Indian Space Research Organization (ISRO) Remote Sensing Activities in Forestry and Land Use including Capacity Building Activities

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Indian Institute of Remote Sensing (IIRS)
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**Vision**: Harness space technology for national development, while pursuing space science research and planetary exploration.

**Space Transportation**
- PSLV
- GSLV
- Reusable LV
- Modular LV

**Space Infrastructure**
- Earth Observation
- Communication
- Navigation
- Space Science & Planetary Missions

**Capacity building**
- Human Resource Development
- Indigenization
- Technical Infrastructure
- International Cooperation
- Industry, Academia,
  Outreach

**Space Applications**
- Socio economic Security,
  Sustainable Development,
  DRR & Governance
- Synergistic Applications
  (EO, SatCom & Navigation)
Current Operational Remote Sensing Capabilities

**Natural Resources Inventory & Disaster Management**
RESOURCESAT-2 & 2A

**Large Scale Mapping, Infrastru. Planning & Cartography**
CARTOSAT-1, CARTOSAT-2 (3) & 2S (4)

**Oceanography**
OCEANSAT-2 ; SARAL ; SCATSAT-1

**Weather & Climate**
INSAT 3D & 3DR ; MEGHA-TROPIQUES

- Three tier imaging: 56 m / 23 m / 5.8 m
- Revisit Capability: 03 / 11 / 03 days

- 2.5 m Stereo imaging
- Sub-meter PAN and 1.5 m Multi-spectra
- 1.2 m MX and 0.6 PAN

- Ocean color 360 m with 2 days revisit
- PFZ, Ocean State Forecast
- Ocean Altimetry, Surface Wind Vector

- 6 channel Imager – 48 images per day
- 19 Channel Sounder – Atm. Profiles
- Radio Occultation – humidity profiles
RS and GIS Applications in Forestry and Land Use

- National level LULC mapping
- National wetland mapping
- National forest cover assessment
- National level biodiversity assessment
- National level forest biomass assessment
- Forest fire monitoring and burnt area assessment
- ISRO’s geoportals
### National Wetland Inventory and Assessment (NWIA)
(Based on Resourcesat-1 LISS-III data of post-monsoon-2006 and pre-monsoon-2007)

<table>
<thead>
<tr>
<th>Wetland Type code</th>
<th>Wetland category</th>
<th>Area (ha)</th>
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<tbody>
<tr>
<td>1101</td>
<td>Lake/Pond</td>
<td>729532</td>
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<td>1102</td>
<td>Ox-bow lake/Cut-off meander</td>
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<td>1103</td>
<td>High altitude wetland</td>
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<td>1104</td>
<td>Riverine wetland</td>
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<td>1106</td>
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<td>1201</td>
<td>Reservoir/Barrage</td>
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<td>1202</td>
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<td>1203</td>
<td>Waterlogged (Man-made)</td>
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<td>1204</td>
<td>Salt pan (Inland)</td>
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<td>2101</td>
<td>Lagoon</td>
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<tr>
<td>2102</td>
<td>Creek</td>
<td>206698</td>
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<tr>
<td>2103</td>
<td>Sand/Beach</td>
<td>63033</td>
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<tr>
<td>2104</td>
<td>Intertidal mud flat</td>
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<td>2105</td>
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<td>2201</td>
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<td></td>
<td>Total</td>
<td>14705015</td>
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</tbody>
</table>
Level Land Use Land Cover Monitoring

- **Natural Resource Census (NRC) Programme, NRSC**
  - Annual LULC mapping at 1:250,000 scale
  - LULC mapping once in 5 years at 1:50,000 scale
  - LULC at 1:10,000 scale for land resources planning village level

- **Wasteland monitoring, NRSC & DoRD**
  - Wasteland change mapping (2005-06 & 2008-2009) at 1:50,000 scale

- **Decadal LULC monitoring under IGBP, IIRS & NRSC**
  - LULC change analysis for 1985, 1995 and 2005 at 1:250,000

- **National Wetland Inventory and Assessment (NWIA), SAC**
  - IRS- P6 LISS-III data at 1:50,000

- **Desertification/land degradation status mapping, SAC**
  - IRS AWiFS data of 2011-13 and 2003-05
First Forest Cover Assessment of India

- Started at ISRO/NRSA and subsequently being done at FSI, GOI
Operational Forest Cover Assessment by FSI

