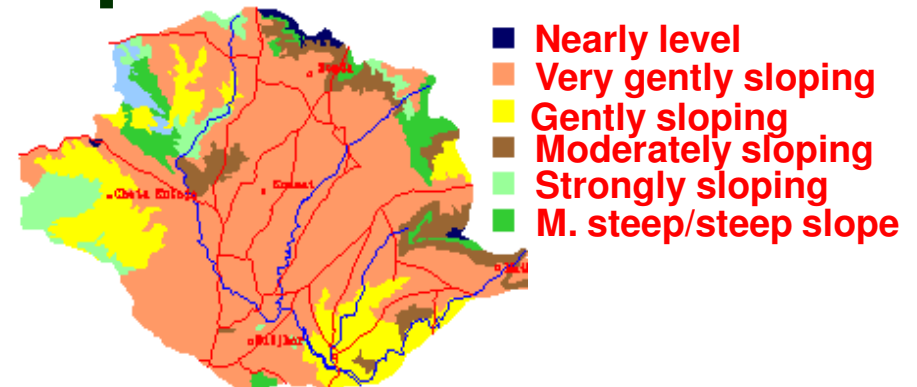


Sustain. Development of U. Hatni W/S, Jhabua

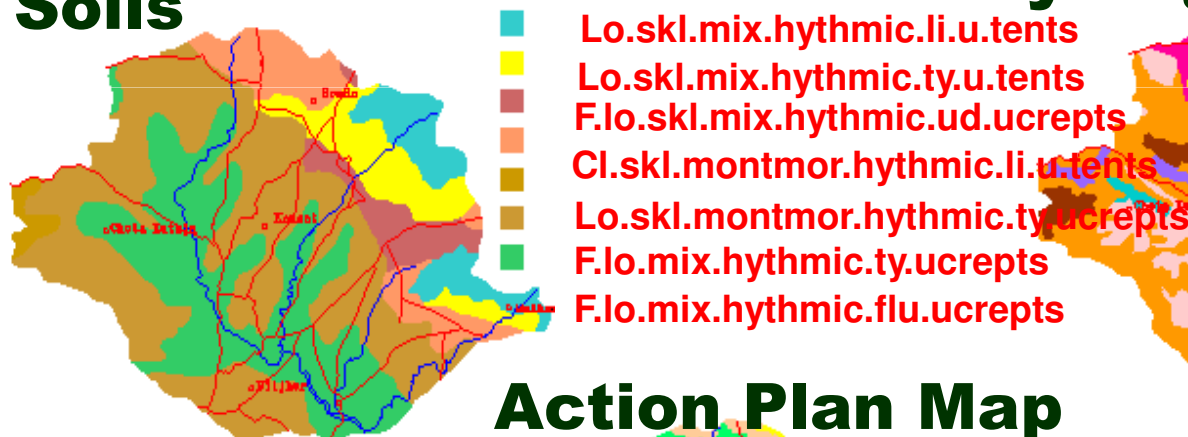
Land Use/Land Cover



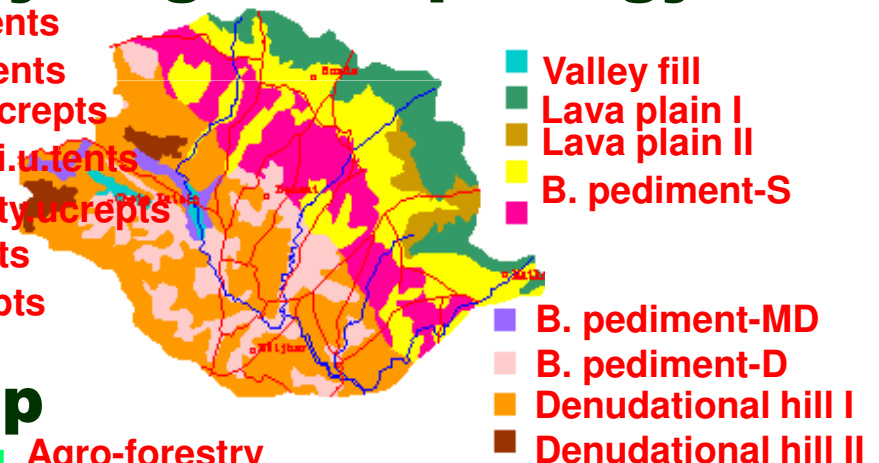
Slope



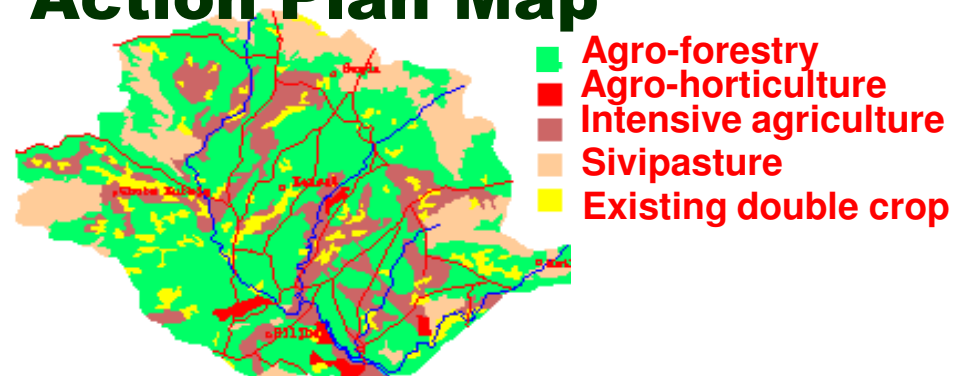
Soils



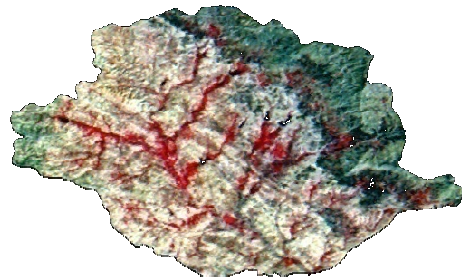
Hydrogeomorphology



Action Plan Map

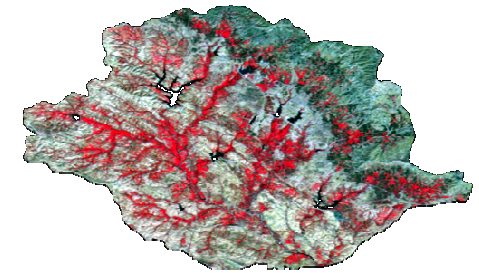


Crop Cover in Upper Hatni from 1992 to 1997

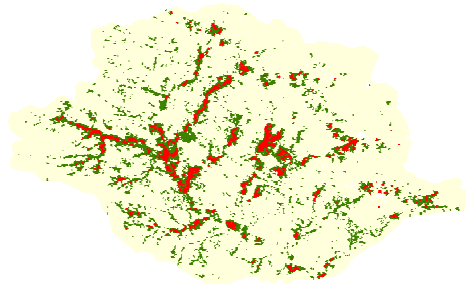


IRS-1B LISS-II (1992)

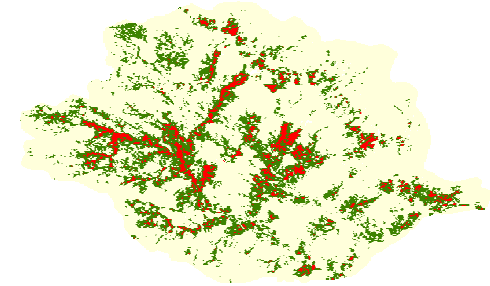
**Vegetation Change (NDVI)
1992-97**



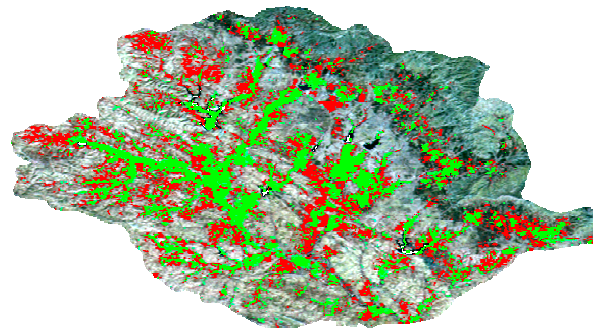
IRS-1C LISS-III (1997)



