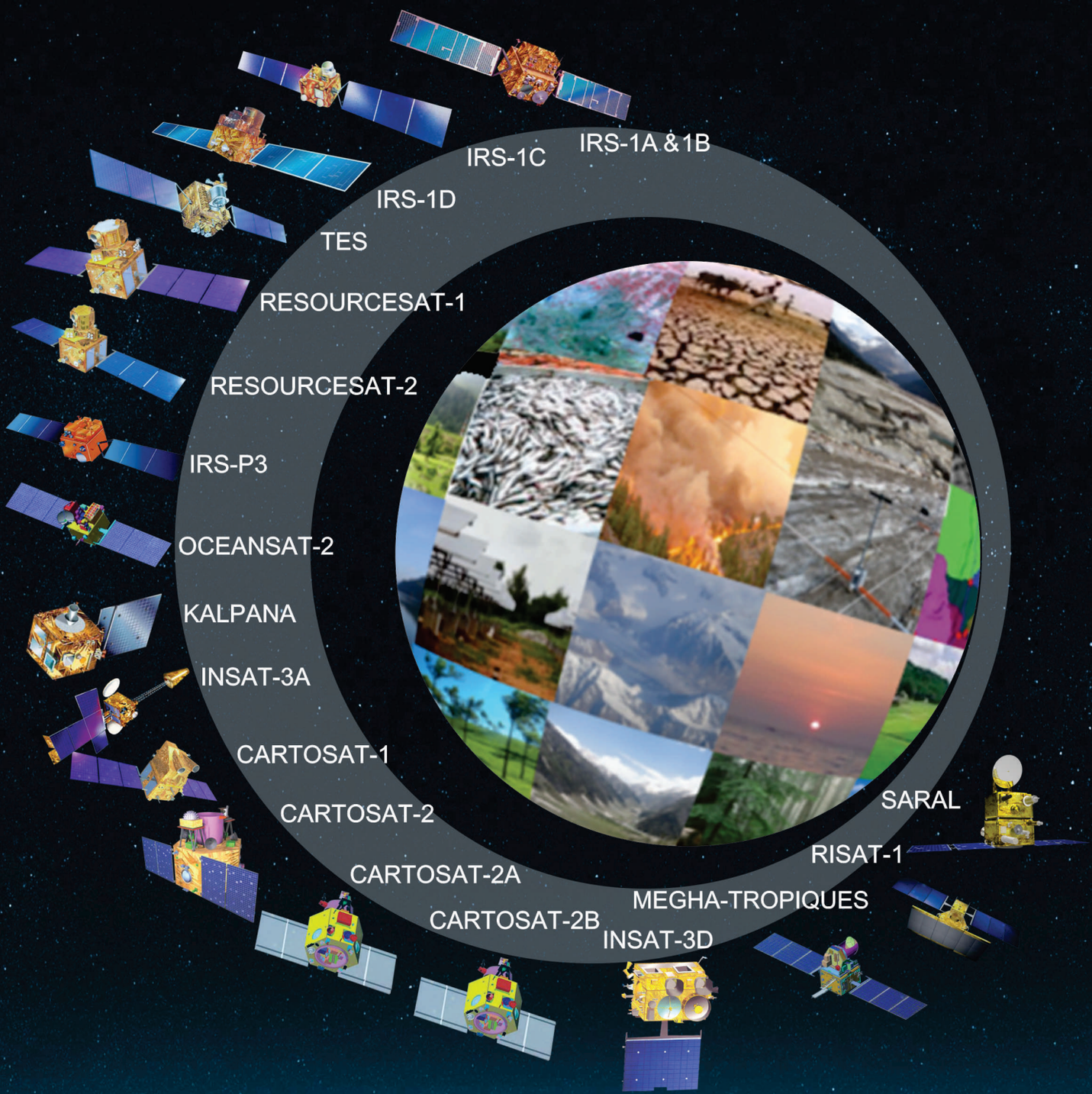


अंतरिक्ष प्रौद्योगिकी के प्रभावी उपयोग
Effective Use of Space Technology

भारतीय अंतरिक्ष अनुसंधान संगठन
Indian Space Research Organisation

Contents

☞ **Geology and Mining**

- Mineral Exploration
- Mining and Environment
- Planetary Geosciences

☞ **Ocean and Atmosphere**

- Potential Fishing Zones
- Ocean State Forecast and Ocean Models
- Rainfall Estimation and Applications
- Weather Prediction

☞ **Development Planning**

- Integrated Watershed Management
- Space Based Information Support for Decentralised Planning
- Mobile Applications
- Asset Mapping
- Modernisation of Land Records
- Election GIS

☞ **Infrastructure Planning**

- Urban Planning

☞ **Disaster Management Support**

- Floods and Cyclones
- Flood Early Warning System and Damage Mitigation
- Cyclone Monitoring and Prediction
- Landslides
- National Database for Emergency Management
- SATCOM Applications for Disaster Management Support

Space Applications in North Eastern Region

- Forest Working Plan in North Eastern Region
- Sericulture Development
- District Resource Planning and Space Based Information Kiosk in North Eastern Region
- Flood Early Warning System in North Eastern Region
- SATCOM Applications in North Eastern Region
- Atmospheric and Space Science Research in North Eastern Region

Communication and Navigation Applications

- Communication Satellites
- Satellite Communication – Ground Infrastructure
- Indian Regional Navigation Satellite System and GPS Aided Geo Augmented Navigation (GAGAN)
- SATCOM Applications

Technology Diffusion and Space Education

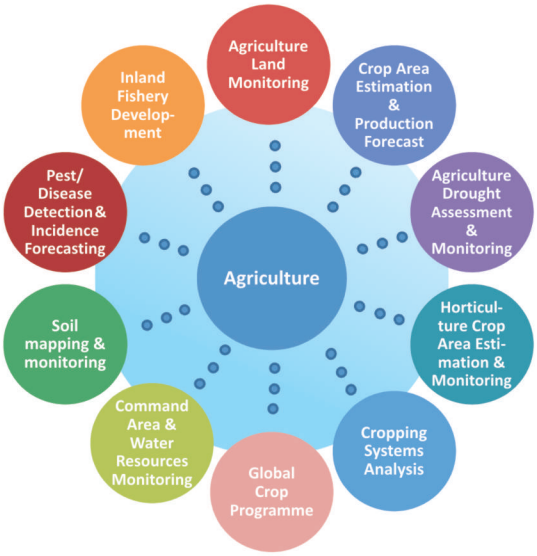
- Web Portals for Dissemination of Space-based Products and Services
- Bhuvan Geoportal
- Bhuvan Panchayats – A Web Portal for Decentralised Planning
- India – Water Resources Information System (India-WRIS)
- MOSDAC – A Portal for Meteorology, Oceanography Data and Services
- Tele-medicine and Tele-education
- Village Resource Centres
- Capacity Building

AGRICULTURE

AGRICULTURE

Agriculture is the backbone of Indian economy and the pivotal sector for ensuring food security. Timely availability of information on agriculture is vital for taking informed decisions on food security issues. India is one of the few countries in the world that uses space technology and land-based observations for generating regular updates on crop production statistics and providing inputs to achieve sustainable agriculture.

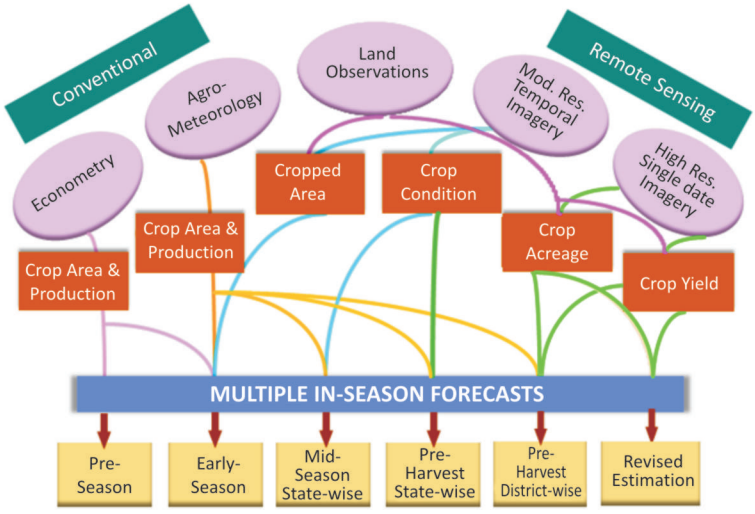
Satellite-based optical and radar imagery are used widely in monitoring agriculture. Radar imagery are especially used during monsoon season. Integrated use of geospatial tools with crop models and in-situ observation network enables timely crop production forecasts and drought assessment & monitoring.