- Indian State of Forest Report
- Biennial report
- At 1:50,000 scale
- 15 cycle competed
- Forest loss/gain
- Estimate of TOFs
- Forest density change (indicate degradation & improvement)
- Forest growing stock/carbon
Automated Forest Change Monitoring

STATE WISE CHANGE LOCATIONS

- WEST BENGAL
- UTTAR PRADESH
- UTTARANCHAL
- TELANGANA
- TRIPURA
- TAMILNADU
- SIKKIM
- RAJASTHAN
- PUNJAB
- PONDICHERRY
- ORISSA
- NAGALAND
- MIZORAM
- MADHYA PRADESH
- MANIPUR
- MEGHALAYA
- MAHARASHTRA
- KERALA
- KARNATAKA
- JAMMU & KASHMIR
- JHARKHAND
- HARYANA
- HIMACHAL PRADESH
- GUJARAT
- GOA
- CHHATTISGARH
- BIHAR
- ASSAM
- ANDHRA PRADESH
- ARUNACHAL...

• **Issues**
  - Time of deforestation is during April – June
  - Effects of Burnt Area & Phenology
  - Clouds – data availability.

NRSC

Legend
- Loss Locations 2012-2013
  - Forest Cover > 5% (96)
  - Forest Cover < 5% (10)
  - NoForest (26)
  - Suitable Data Not Available (02)
  - Persistent Cloud Cover (16)
  - India Boundary
  - Forest Cover 2013


IFZ Profile of a pixel exhibiting change during 2005 - 2012

FOREST LOSS LOCATIONS 2013

Ongoing Projects on Biodiversity Assessment

Himalayan Alpine Biodiversity Characterisation & Information System-Network, National Mission for Himalayan Studies, MoEFCC, 2020-2023
The project aims at Earth observation data based multiscale alpine plant communities classification and species richness patterns modelling and involves 6 research institutes/universities for extensive field inventory in western Himalaya.

Biodiversity Characterisation at Community Level
DOS-DBT 2018-2022
The project aims at assessment of decadal changes in landscape, spatial characterization of vegetation communities, intensive field inventory of plants, identification of EO variables for biodiversity monitoring and integration of data to IBIN/BIS and Bhuvan portals.

Indian Bioresource Information Network (IBIN)
Phase III 2018-2021
The project aims at enriching species and spatial databases on bioresources, promoting its utilisation for conservation, bioprospecting and bioresource education, Augment IBIN portal and services and expand it through new BRICs and crowd sourcing.
Biomass Assessment using MODIS (250 m)  High resolution biomass mapping

Forest Carbon Density
Baseline year: 2010

- Data mining techniques
- Meteorological and phenological information
- 6000 ground inventory plots across country

Tree crown projection Area (CPA) delineation on VHR satellite image

Barkot forest, Uttarakhand

Based on CPA and DBH relationship
CARTOSAT-2S Very High Resolution Optical Data
Soil-Vegetation-Atmosphere Flux Studies
ISRO-Geosphere Biosphere Programme (IGBP)

Under IGBP National Carbon Project, a network of 5 forest and 5 agriculture towers have been established to measure the exchange of carbon, methane, water and energy at the interface of vegetation canopy and atmosphere.

Flux tower at Barkot

![Graph showing carbon exchange over time for different ecosystems.]

- Moist Mature Sal Forest (2015): 527.11 gCm²yr⁻¹
- Mixed Deciduous Plantation (13 years old): 702.73 gCm²yr⁻¹
Time Lapsed Data Cube for
Large Scale Deforestation in Assam

Arunachal Pradesh

Assam

Sonitpur District of Assam
Forest Change detection in Assam

- ~ 107.1 km sq of forest loss
- Maximum loss in year 2004
Forest Disturbance & Biomass Assessment using Synthetic Aperture Radar

Current fellow on hills

Burnt area

Forest patches of different age

Dudhwa NP

Terai forest plantation

AGB from ALOS-1 PALSAR
RMSE=59.77 tons/ha

AGB from ALOS-2 PALSAR
RMSE=35.00 tons/ha
Space and Terrestrial LiDAR based Forest Mensuration

ICESat/GLAS Tracks over NE India

- ICESAT-2 GLAS data was used effectively to estimate canopy height and biomass. ICESAT-2 and GEDI (on board ISS) is being explored to refine the canopy height estimates.
- Terrestrial Laser scanner (TLS)- Accurate field allometry and validation of space-borne SAR and LiDAR height and biomass products.