■ Low density vegetation
■ High density vegetation



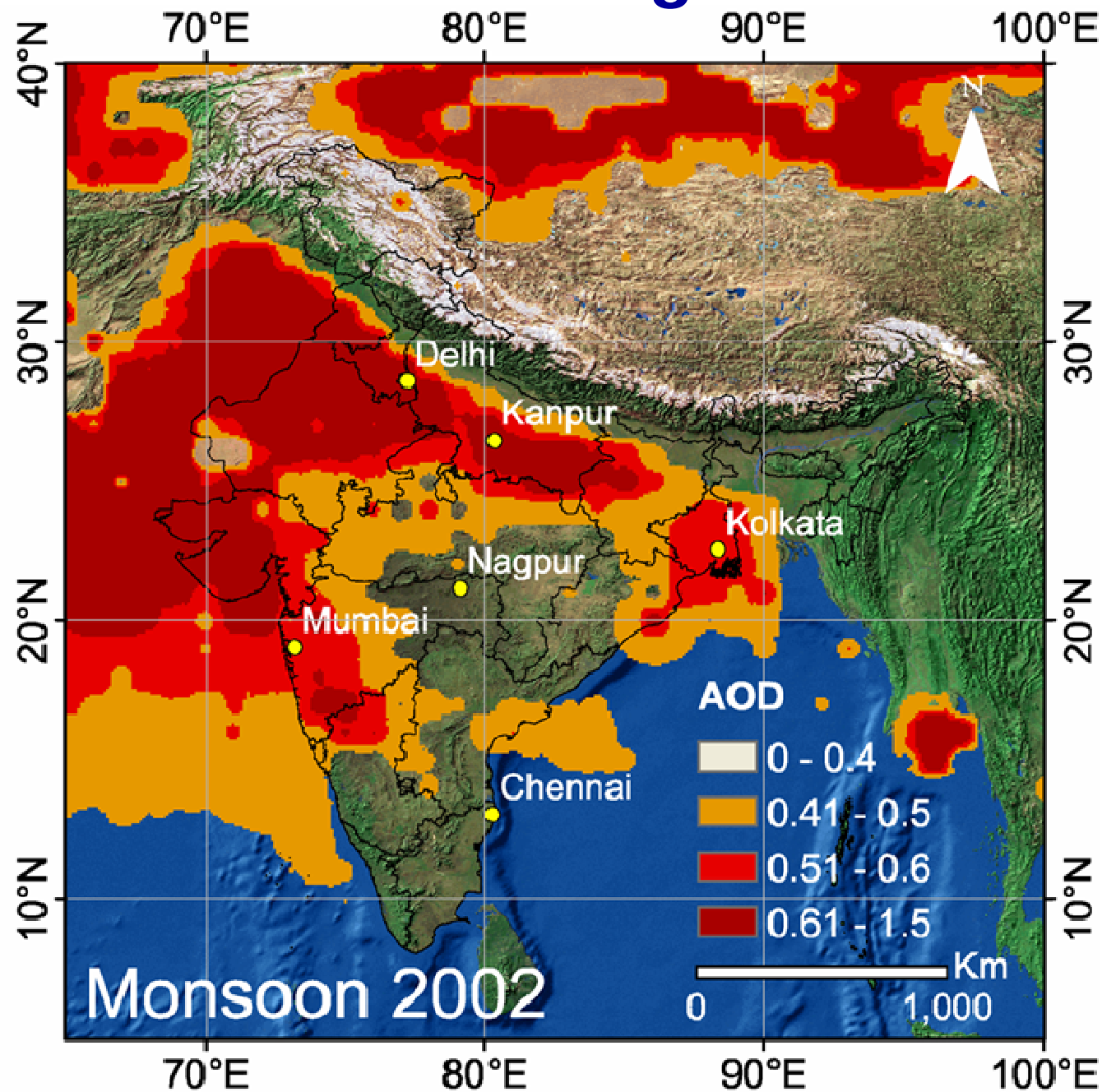
**1992 - 1533 ha
1997 - 2321 ha**



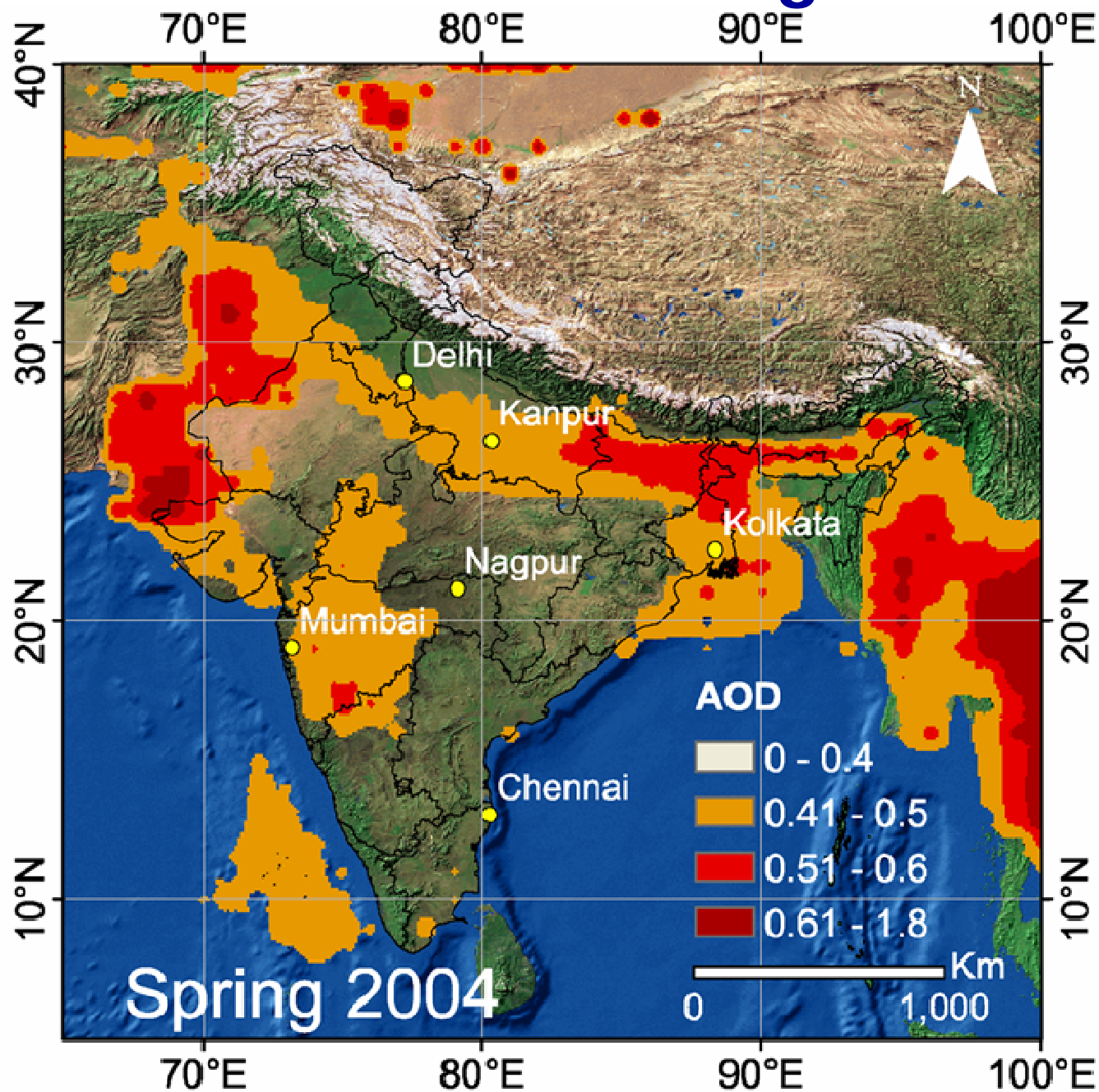
**1992-97: +788 ha
Watershed - 9160 ha**