Major Programmes

- Forecasting Agricultural output using Space, Agro-meteorology and Land based observations (FASAL)
- National Agricultural Drought Assessment and Monitoring System (NADAMS)

FASAL – Methodology Framework



Methodology operationalised for crop forecasting in India

MAJOR HIGHLIGHTS

- Establishment of Mahalanobis National Crop Forecast Centre in Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, for operational use of space technology to provide in-season crop forecasts and assessment of drought situation
- Crop production forecasting for 8 major crops
- National agricultural drought assessment and monitoring
- Country-wide agricultural land-use mapping
- Horticultural crop inventory
- Agro-meteorological parameter retrieval and inputs to agro-advisory services
- Methane emission inventory & carbon accounting

MAJOR BENEFITS

- Agricultural policy decisions
- Declaration of drought and shortfall in food grain and contingency planning
- Support to crop damage-assessment
- Advance crop planning and diversification
- Timely tailoring of agronomic practices
- Demand-based irrigation scheduling

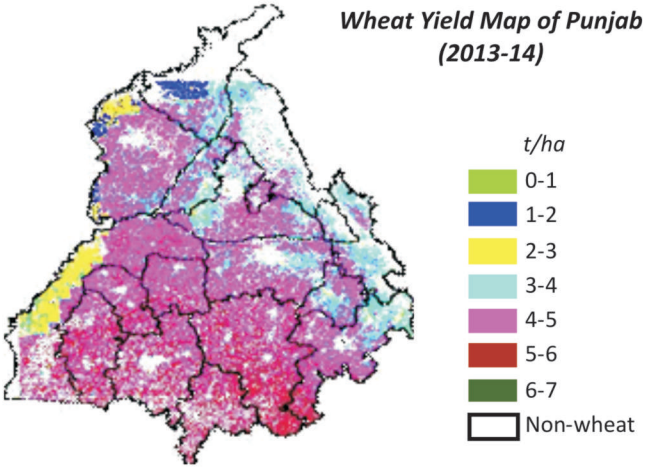
AGRICULTURE

OPERATIONAL PRODUCTS / SERVICES

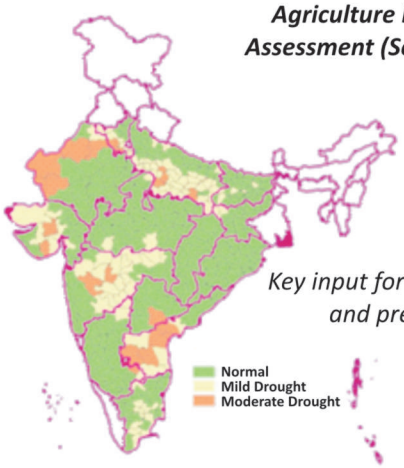
- Acreage and production estimates of 8 major crops (rice (Kharif & Rabi), wheat, mustard, jute, cotton, sugarcane, potato, sorghum) at District level
- Periodic agricultural drought assessment in 13 States
- Annual agricultural land-use mapping for crop intensification
- Horticultural crop inventory
- Cropping system analysis
- Satellite-based bio-geophysical products (vegetation index, rainfall, solar radiation) for agricultural crop monitoring and agromet-advisory services
- Capacity building in remote sensing & GIS applications for sustainable agriculture

RESEARCH AREAS

- Climate change impact on agriculture
- Carbon sequestration potential of agriculture land-use
- Geomatics application for soil & crop health assessment
- Early detection and fore-warning of biotic (pests & diseases) and abiotic stresses
- Technique development for retrieval of crop biophysical parameters
- Automated target crop mapping
- Coupling of crop models and geospatial tools for improved crop production forecast and early drought warning

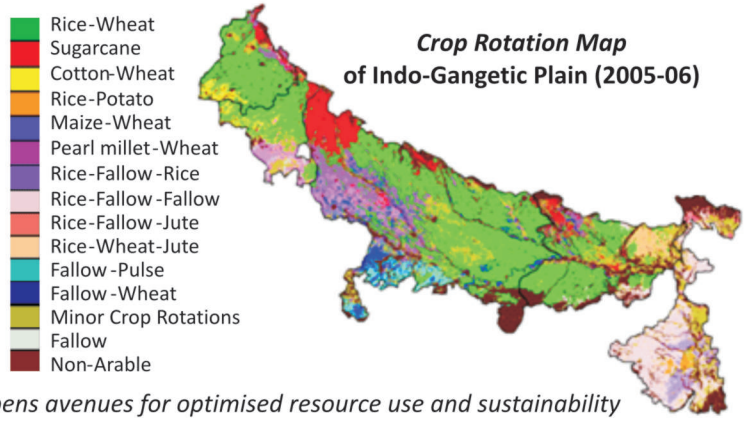


Wheat Yield Map of Punjab (2013-14)



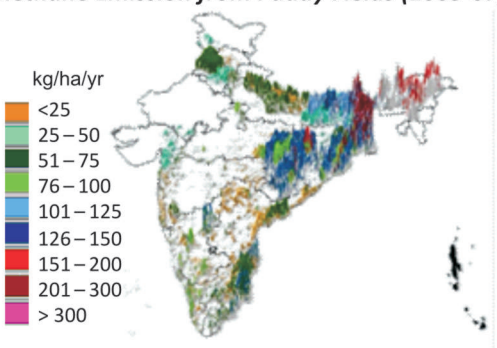
Agriculture Drought Assessment (Sept., 2014)

Key input for drought - watch and preparedness



Crop Rotation Map of Indo-Gangetic Plain (2005-06)

... Opens avenues for optimised resource use and sustainability



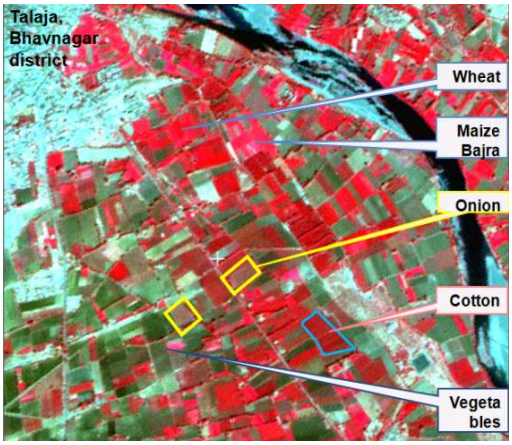
Methane Emission from Paddy Fields (2003-07)

... National communication to IPCC on methane emission

HORTICULTURE CROPS ASSESSMENT

Horticulture includes fruits, vegetables, spices, flowers and medicinal & aromatic plants. Horticulture sector is a major driver for the growth of Indian agriculture. India is the second largest producer of fruits and vegetables in the world. The total area occupied by horticultural crops in India was 23.69 Mha and total production was 268.8 MT in 2012-13.

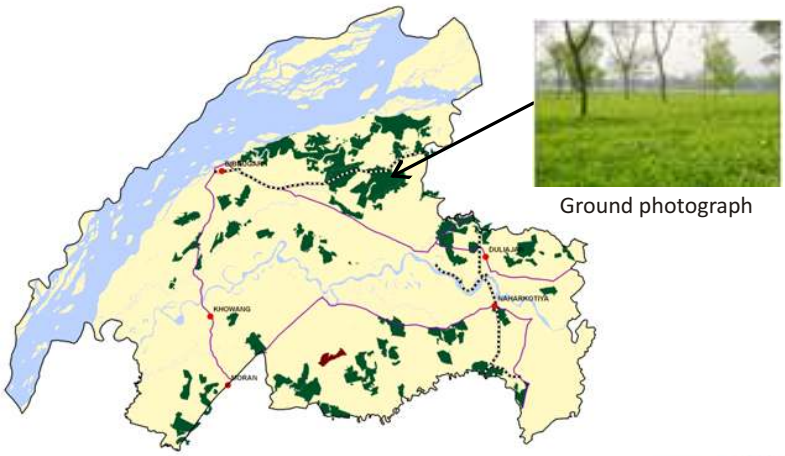
Indian Satellite sensors such as AWiFS, LISS-III & IV are being used for inventory of fruits, vegetables, plantation crops, crop health, disease mapping, yield modeling and year to year changes, site suitability and post-harvest studies.



Major Projects:

- Coordinated programme on Horticulture Assessment & Management using geoinformatics (CHAMAN) by Ministry of Agriculture
- Onion crop inventory
- Plantation crop inventory - Tea, Coffee & Rubber

Tea Plantation, Dibrugarh District (Assam)



Ground photograph

MAJOR HIGHLIGHTS

- Operational production forecasts at national level for winter potato & onion (late kharif, rabi)
- Inventory of grapes, mango, banana, apple, chilli and arecanut
- Techniques development under Technology mission on horticulture in northern region including Sikkim
- Site suitability studies for horticulture crop intensification
- Post-harvest infrastructure, pests & diseases, precision farming
- Impact of climate change scenario for apple crop

MAJOR BENEFITS

- Horticultural policy decision: crop monitoring, domestic needs, pricing, processing, import/export, planning cold storage & agro-processing units
- Planning for expansion and development
- Support for crop insurance schemes
- Crop intensification and diversification

HORTICULTURE CROPS ASSESSMENT

OPERATIONAL PRODUCTS / SERVICES

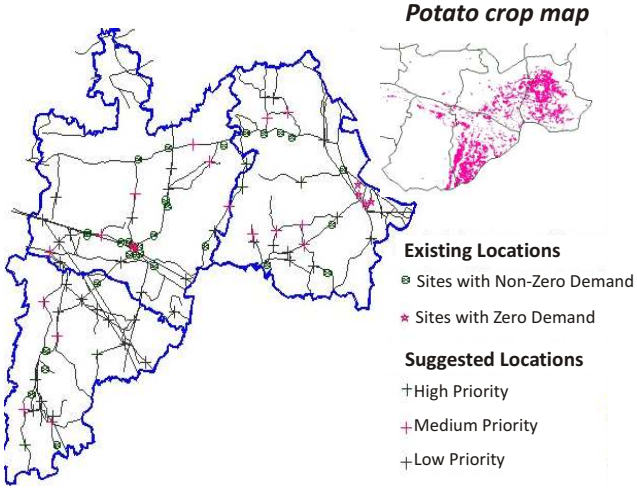
- Acreage and production estimates of potato and onion crops
- Technology Mission on the Integrated Development of Horticulture in North-Eastern States including Sikkim
- Tea garden information system
- Techniques demonstrated for inventory of major orchards, such as chilli, rubber, coffee, cashew and others
- Large-scale mapping and inventory being aimed under CHAMAN project of DAC, MoA.
- Capacity building on horticulture crop assessment