Riegl VZ-400 TLS

3-D canopy profile
Forest Fire Management using Space Data

- Forest Fire Alert System based on thermal RS – MODIS & NPP
- Burnt scars and damage reporting

Burnt Scars and active fire locations observed in Resourcesat-2 LISS III data over Uttarakhand due to wide spread forest fire on May 21, 2018
FOREST FIRE DETECTION USING SENTINEL-2 FCC(12,11,8)
NAINITAL DISTRICT UTTARAKHAND

Legend
- District Bound

FCC
- Red: Band_6
- Green: Band_3
- Blue: Band_4

Data used: Sentinel-2A (07/05/2019)
Datum: WGS-84
Projection: WGS-84 _UTM 44N

0 0.175 0.35 0.7 1.05 1.4
KM
Conservative estimate of fire affected area is around 690 sq km.
Thick Smoke observed in OCEANSAT-2 OCM (NCC) data over Uttarakhand due to wide spread forest fire on May 22, 2018
Very High Particulate Matter due to smoke over Uttarakhand detected using INSAT-3D imager on May 22, 2018

Two fold increase in PM 2.5 and PM 10 has been measured at IIRS campus Dehradun

Smoke from forest fires
A thick plume of CO over Uttarakhand on May 22, 2018

Atmospheric Infrared Sounder (AQUA)
Forest Fire Reporting App and Visualisation

Layers used:

Base Layers
- Open Street Map (OSM)
- Forest Fire Mapping points

Overlay Layers
- Jammu & Kashmir division and forest layers
- VIIRS and Modis layers (WMS)

Features
- Visualization of geotagged forest fire points
- Info window feature to show the received information
- Send SMS to field professionals on given mobile number to take any necessary action
A Web based GIS application (Geoportal) enabling environmental information to decision makers, policy planners, scientists and engineers, research workers, etc.

Afforestation & Eco-Development, Climate Change, Conservation & Survey, Desertification, Environment, Forest, Pollution, River Conservation, Wildlife
# Planned Indian Earth Observation Satellite Missions

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<th>Q1</th>
<th>Q2</th>
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<th>Q4</th>
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<td><strong>RESOURCESAT – 3</strong></td>
<td><strong>RESOURCESAT – 3A</strong></td>
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<td><strong>CARTOSAT- 3</strong> - Very High resolution PAN &amp; High resolution MX</td>
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<td><strong>HRSAT (3) – Phased in Orbit for daily revisit of AOI</strong></td>
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<td><strong>OCEANSAT - 3</strong> Ocean Color &amp; Wind vector – Continuity + SST; ARGOS P/L</td>
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<td><strong>GISAT-1</strong> (Observation from GEO)</td>
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</table>

- **RESOURCESAT – 3**: Wide Swath imaging with improved spatial resolution
- **ALISS3**: 20m Res; 925km swath;
- **RESOURCESAT – 3A**: Adv. stereo PAN & MX; HR DEM
- **TRISHNA**
- **CARTOSAT- 3** - Very High resolution PAN & High resolution MX
- **HRSAT (3) – Phased in Orbit for daily revisit of AOI**
- **OCEANSAT - 3** Ocean Color & Wind vector – Continuity + SST; ARGOS P/L
- **OCEANSAT – 3A**
- **GISAT-1** (Observation from GEO)
NISAR Mission Overview

- Major partnership between US National Aeronautics and Space Administration (NASA) and Indian Space Research Organisation (ISRO)
- Baseline launch date: No earlier than December 2020
- Dual frequency L- and S-band Synthetic Aperture Radar (SAR)
  - L-band SAR from NASA and S-band SAR from ISRO
- NASA 4 Gbps Ka-band telecom system to polar ground stations (> 26 Tbits/day downlink capability)
- ISRO I3K Spacecraft with 2.8 Gbps telecom system
- ISRO Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II (4-m fairing)
- 3 years NASA science operations (5+ years consumables)
- All science data (L- and S-band) will be made available free and open

NISAR Mission Science Objectives:
- How does climate change affect the carbon cycle?
- How does land use affect the carbon cycle and biodiversity?
- What are the effects of disturbance on productivity, carbon, and other ecosystem functions and services?
**Mission Science**

- **Ecosystem Structure**
  - Biomass disturbance; effects of changing climate on habitats and CO₂
- **Cryosphere**
  - Ice velocity, thickness; response of ice sheets to climate change and sea level rise
- **Solid Earth**
  - Surface deformation; geo-hazards; water resource management