■ Vegetation in 1992 ■ Increase in Vegetation

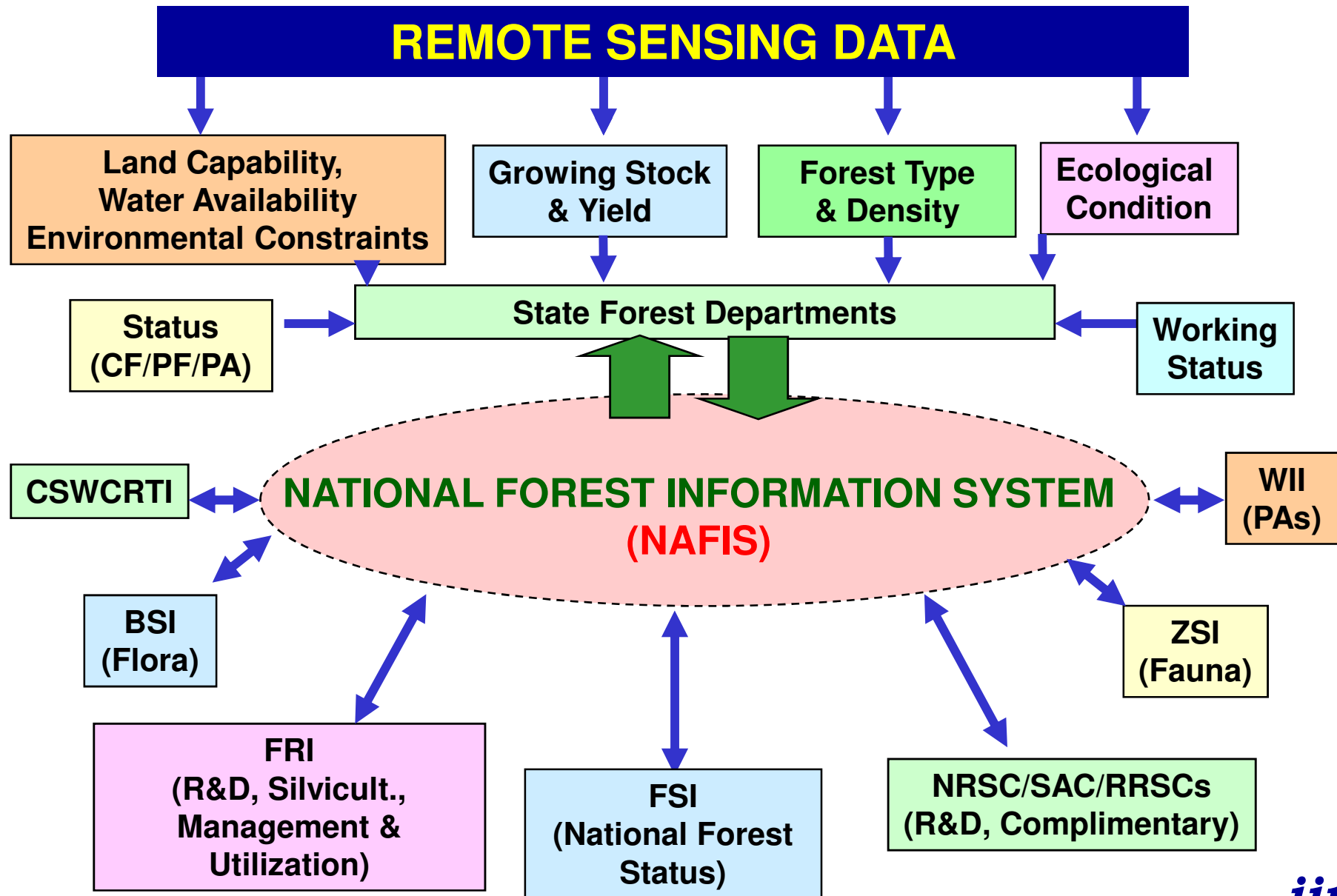
Aerosol Monitoring over India



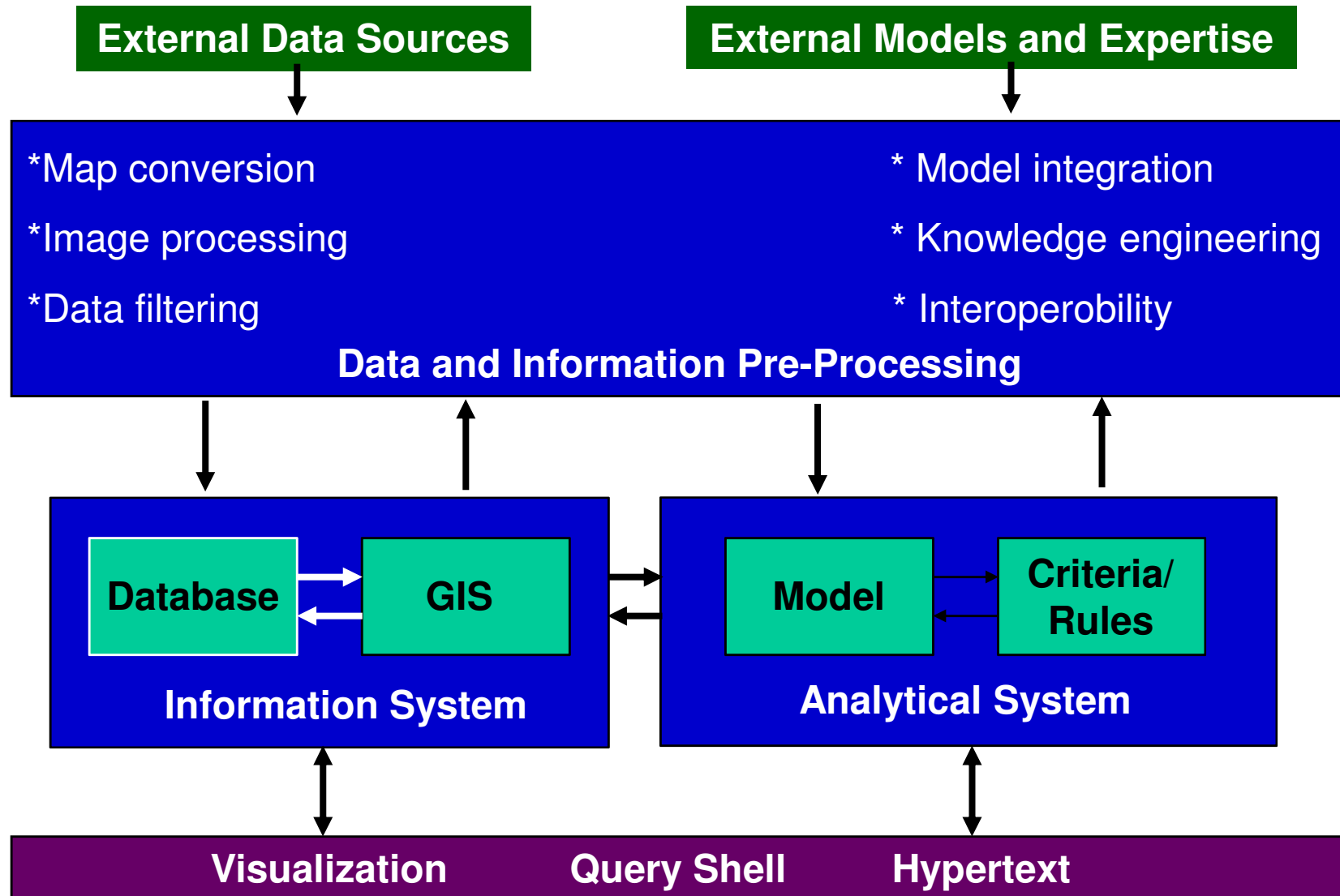
Aerosol Monitoring....