RESEARCH/FUTURE AREAS

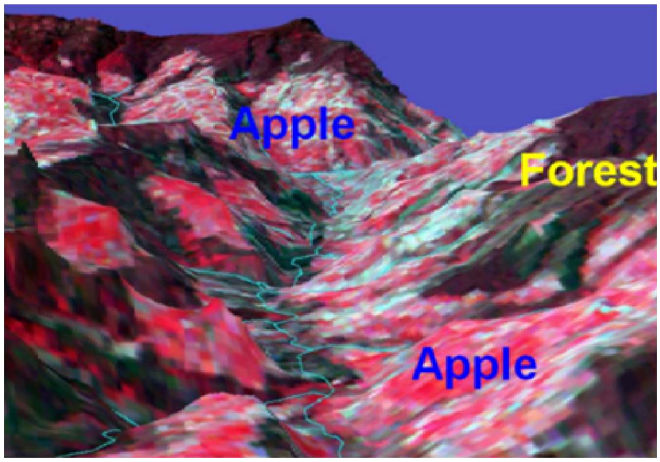
- Technique development for inventory of sparsely distributed horticultural crops, especially in hilly terrains
- Site suitability for horticultural crops
- Post-harvest infrastructure, crop intensification, orchard rejuvenation
- GIS database creation for horticultural crops
- Aqua horticulture – Selection of wetland crops and feasibility study
- Early detection and forewarning of biotic (pests / diseases) and abiotic stresses
- Geomatics supported crop insurance studies

Cold Storage Locations, Burdhawan District (West Bengal)

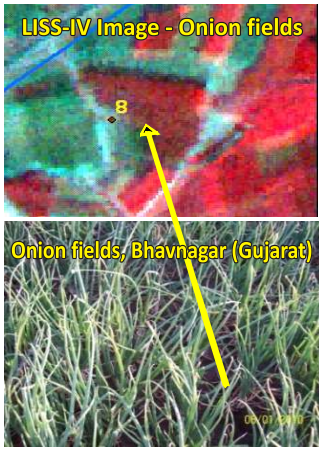
Potato crop map

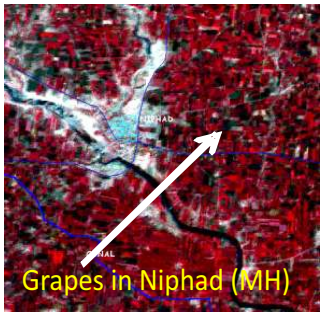


Apple Orchards as seen on IRS LISS-IV Imagery (A part of H.P.)



Resourcesat LISS-IV (27-03-2013) + Cartosat-1 merged data showing Horticulture Plantations





Under the Technology Mission on Integrated Development of Horticulture in NE States (including Sikkim), mapping of current *"Jhum"* and characterisation, identification of areas suitable for a particular fruit and prioritisation for phase-wise implementation was carried out.

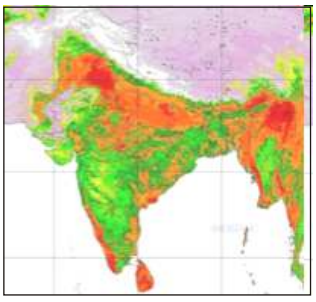
SATELLITE AGRO-METEOROLOGY

Tailor-made daily weather support plays a key role in decision making about farm operations to minimise crop losses and cost of farm operations. The nation-wide data at high temporal frequency are available from meteorological payloads on-board geostationary satellites (Kalpana-1, INSAT-3A, INSAT-3D). Moreover, the land and atmospheric variables are being assimilated to improve the accuracy of weather forecasting. The combination of advanced level products and weather forecast is useful for generating value-added information of practical utility.

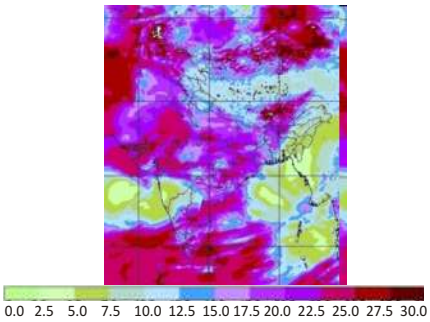
Major Projects:

- INSAT Meteorological Data Processing System; Agro-Met products and applications
- National Agro-advisory services; Value addition through satellite data and products

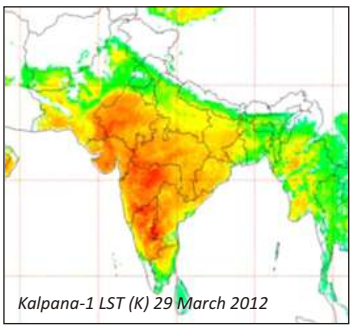
Normalized Difference Vegetation Index



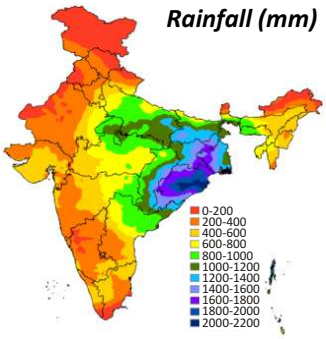
Surface Insolation (MJ/m^2/day)



Land Surface Temperature (K)



Rainfall (mm)



Applications of Geostationary meteorological satellite for agrometeorological monitoring

MAJOR HIGHLIGHTS

- Instant and near-real time high temporal & spatial data & products
- Continental-scale coverage provides rapid assessment of crop growth situations over agricultural land
- Identification of hot spot location, spatial extent, persistence of cold and hot wave, drought and flood

MAJOR BENEFITS

- Value addition to agro-advisory services for farmers
- Improvement in crop monitoring and yield forecasting
- Updated agro-met products assimilated to weather and hydrological forecast models for improved crop yield forecasting
- Deriving different abiotic stress indicators from combination of available agro-met products

SATELLITE AGRO-METEOROLOGY

OPERATIONAL PRODUCTS / SERVICES

- Agro-met products, such as instantaneous and daily surface insolation, rainfall, land surface temperature and vegetation index are available in public domain through an operational server after automated processing
- Developed methodology to track in-season rabi progress area from INSAT-3A CCD, which has been operationalised at Mahalonobis National Crop Forecasting Centre (MNCFC), New Delhi
- The present available agro-met products along with high-resolution weather forecast are used for quick assessment of extreme events, such as hailstorm and cyclones over agricultural area

RESEARCH AREAS

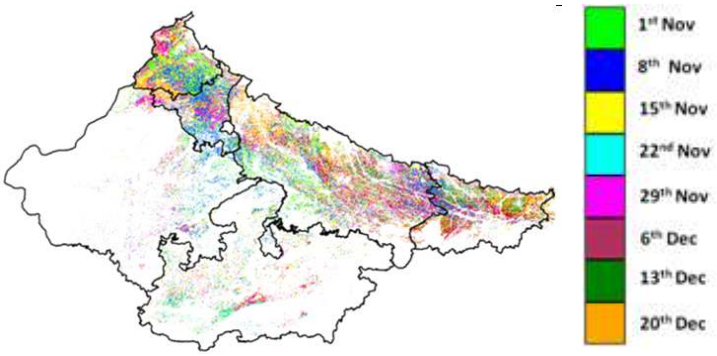
Agriculture phenology and crop calendar

- To develop crop phenological forecasting models using satellite-derived sowing date and high-resolution weather forecast
- Digital crop calendars for all major crops such as rice, wheat and mustard at landscape to regional scale

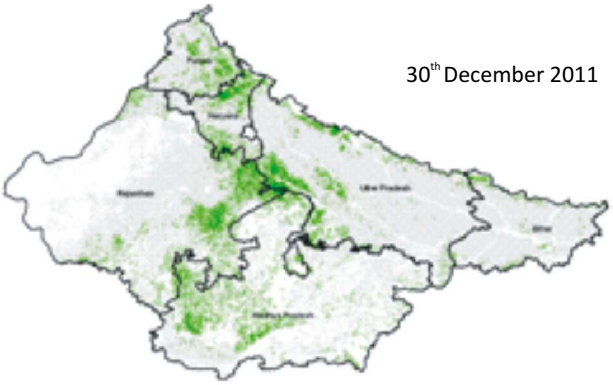
Advanced agro-met products and indicators

- Algorithm development for advanced agro-met products such as net radiation, photo-synthetically active radiation, actual evapotranspiration and soil moisture using geostationary and polar satellite data