**NISAR Uniquely Captures the Earth in Motion**

<table>
<thead>
<tr>
<th>NISAR Characteristic:</th>
<th>Enables:</th>
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<tbody>
<tr>
<td>L-band (24 cm wavelength)</td>
<td>Low temporal decorrelation and foliage penetration</td>
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<tr>
<td>S-band (12 cm wavelength)</td>
<td>Sensitivity to lighter vegetation</td>
</tr>
<tr>
<td>SweepSAR technique with Imaging Swath &gt; 240 km</td>
<td>Global data collection</td>
</tr>
<tr>
<td>Polarimetry (Single/Dual/Quad)</td>
<td>Surface characterization and biomass estimation</td>
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<tr>
<td>12-day exact repeat</td>
<td>Rapid Sampling</td>
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<tr>
<td>3 – 10 meters mode-dependent SAR resolution</td>
<td>Small-scale observations</td>
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<tr>
<td>L/S-band &gt; 50/10% observation duty cycle</td>
<td>Complete land/ice coverage</td>
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**Science Data Products**

1. Forest cover map 1 ha, at 90% accuracy, 3 months interval
2. Forest AGB 1 ha within 20% error every 120 days (state/entire India)
3. Forest disturbance map at 1 ha within 20% accuracy, every 120 days
4. Crop type/cover map at 1 ha pixel within 20% error every 12/24 days (selected region)
IIRS Training & Education Programmes

- **Training Programs**
  - **PG Diploma** (10 months, 9 Specialisations)
  - **Certificate Course for University Faculty** (8 weeks, NNRMS–ISRO Sponsored)
  - **Certificate Course** (8 weeks) (ITEC/MEA, Open)
  - **Decision Makers Course** (1 week)
  - **Special / Tailor made Courses** (for User Depts.)

- **Education Programs**
  - **M.Tech. in RS & GIS** (8 Specialisations) (Affiliated to Andhra University)
  - **M.Sc. in Geo-information Science & Earth Observation** (Specialisation – Geoinformatics) (JEP with ITC, University of Twente, The Netherlands)

- **Outreach Program**
  - Live & Interactive courses
  - E-Learning courses
Capacity Building Activities in Forestry

- Post Graduate Diploma and MTech Programme on ‘Forest Resources Assessment and Ecosystem Analysis’

- MoEFCC sponsored one week refresher course for Indian Forest Service (IFS) officers, every year in Aug./Sept. So far 183 IFS officers were given training.
  - RS and GIS application in forestry (2009-2013)
  - Advances in RS, GIS and GNSS applications in forestry (Since 2018)

- Directorate of Forestry Education Sponsored one week orientation course on ‘RS and GIS application in Forestry’ for Forest Range Officers, every alternate year. Total number of officers trained: 109

- Summer School on environmental studies every year since 2012

- Distance learning Courses:
  - Advances in Forest Remote Sensing (2019)
  - Geoinformatics for Forest Fire Management (2017)
  - Overview of RS & GIS Applications for NRM (2017)
  - RS and GIS Applications in Carbon Forestry (2017)
NRSC Training Programmes

The program at NRSC is designed to prepare the user community for effective utilization of satellite data and technology for Development and Societal Benefits.

- **Training Programs**
  - Each year about 20 courses covering about 500 officials
  - 1 to 2 weeks theme-oriented and special courses
  - Regular courses of 2 weeks and 12 weeks duration
  - 3 days Bhuvan Geo-portal overview familiarisation
  - Customised courses for Departments/Ministries

- **Outreach Facility at Jeedimetla**

SAC Training Programmes

- **TREES (Training and Research in Earth Eco-System)** Programme of Space Applications Centre, ISRO is an initiative to promote research and training in Earth-ecosystem’s applications among students, academics and researchers
CSSTEAP Training & Education Programmes

- Affiliated to the United Nations
- Established in India during Nov, 1995
- Headquarter at IIRS, Dehradun
- Courses conducted by IIRS, SAC and PRL

- **PGD courses:**
  - Remote Sensing & GIS
  - Satellite communication
  - Satellite Meteorology & Global Climate Space & Atmospheric Science
  - Global Navigation Satellite Systems

- MTech degree from Andhra University

- About 2040 participants (36 countries in Asia-pacific region), 19 countries from outside Asia-Pacific region. PG Courses have benefitted 916 participants. Short Courses have benefitted 1124 participants.

- **Project/Research Guidance to PG/ M Tech students**
Welcome to Gateway to Himalaya
Indian Institute of Remote Sensing, Dehradun

Thank You