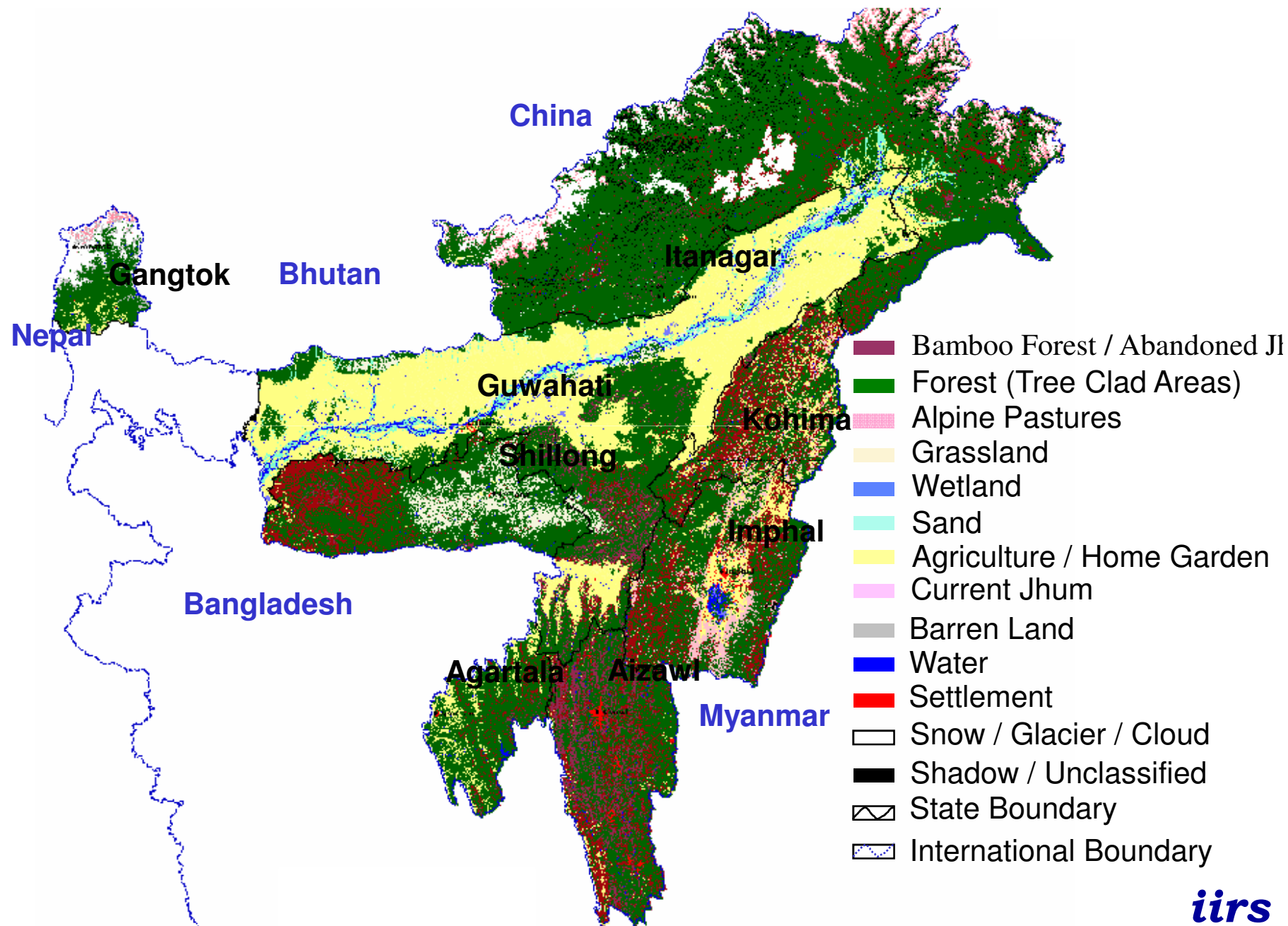
National Forest Information System (NAFIS)



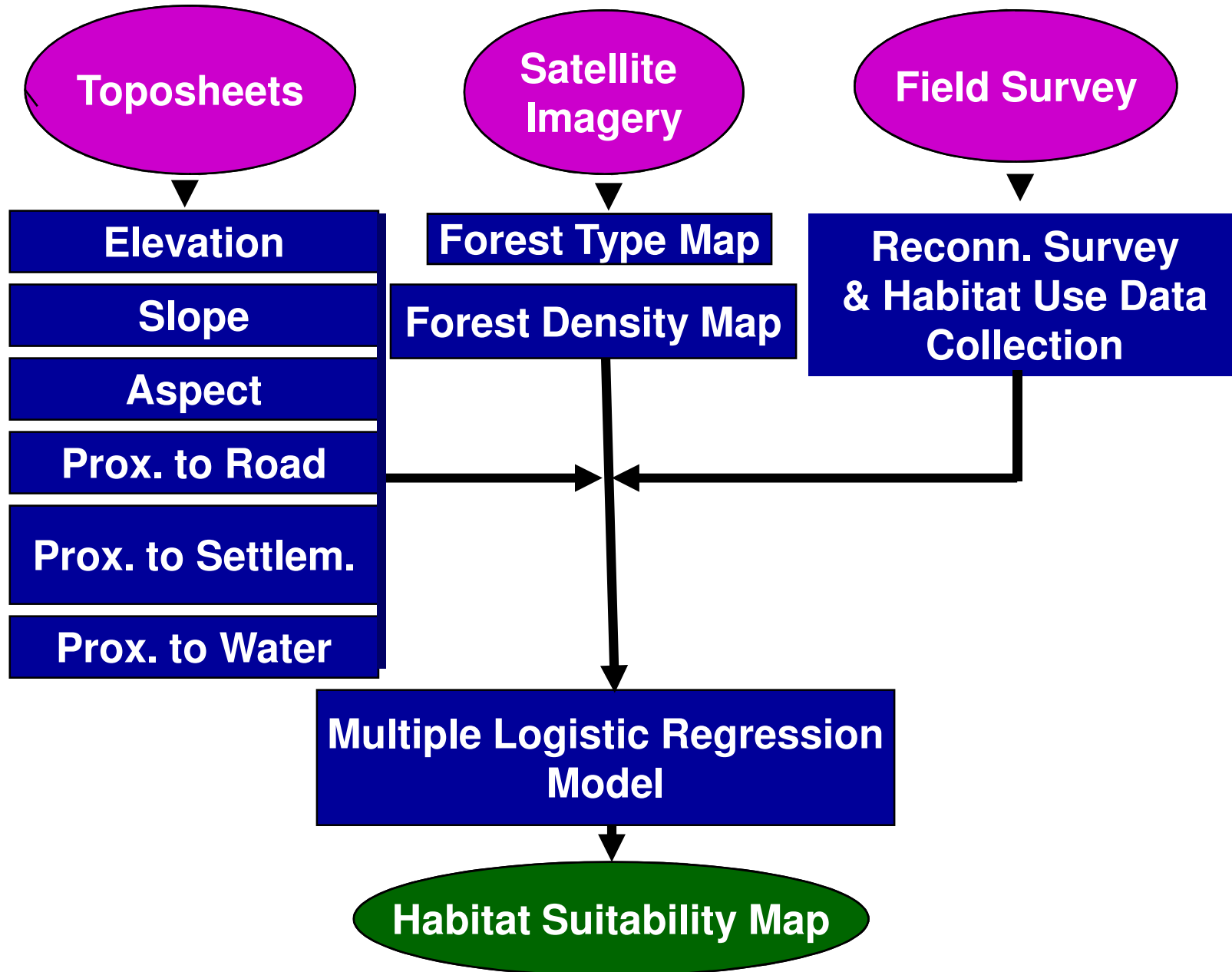
Wildlife Information System (WILIS)