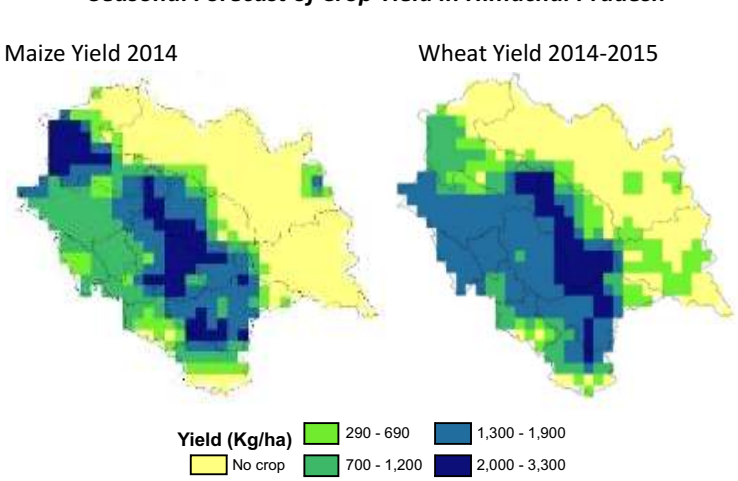
Wheat Sowing Dates

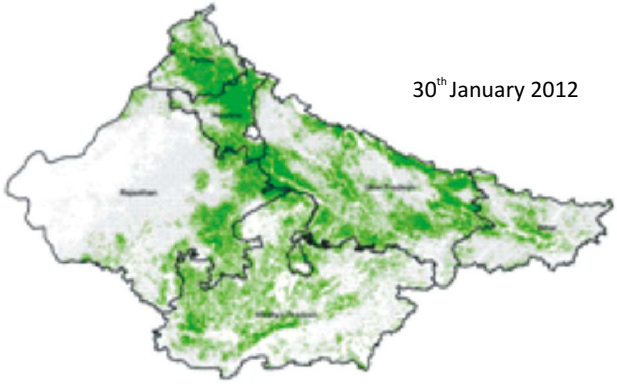


Monitoring Progress of Rabi Crop



Seasonal Forecast of Crop Yield in Himachal Pradesh



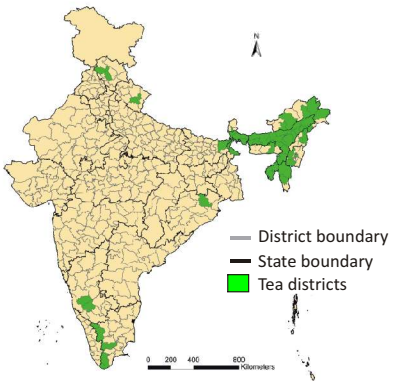


TEA GARDENS INVENTORY AND MANAGEMENT

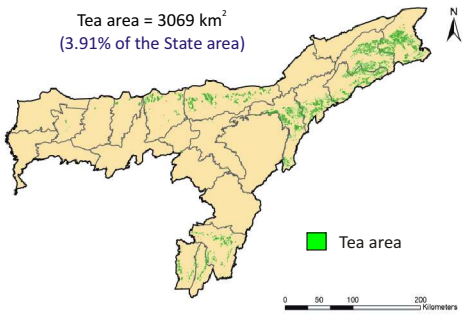
Tea is one of the most popular stable beverages in India and constitutes 21% of global area and 23% of world tea production. With an annual export of about 193 million kg, tea is a major foreign exchange earner. Maintaining the quality and targeted export of tea require reliable, periodic and latest information about the extent and condition of tea bushes in space and time.

Tea Board of India has taken a major initiative towards creation of tea garden inventory including small growers, monitoring of uprooted and replanted areas using geospatial technology to foster better linkages across all the stakeholders. The main objective of the project is to strengthen the Tea Board, Tea Research Association, Tea Gardens and Tea Industries by adopting geospatial technologies for better coordination, garden management and informed decision making at Tea Board level.

Tea Growing Districts of India



Extent of Tea Cultivation in Assam



Tea GIS-MIS Portal

This portal allows map visualisation, database query, output generation and information exchange for management of tea gardens.

MAJOR HIGHLIGHTS

- Extent of area under tea cultivation with location on 1:10,000 scale including small growers
- Mapping of garden land-use with sections overlaid
- Identification of eroded, degraded, uprooted and newly planted areas
- Spatial variability of crown densities of shade trees
- Generation of Tea garden MIS with data entry module
- Generation of Tea GIS-MIS Portal with hosts of facilities for tea garden management

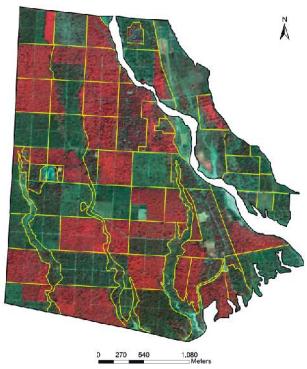
MAJOR BENEFITS

- Better linkage among Tea Board of India, large gardens, bought leaf factories, small growers, and Industry
- Monitoring of uprooting and re-planting activities towards rejuvenation over a large area with minimum effort and manpower

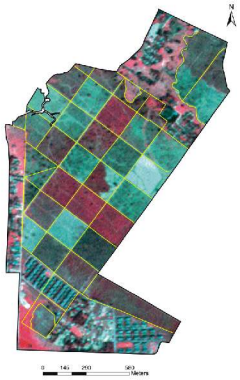
TEA GARDENS INVENTORY AND MANAGEMENT

OPERATIONAL PRODUCTS / SERVICES

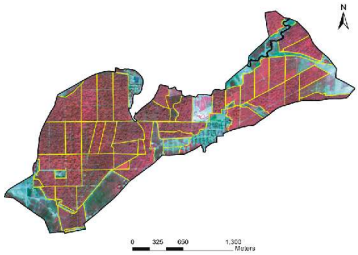
- Spatial database of tea gardens with section details, land-use, shade tree density
- Ancillary geospatial databases as supporting layers for decision making
- User interaction forum for uploading of information from tea garden and posting of query
- Customised stand-alone open source Tea garden census software with sub-modules
- Tea garden atlas (Jalpaiguri and Dibrugarh) Tailor-made training to different levels of stakeholders



Hantapara Tea Estate (Jalpaiguri, West Bengal) as seen on IRS LISS-IV image of 24.02.2005. The rivulets originating from the hills of Bhutan causes flash flood during monsoon and bring large amount of sediment load.



Pruned sections (bright patches) of the Bijlibar Tea Estate (Dibrugarh, Assam) as seen on IRS LISS-IV image of 10.03.2008. The uprooted areas can be precisely measured on image.



Unpruned sections of Kenduguri Tea Estate (Dibrugarh, Assam) as seen on IRS LISS-IV image of 24.09.2007.

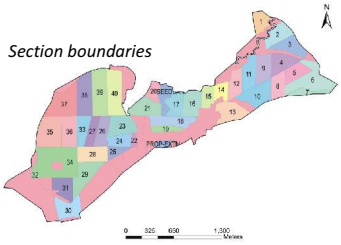
Pruned sections (in green) of Kenduguri Tea Estate (Dibrugarh, Assam) as seen on IRS LISS-IV image of 15.02.2008.

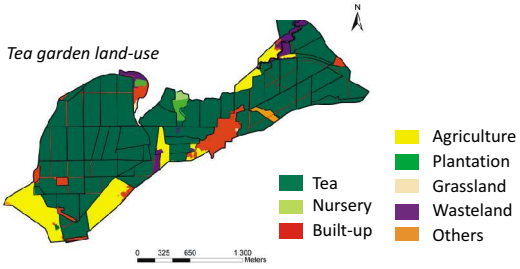
RESEARCH AREAS

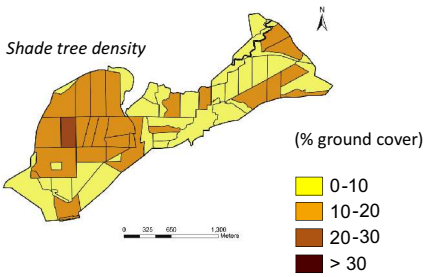
- Foliar nutrient quality of tea leaves
- Remote prediction of water stress in tea canopy
- Forewarning of Red Spider Mite

Red Spider Mite affected tea leaves, a major pest of Tea which creates havoc during March-April.

Section boundaries, Land-use and Shade Tree Density of the Tea Garden
(Kenduguri Tea Estate, Dibrugarh, Assam)

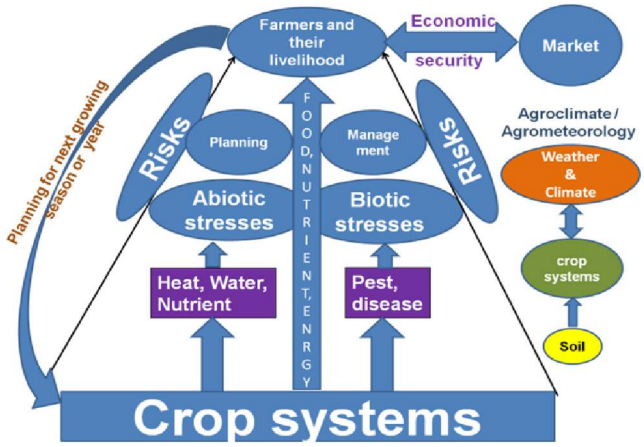






CLIMATE VULNERABILITY AND FOOD SECURITY

Agro-climatic risks govern regional food security, which are mainly expressed through abiotic (water/nutrients stress) and biotic stresses (pests/diseases). Quantification of these stresses at periodic intervals over large agricultural areas are essential. Temporal satellite data and bio-geophysical products retrieved from optical, thermal and microwave satellite imagery are being used in energy balance and productivity model frameworks to quantify stresses, predict yield and map vulnerability of food systems.