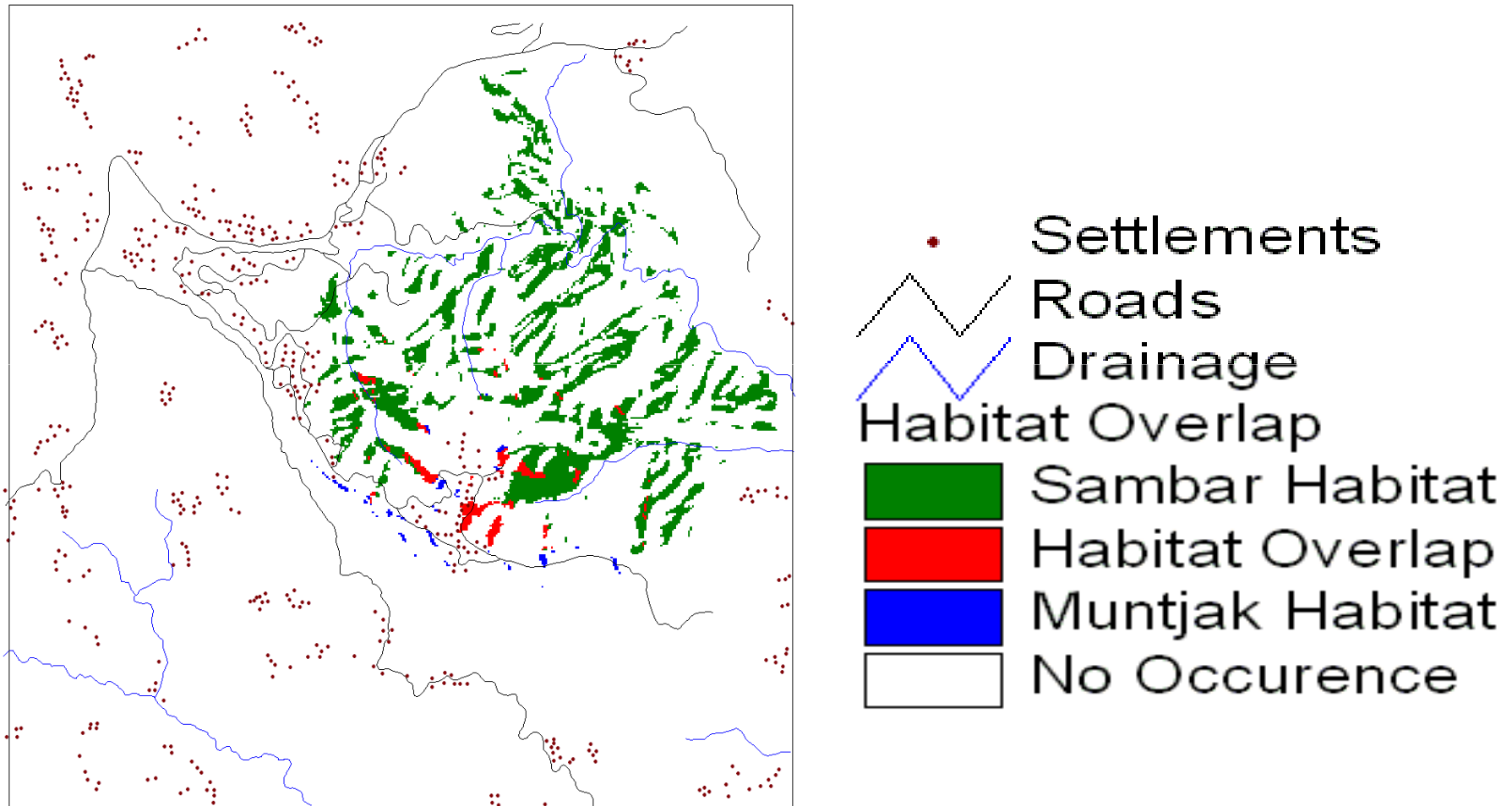
Bamboo Forests in North-Eastern India



Wildlife Habitat Evaluation

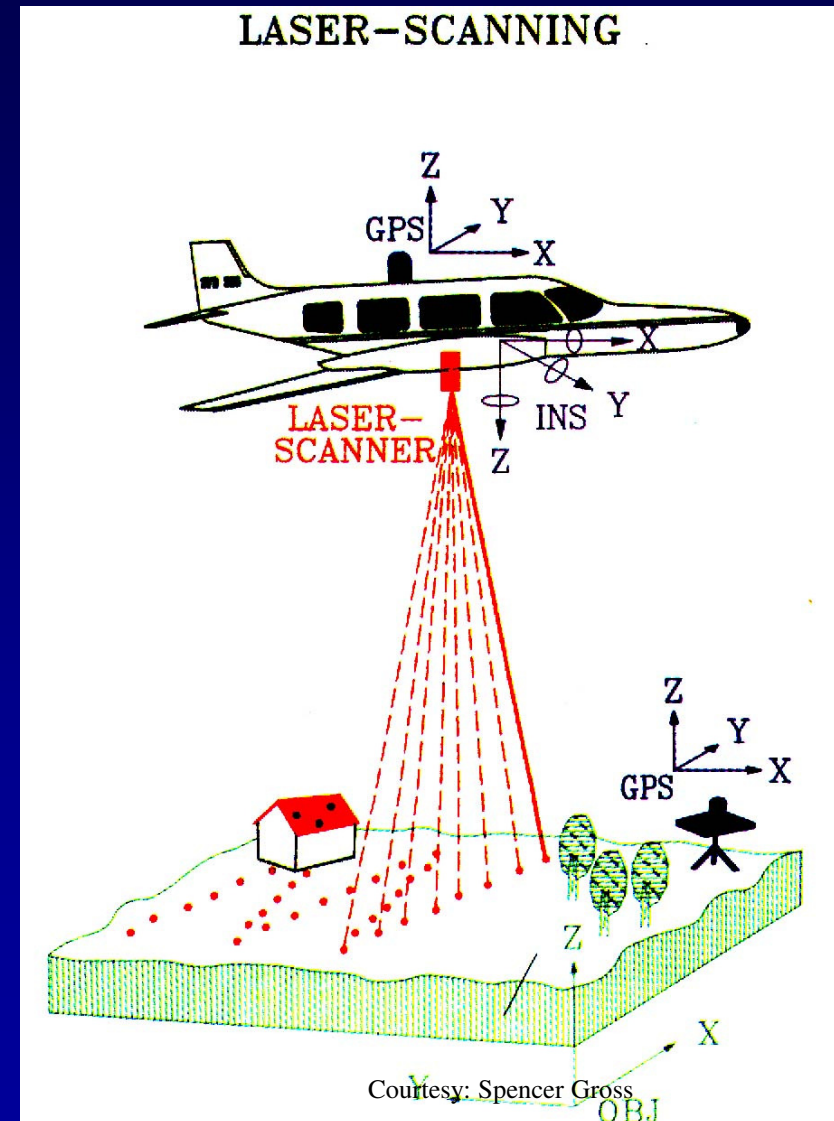


Wildlife Habitat Evaluation....

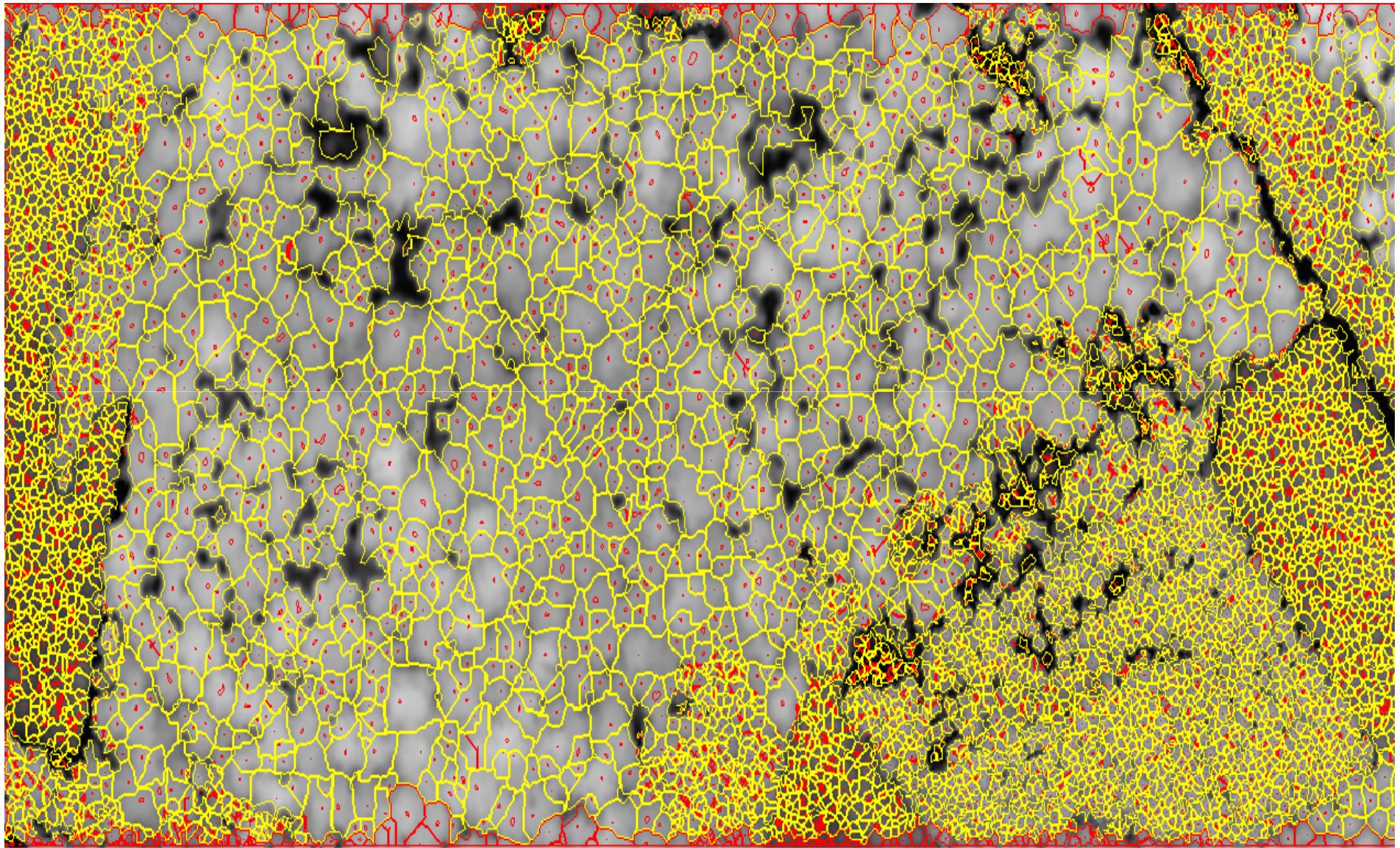


LiDAR (Light Detection And Ranging)

- Active airborne sensor emits several thousand infrared laser pulses per second.
- Operates on principle that if location and orientation of laser scanner is known, we can calculate a range measurement for each recorded echo from a laser pulse.
- Components of system include INS (inertial navigation system), airborne differential GPS, and laser scanner.
- Range measurements are post-processed and delivered as x,y,z coordinates.



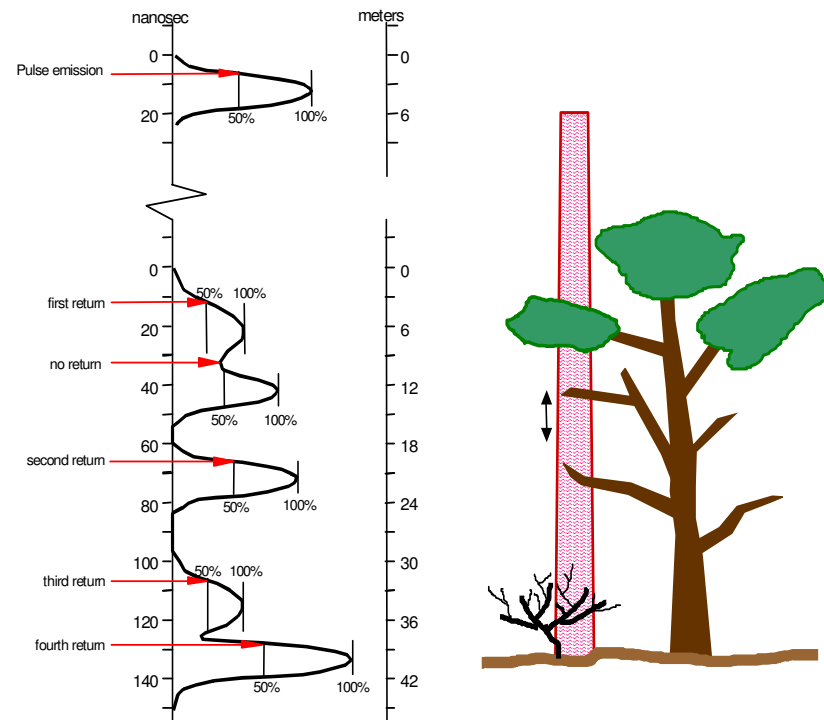
Tree Crown Shapes and Sizes from LiDAR Data



LiDAR for Forest Structure Analysis

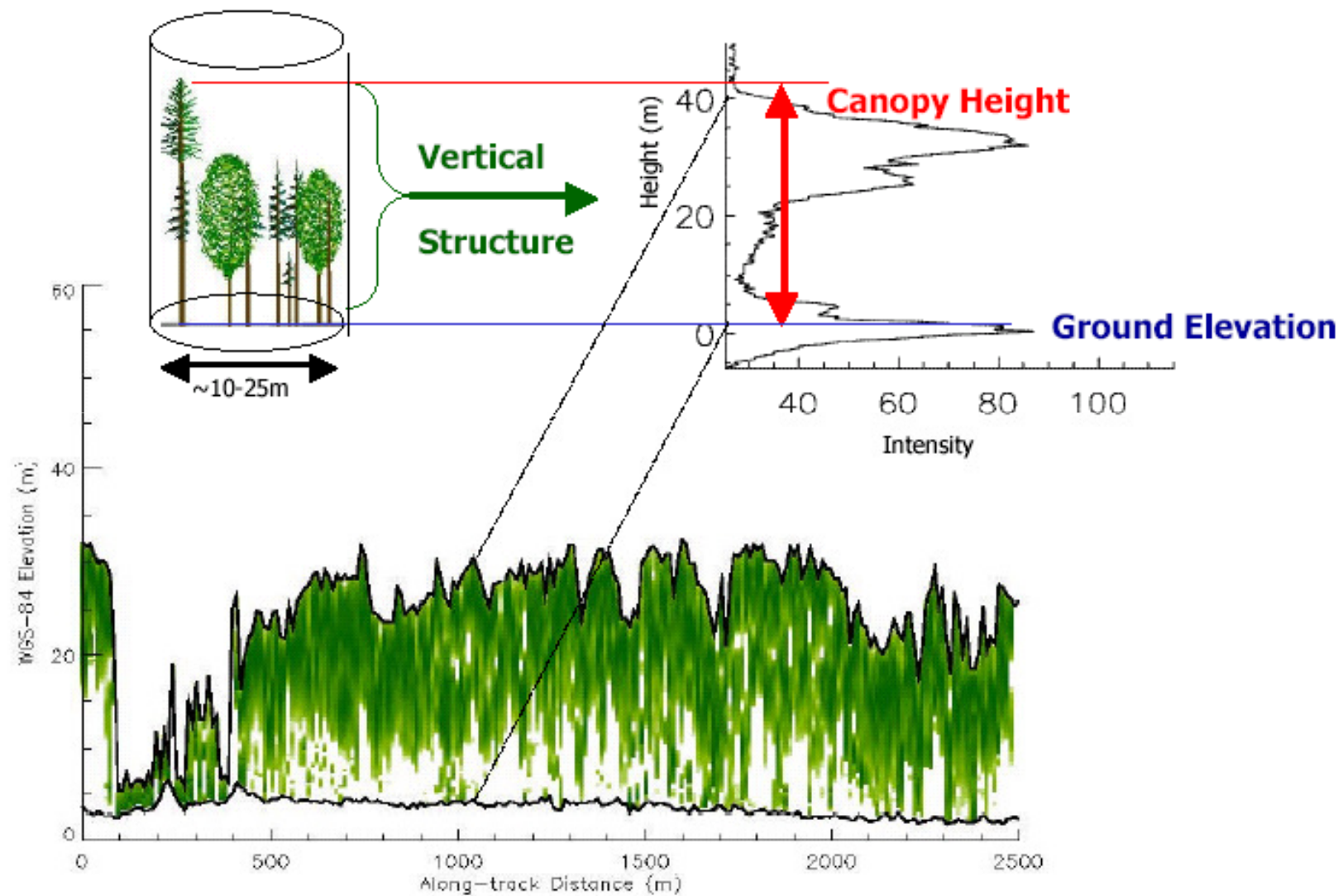
LIDAR measures three-dimensional forest structure:

- “Small-footprint” vs. “large-footprint” systems
- “Continuous waveform” vs. “discrete return” systems
- Many small footprint, discrete return LIDAR systems can acquire multiple measurements from a single laser pulse