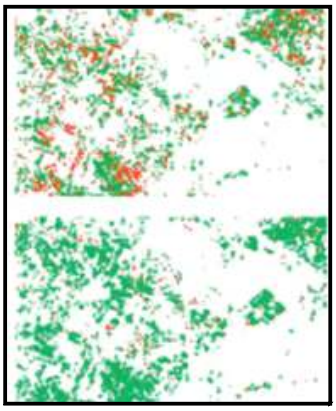


Major Projects:

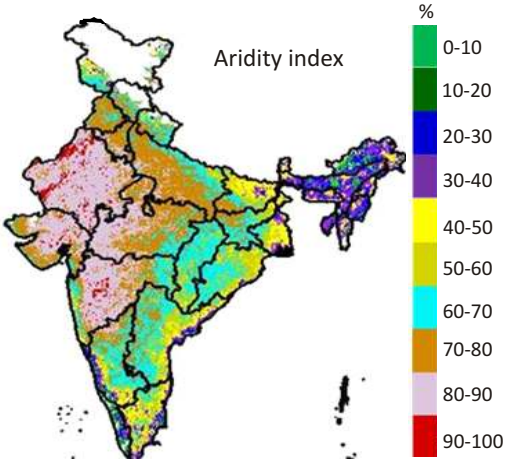
- Energy and Mass Exchange in Vegetative Systems under ISRO-GBP
- Soil-Vegetation-Atmosphere-Fluxes under National Carbon Project ISRO-GBP

Abiotic & Biotic Stresses

Mustard rot disease



Diseased Healthy



MAJOR HIGHLIGHTS

- Regional climatology of energy fluxes and water loss through evapo-transpiration using long-term satellite data
- Regional climatology of primary productivity, trends and linkages to natural and anthropogenic forcing factors
- Prediction and tracking of pests and diseases using satellite meteorology and hyperspectral data

MAJOR BENEFITS

- Availability of long-term databases to support drought vulnerability analysis & sustainable agriculture
- Inputs for improved agro-meteorological, hydrological and ecological forecasting
- Monitoring of irrigated and rain-fed agriculture for water saving practices
- Augmentation of currently existing pests/diseases forewarning systems

CLIMATE VULNERABILITY AND FOOD SECURITY

OPERATIONAL PRODUCTS / SERVICES

- A network of 23 Agro-Met Stations (AMS) of 10m height has been established over different agro-climatic zones and crop-grass cover types in India. These Agro-Met stations measure micro-meteorological parameters (air temperature, relative humidity and wind speed) and energy balance components. The data from this network are transmitted through data relay transponder (DRT) of INSAT.
- Eddy covariance towers established over major agricultural systems in western UP & Andhra Pradesh for up-scaling of carbon & water vapor fluxes using remote sensing and modeling
- Up-scaling techniques using satellite data explored to develop operational approaches for generating primary productivity and agricultural carbon accounting

RESEARCH AREAS

Agricultural stress and productivity

- Geospatial accounting of consumptive use of green & blue water and water-use efficiency to support water security
- Diagnosis, characterisation and quantification of nutrient stresses using hyperspectral satellite data

Mountain agriculture & climate change

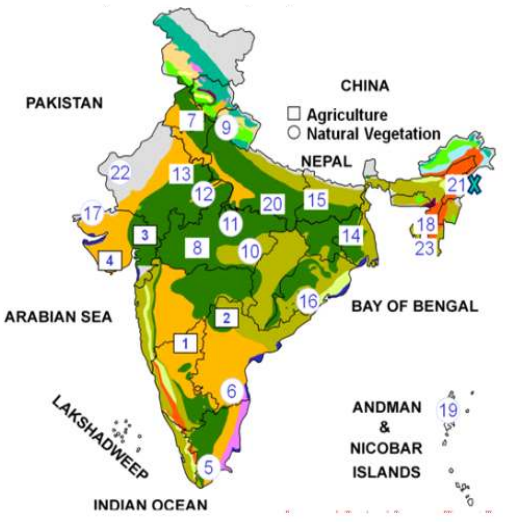
- Understanding of agro-ecosystem processes
- Assessing climate change impacts on productivity of major food crops in Western Himalaya
- Measurement and modeling of GHG emissions in terms of Global Warming Potential (GWP) from agricultural systems
- Carbon accounting of major agro-ecosystems

Agro-ecological forecasting

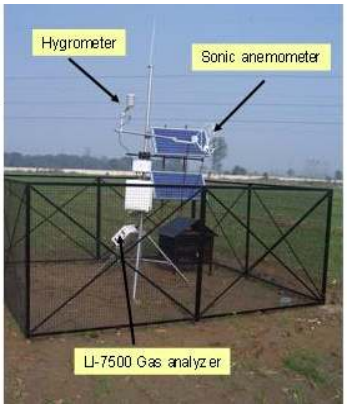
- Forecasting schemes for short and medium-term agricultural risks

Satellite-linked Network of Agro-Met Stations

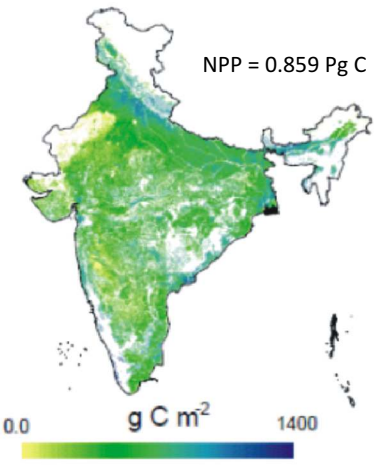
1. Bijapur, Karnataka
2. Hyderabad, AP
3. Nawagam, Gujarat
4. Junagadh, Gujarat
5. Mahendragiri, TN
6. SHAR, AP
7. Naraingarh, Punjab
8. Powerkheda, MP
9. Dehradun, Uttarakhand
10. Kanha , MP
11. Bandhavgarh, MP
12. Madhav N. P., MP
13. Sewar, Rajasthan
14. Chakdah, WB
15. Samastipur, Bihar
16. Chandraput, Orissa
17. Bhuj, Gujarat
18. Kolasib, Mizoram
19. Diglipur, A & N
20. Barakaccha, UP
21. Jharnapani, Nagaland
22. Jaisalmer, Rajasthan
23. Khazwal, Mizoram



Eddy Covariance Tower



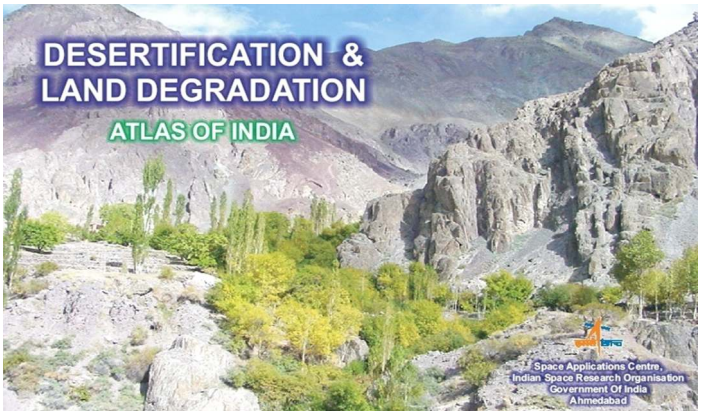
Net Primary Productivity



Satellite data and ground instrumentation help strengthening the water-carbon science area and to provide inputs for National Communication to IPCC

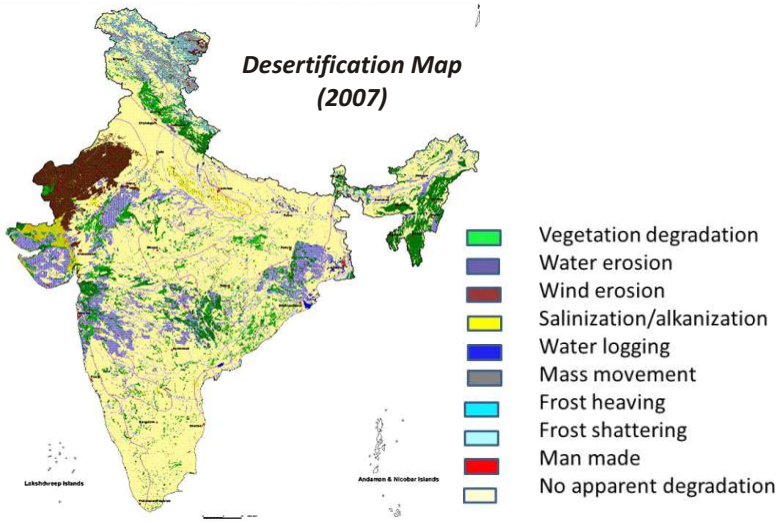
LAND DEGRADATION / DESERTIFICATION ASSESSMENT

Land degradation leads to a persistent decline in biological and economic productivity of the land resulting from various factors, including climatic variations and human activities. Desertification is land degradation in arid, semiarid and dry-sub humid regions. In India, 32% of total land area is affected by land degradation, of which about 25% is under desertification. Optical & active microwave satellite instruments are extensively used to map land degradation categories (salt-affected area, gully/sheet erosion, wind erosion, water-logged areas, deforestation and deserted croplands).



Major Projects:

- Desertification Status Mapping over India (1:500,000 scale) using IRS AWiFS data
- Land degradation mapping (1:50,000 scale) and vulnerability assessment



MAJOR HIGHLIGHTS

- ISRO is the nodal agency to report desertification status of India to the United Nations Convention to Combat Desertification (UNCCD) and has published “Desertification and Land degradation Atlas of India in 2007”

MAJOR BENEFITS

- Land degradation/ desertification monitoring and vulnerability assessment is helping to prioritise the affected areas for implementing appropriate measures/ action plans for combating desertification

FUTURE PLAN

- Develop and realise an early warning system which can identify vulnerable areas along with their severity using geoinformatics

LAND DEGRADATION / DESERTIFICATION ASSESSMENT

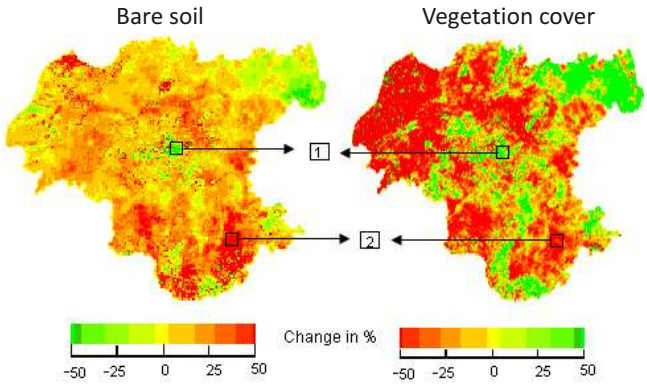
OPERATIONAL PRODUCTS / SERVICES

- Developed the methodology for digital mapping and monitoring of salt-affected and water-logged areas
- Technique development for land cover change & long-term monitoring of desertification
- Nation-wide mapping of desertification categories at 1:500,000 scale
- Mapping of land degradation (1:50,000 scale) categories using IRS LISS-III imagery
- Capacity building on land degradation and desertification assessment