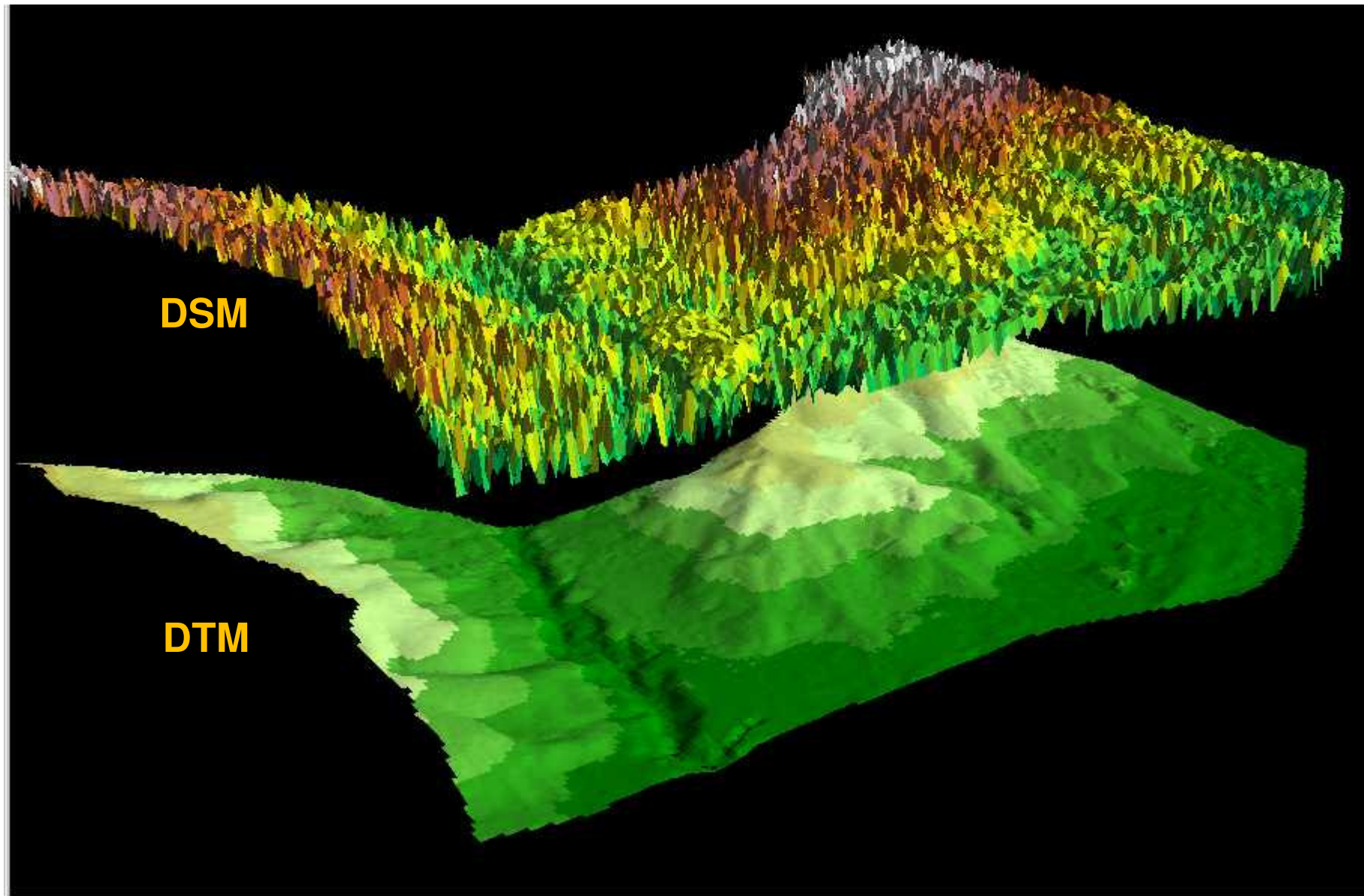


Courtesy: Spencer Gross

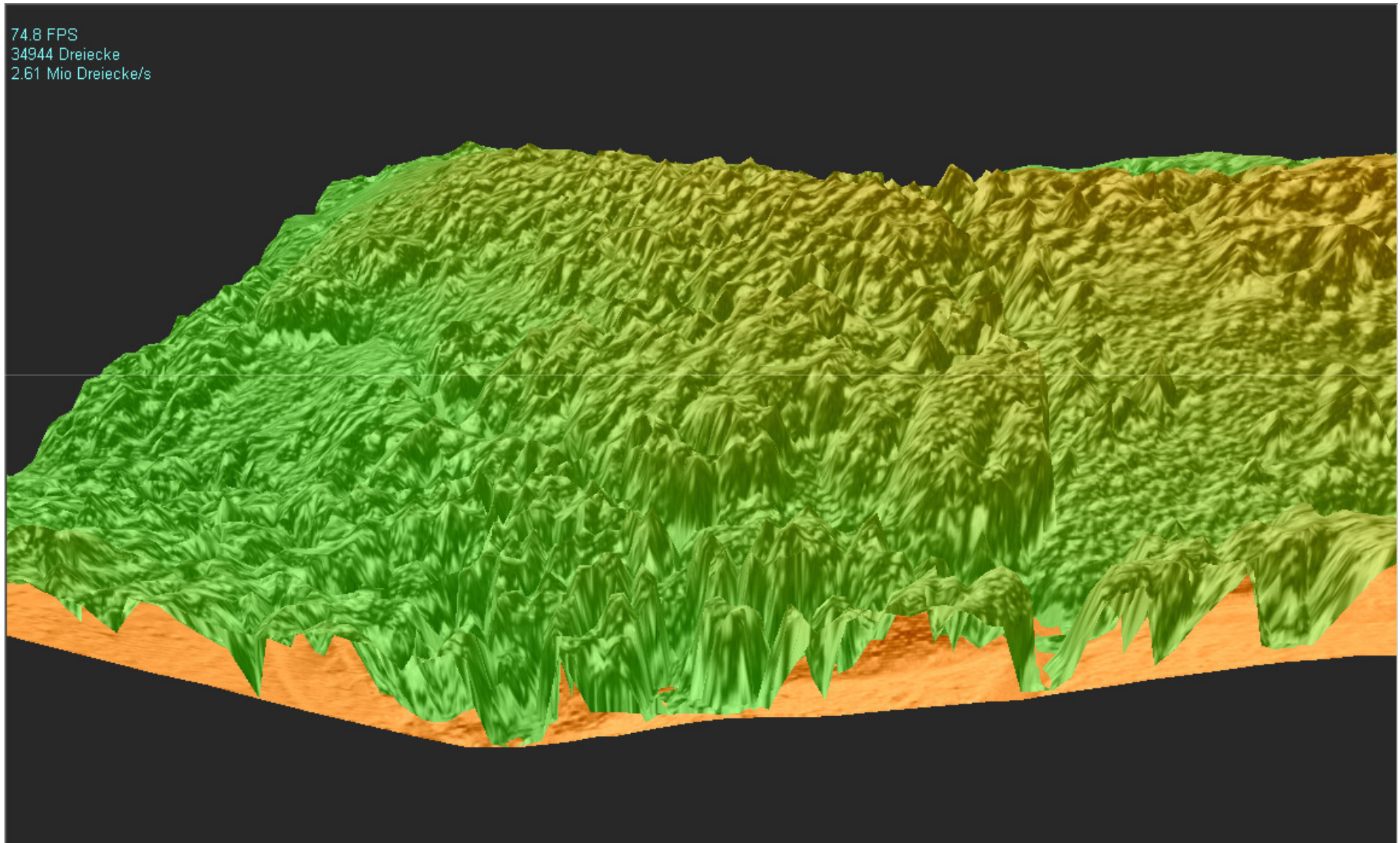
Principles of LiDAR Sensing



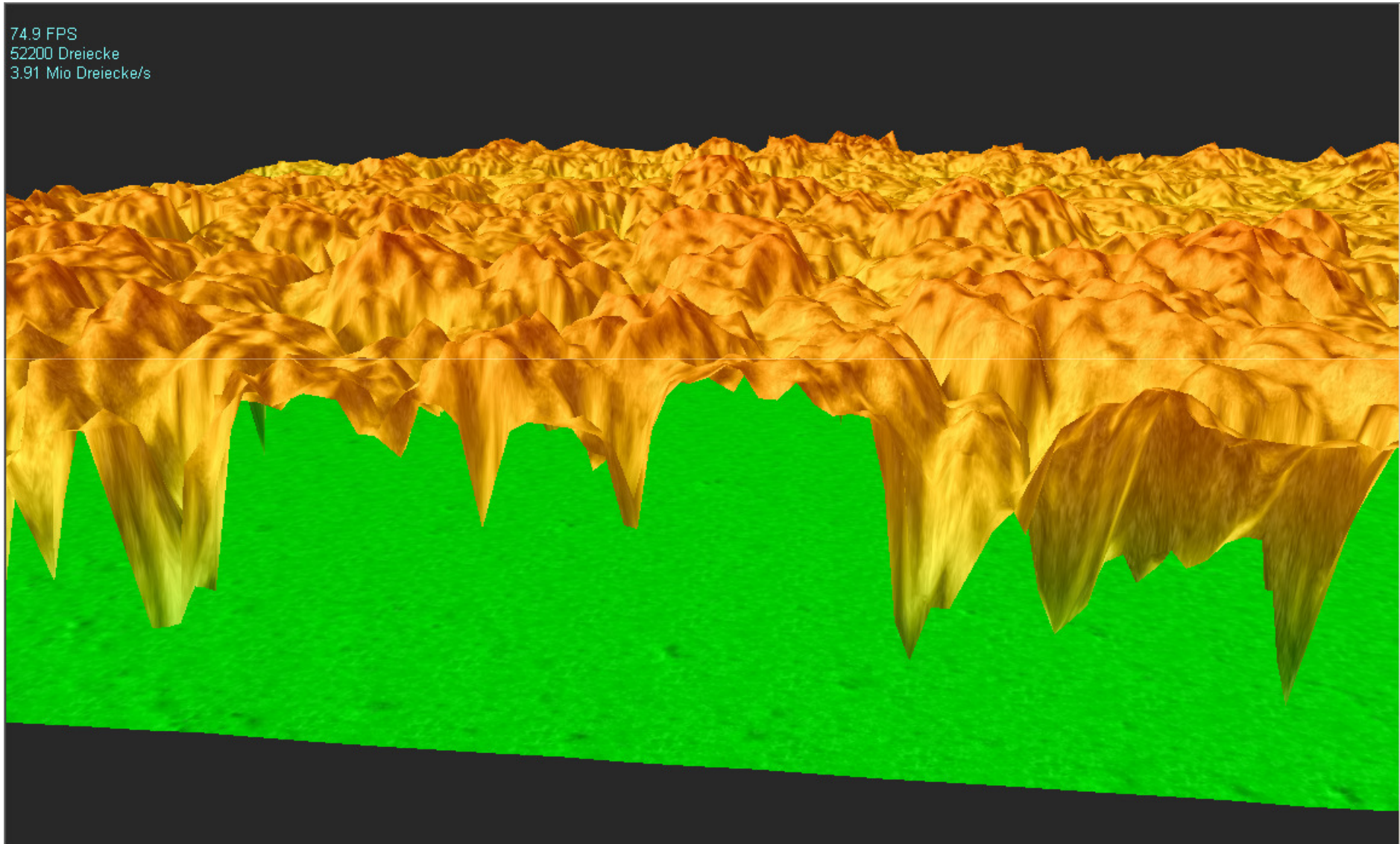
DSM and DTM from LiDAR



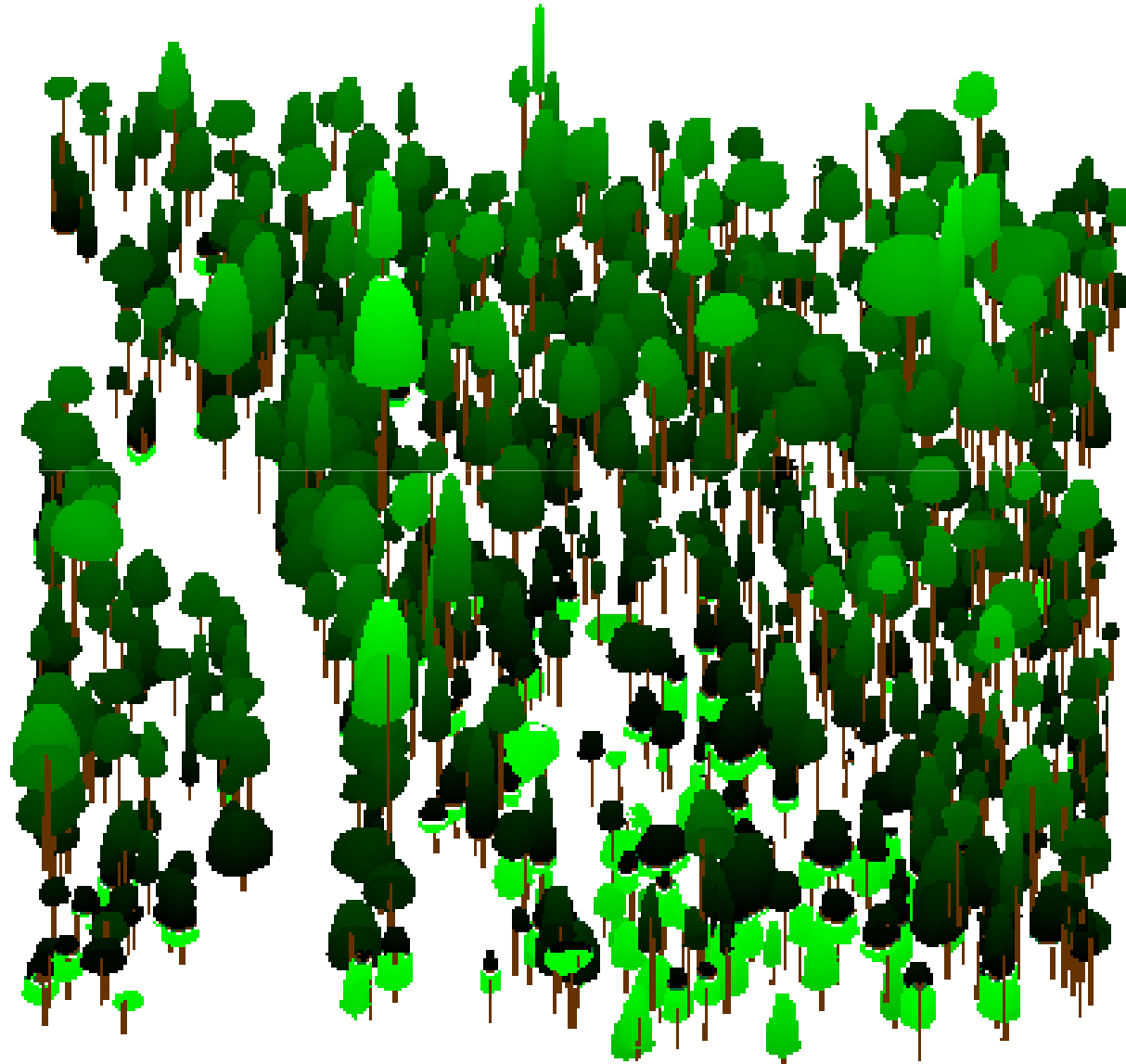
Digital Surface Model of a Forest Area



Canopy Height Over Terrain



3D Perspective View of Forest from LiDAR



Constraints

- **Cloud, Fog, Snow, Rain, Dust Storm, Smoke etc.**
- **Negligible information about under-storey vegetation.**
- **Reflectance, though directly related to green biomass, is not so well related to timber or wood/grey biomass.**
- **Species identification in mixed forests often a problem although hyperspectral data has been helpful of late.**

Milestones in Forest Remote Sensing

1.	1965	Establishment of Pre-Investment Survey of Forest Resources (PISFR) at Dehradun	Bamboo/wood survey using aerial photographs
2.	1966	Establishment of Indian Photo-Interpretation Institute (IPI) at Dehradun	Natural resources inventory using aerial photographs and training
3.	1981	Establishment of Forest Survey of India (FSI) at Dehradun	Biennial forest cover monitoring using satellite imagery
4.	1975	Establishment of National Remote Sensing Agency (NRSA) at Hyderabad	Natural resources survey and monitoring using aerial photos and satellite imagery
5.	1976	Takeover of IPI by NRSA, Dept. of Space, Govt. of India	Inclusion of satellite and other forms of remote sensing
6.	1979	Satellite remote sensing survey of natural resources of Nagaland	First large area application of digital image interpretation for NR survey
7.	1982	Nationwide forest cover mapping on 1:1M scale using Landsat MSS data	First-ever forest cover monitoring in India using satellite imagery for two periods, 1980-82 and 1972-75
8.	1995	Establishment of Centre for Space Science and Technology at IIRS campus, Dehradun	Natural resources survey, training and education in Asia-Pacific Region
9.	1998	Nationwide landscape level biodiversity survey on 1:250,000 scale	Completed in 2010 (1998-2010)

“The satellite imagery and related technology is one of the top ten advances in forestry in the past one hundred years”

- Society of American Foresters

“Remote sensing can play a prominent role in promoting growth for sustainable Development”

- Rio Conference, 1992

Thank you

An aerial photograph of a vast, dense forest covering a hillside. The trees are mostly green, with some lighter green and yellowish patches visible, suggesting a mix of species or perhaps the beginning of autumn. The canopy is thick and textured. In the lower right portion of the image, the words "Thank you" are written in a large, yellow, cursive script.

Thank you