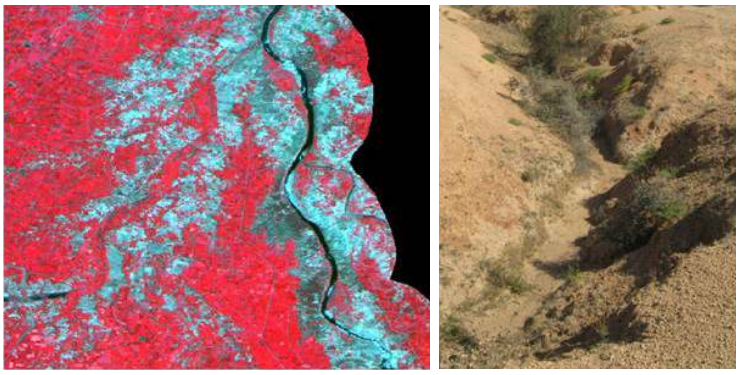
RESEARCH/FUTURE AREAS

- High-resolution land degradation mapping
- Quantification of soil erosion through GIS supported erosion processes modeling
- Addressing desertification vulnerability and sustainability issues
- New indicators of desertification processes from long-term satellite and climate datasets
- Climate change impact on soil erosion and desertification processes

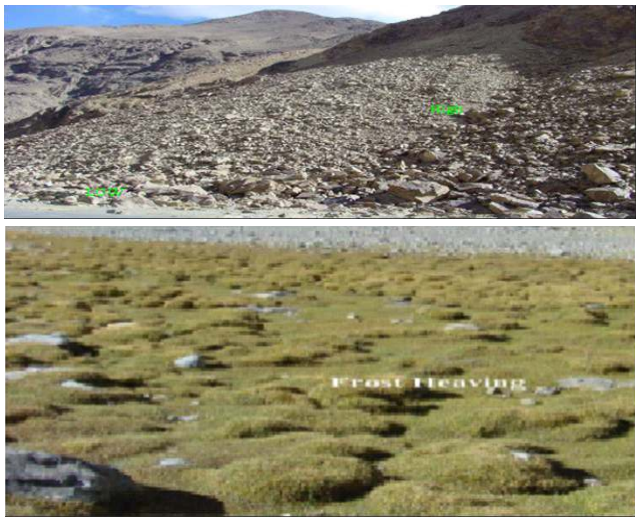
Desertification study by Linear Spectral Un-mixing



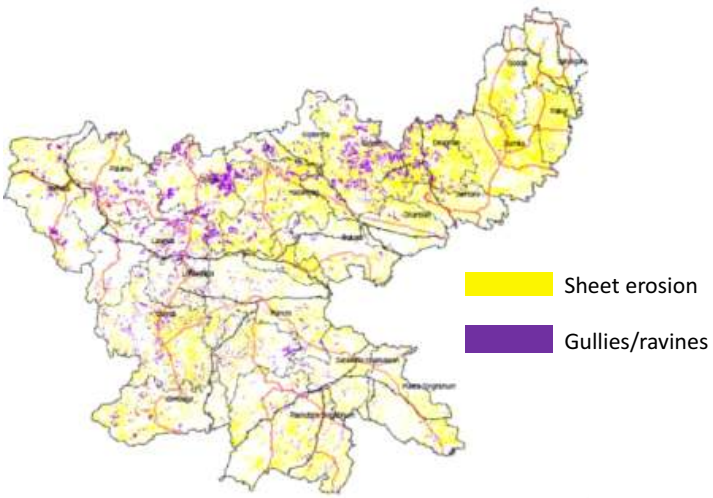
Water Induced Erosion



Frost shattering/heaving (part of Himalaya)



Water Erosion in Jharkhand



New tools for soil-water conservation planning

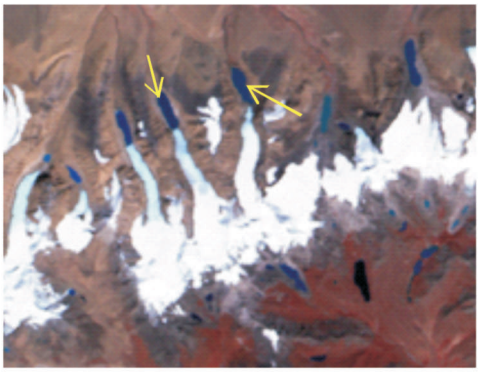
WATER RESOURCES

WATER RESOURCES

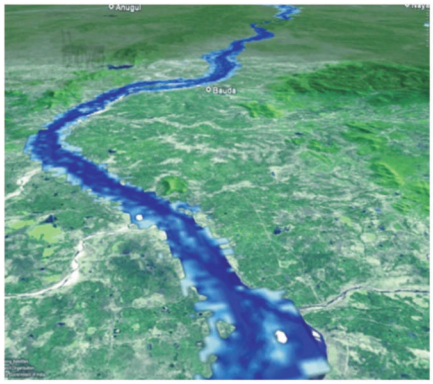
Managing water resources is a major challenge for the country. Earth Observation (EO) satellites are tailored to meet the critical information needs of water sector and provide unique opportunity towards comprehensive monitoring and evaluation of the physical attributes of water resources in the country. Over the years, the remote sensing applications scenario has witnessed a phase transition from resource mapping to decision-making. EO data derived parameters can be used in providing a host of hydrological services through National-scale or Regional-scale theme-specific models addressing flood, basin-wise water availability, snowmelt runoff and Dam breach/Glacial lake outburst hazards, etc. With the improved observational capabilities of satellites and augmented field observational networks, the focus would be on scientific assessment, development and monitoring of the available water resources.

Mapping of Irrigation Infrastructure

Monitoring of Glacial Lakes, Water Bodies



Flood Forecasting and Inundation Modeling

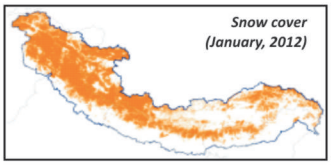


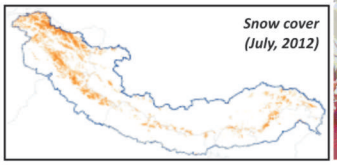
India-Water Resources Information System (India-WRIS)

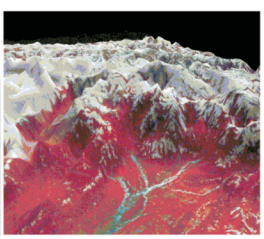
(http://www.india-wris.nrsc.gov.in)

A 'Single Window' solution for information of India's water resources: containing 12 major info systems, 35 sub-info systems having 95 spatial layers along with large attribute data of the water resources assets and temporal data of 5-100 years along with allied natural resources data.

Snow Cover Dynamics and Seasonal Snowmelt Runoff Forecasting in the Himalaya







MAJOR HIGHLIGHTS

- Irrigation infrastructure monitoring & performance assessment
- Glacial lakes/ Water bodies monitoring
- Basin-level water resources assessment
- Development of snowmelt runoff forecasting models
- Flood forecasting and inundation modeling
- Reservoir capacity loss assessment
- Feasibility assessment of river linking projects
- Nation-wide Ground Water Prospects (GWP) mapping at 1:50,000 scale
- Hydrological information products and services
- India-Water Resources Information System (India-WRIS) – a single window solution for information of India's water resources

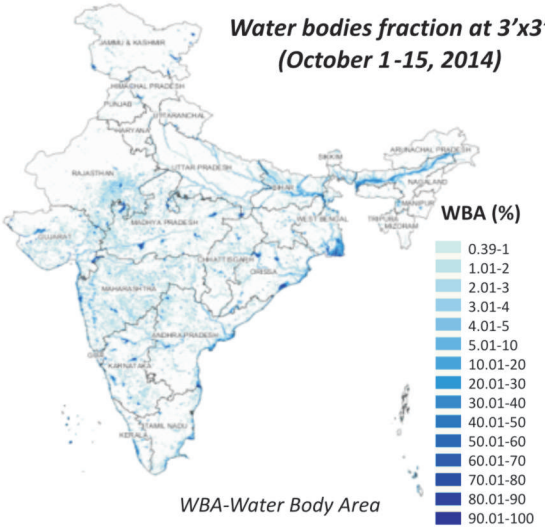
MAJOR BENEFITS

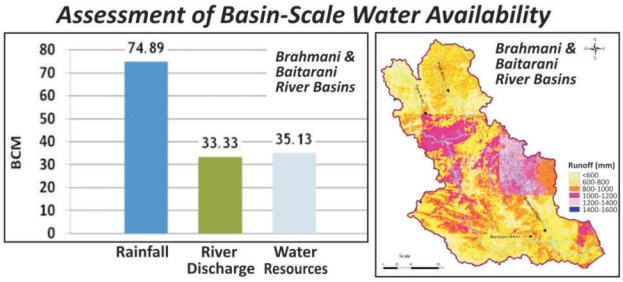
- Baseline information for decision support for effective planning, monitoring and management of water resources
- Frameworks for water resource models

WATER RESOURCES

OPERATIONAL PRODUCTS / SERVICES

- Methodology and modeling frameworks for Water Resources (WR) assessment
- Snowmelt runoff forecast models for Ganga, Yamuna, Sutlej, Chenab and Beas basins
- Development and operationalisation of flood forecasting and inundation models
- Monitoring tools for Accelerated Irrigation Benefit Programme (AIBP) through Bhuvan geoportal
- Hydrological information products and services (surface runoff, soil moisture, evapotranspiration, water bodies/ glacial lakes, snow cover, and flood forecast information)
- Preparation of feasibility reports for new water resource projects
- Irrigation performance and reservoir capacity loss assessment
- Hydrogeomorphological/ ground water prospects mapping



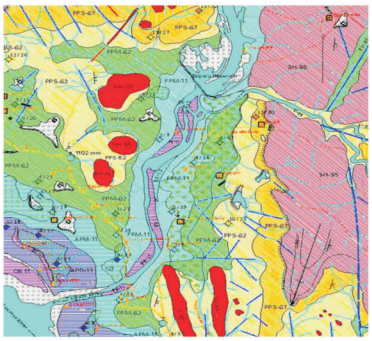


RESEARCH AREAS

- Development of real-time tracking and decision support systems to provide hydrological outlook for the country
- Assessment of Hydrological drought
- Specific inputs for Inter-linking of rivers
- Glacial lake hazard zonation and GLOF (Glacial Lake Outburst Flood) simulations
- Software tools for online monitoring and assessment mechanisms
- Development of WR assessment and forecast models
- Quantification of ground water recharge
- Effect of climate and land-use/ land-cover change on hydrologic regime of river basins

National Drinking Water Mission

Preparation of Ground Water Prospects maps at 1:50,000 scale to facilitate selection of sites for drilling of wells and putting up ground water recharge structures



- Maps extensively used by the State Line Departments
- Success rate of wells is reported to have increased significantly, especially in hard rocks
- Facilitated putting up thousands of recharge structures

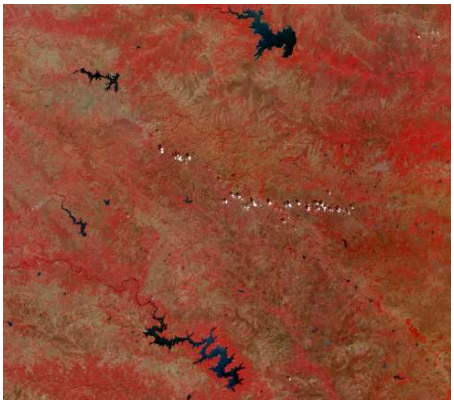
Ground water prospects are depicted in VIBGYOR colour scheme (violet to red); violet colour indicates high ground water prospects, while red colour indicates least prospects. These maps provide scientific database for detailed ground-based hydrogeological and geophysical investigations followed by drilling of wells.

Partner Institutions: Ministry of Drinking Water & Sanitation, Govt. of India; State Remote Sensing Centres; R & D institutions; Universities; Geospatial Industry

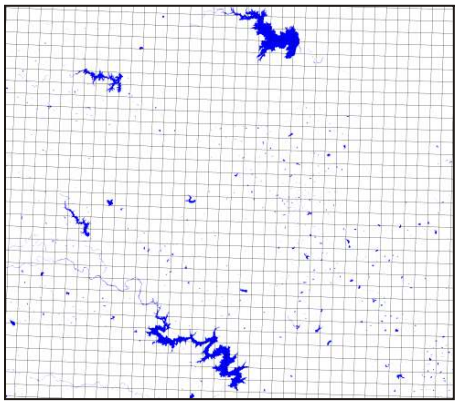
MONITORING WATER BODIES AND SNOW COVER

Water bodies and snow cover are dynamic in nature and require continuous monitoring which is helpful for monitoring the land surface processes and the regional water and snow cover dynamics. In view of this, ISRO has developed quick processing algorithms for extraction of minimum size of water body by AWiFS 2.25 ha and RISAT-1 MRS 0.4 ha and snow cover information from satellite data. Water bodies information is being extracted from Resourcesat AWiFS, RISAT-1 MRS data and snow cover information from AWiFS at 15 days interval. IMGEOS (Integrated Multi-Mission Ground Segment for Earth Observation Satellite) facility is being used for quick data processing to capture near real time scenario.

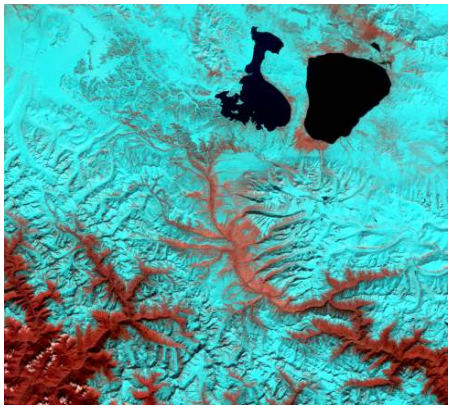
Resourcesat-2 AWiFS Image



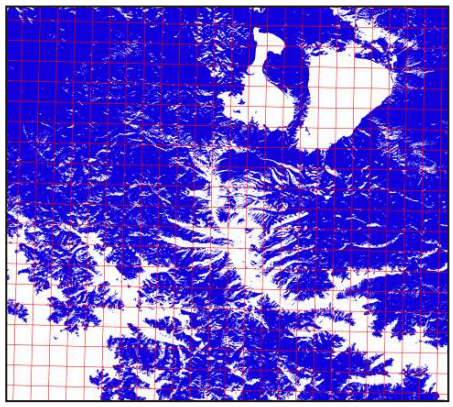
Water Bodies Layer derived from Automated Algorithm



Resourcesat-2 AWiFS Image Manas Sarovar and surroundings



Snow Cover Layer derived from Automated Algorithm



MAJOR HIGHLIGHTS

- Development of automated feature extraction algorithms
- Implementation of algorithms in IMGEOS data processing chain
- Quick processing of data in scheduled chain of activities through customised software
- Water bodies and snow cover information at every 15 days interval
- Spatio-temporal database generation and archival

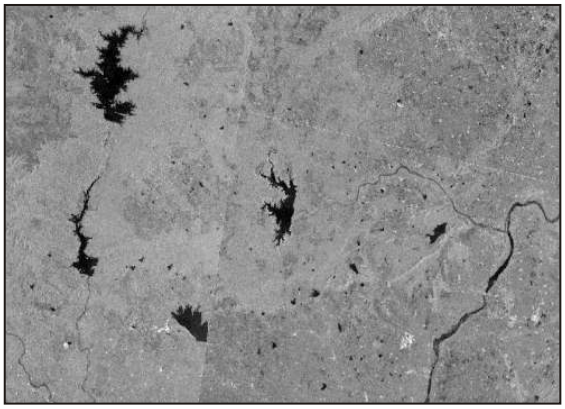
MAJOR BENEFITS

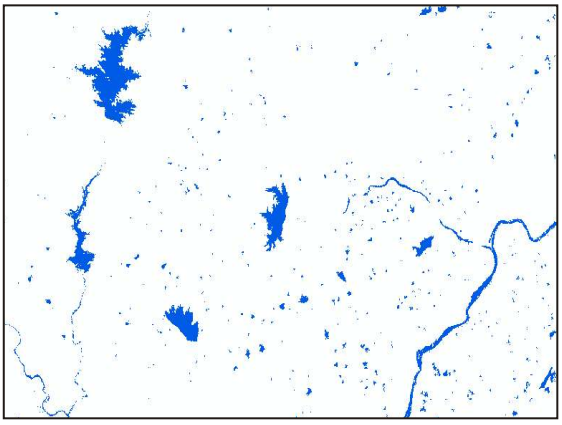
- Quick processing of large number of satellite datasets
- Processing of historic data and study of surface water bodies and snow cover dynamics
- Inputs for hydrological services for the country

MONITORING WATER BODIES AND SNOW COVER

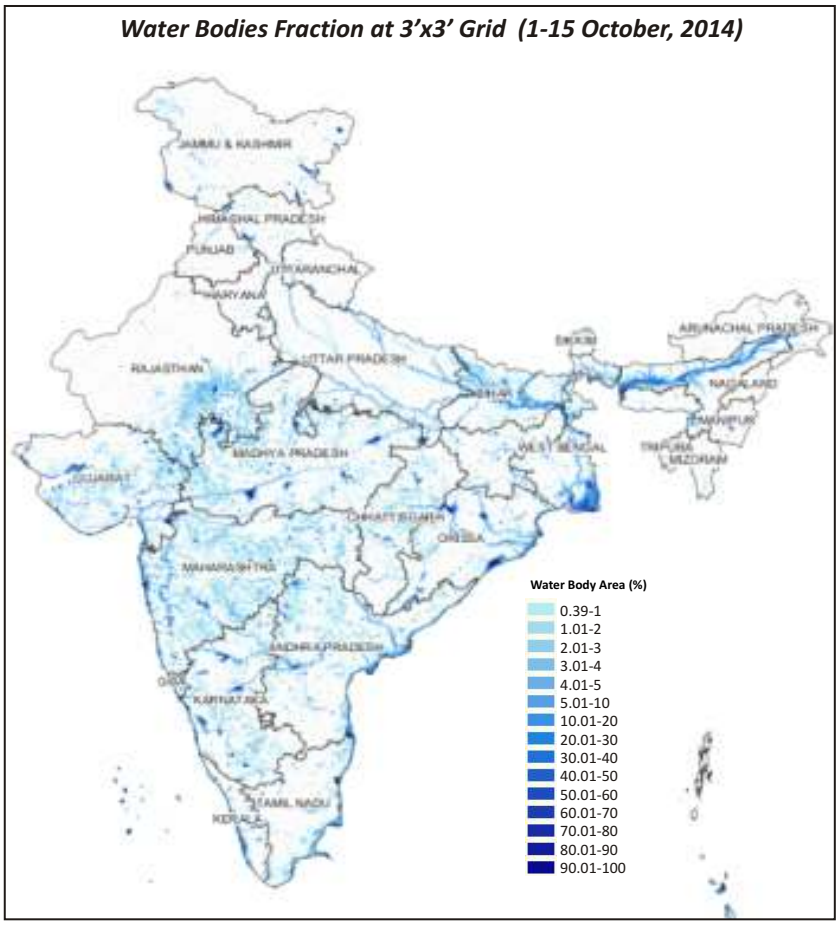
DELIVERABLES

RISAT-1 MRS Data and Water Layer Derived from Automated Water Body Extraction Algorithm

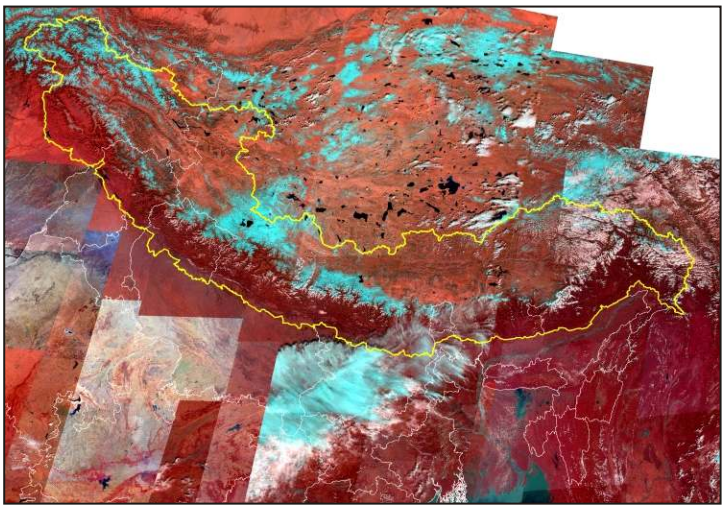




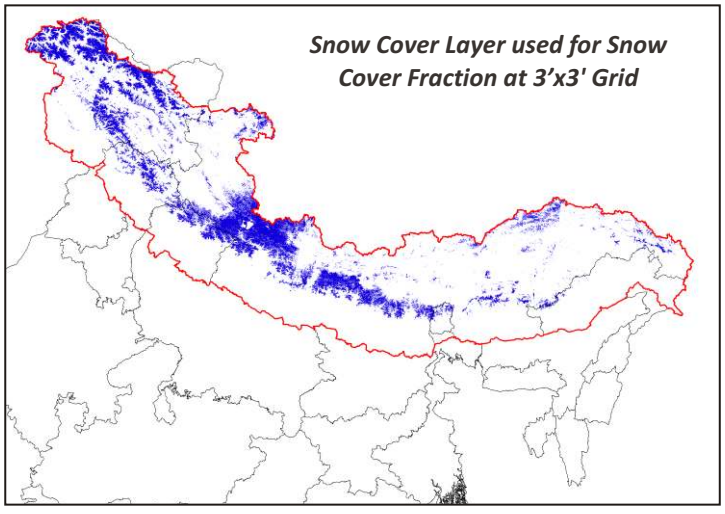
Water Bodies Fraction at 3'x3' Grid (1-15 October, 2014)



Snow cover in Himalayan Region: 21-25 October, 2014

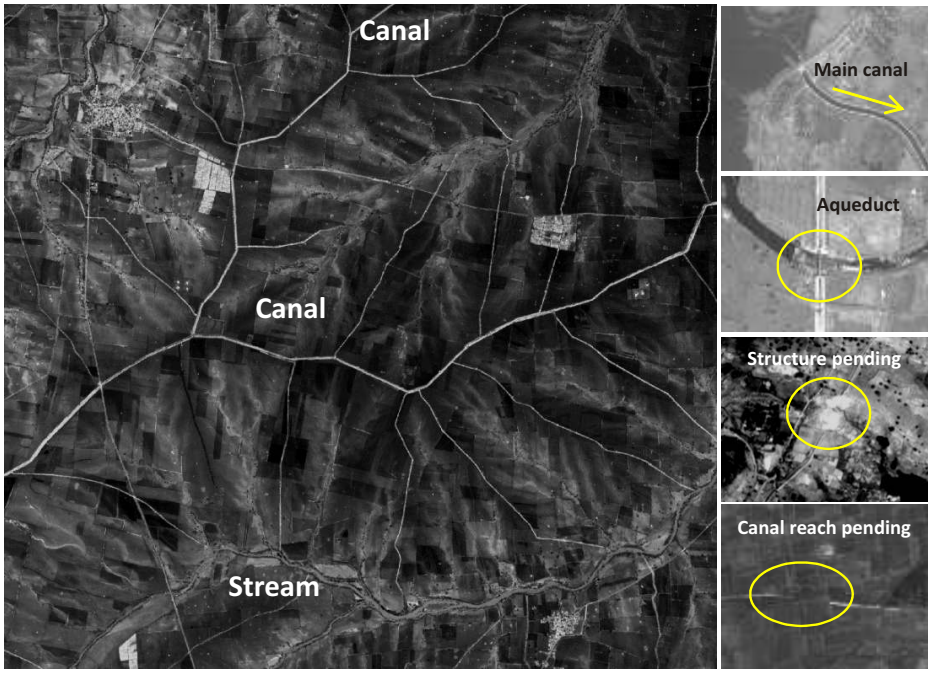


Snow Cover Layer used for Snow Cover Fraction at 3'x3' Grid



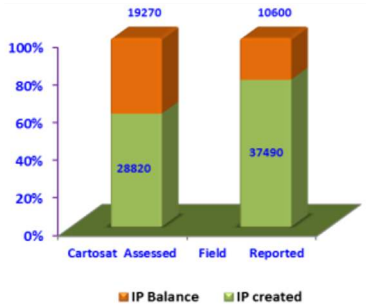
MONITORING IRRIGATION INFRASTRUCTURE

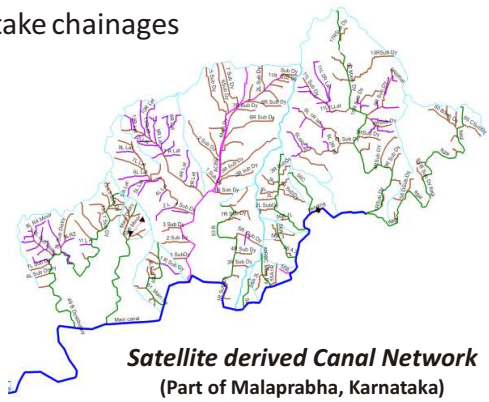
Comprehensive monitoring of irrigation projects is being carried out by Central Water Commission (CWC), Ministry of Water Resources (MoWR), under Accelerated Irrigation Benefit Programme (AIBP) for optimum utilisation of resources, and speedy and timely completion of projects. High-resolution Cartosat satellite data provide inventory of Irrigation Infrastructure (canal network and associated structures), assessment of the progress of Irrigation works, and synoptic view of the progress of construction including critical gaps.



Satellite data enable

- Identification of Canals up to minor level, irrigation & cross drainage structures
- Measurement of lengths, off-take chainages
- Capturing Status of each canal





Satellite derived Canal Network
(Part of Malaprabha, Karnataka)

MAJOR HIGHLIGHTS

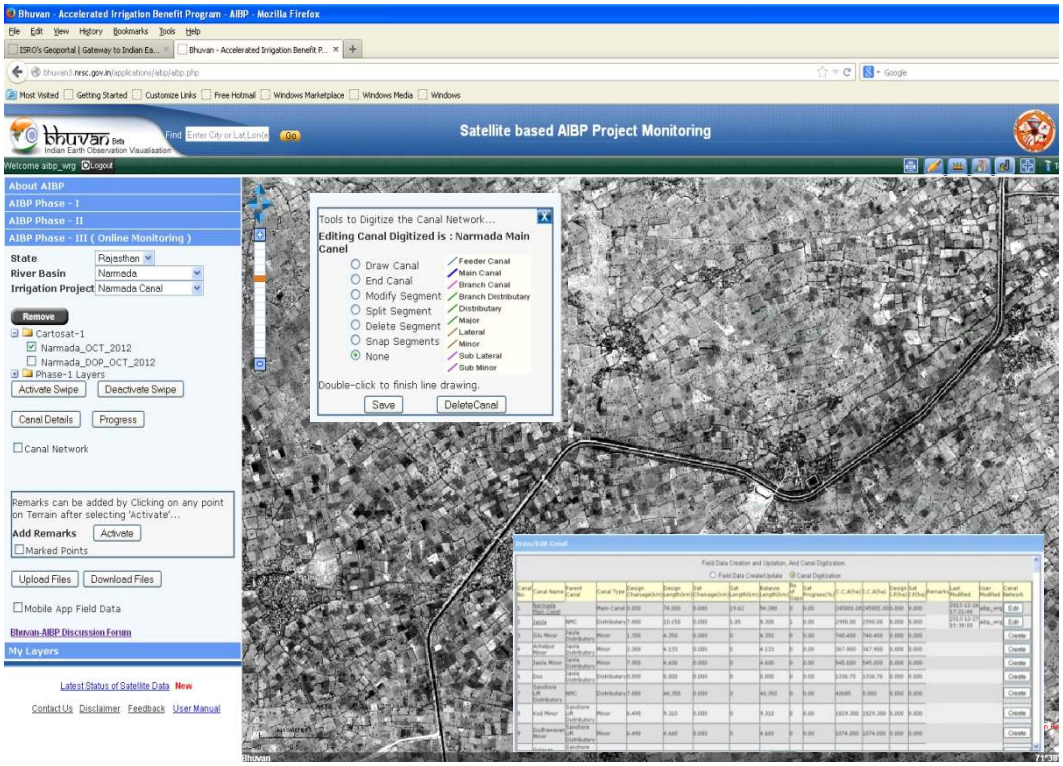
- Operationally implemented in 103 irrigation projects across 20 States
- Technology transferred through Internalisation in CWC/MoWR
- Capacity building carried out in State Remote Sensing Centres
- Developed an easy to use customised *AIBP-Bhuvan* web application for satellite-based online monitoring of AIBP projects

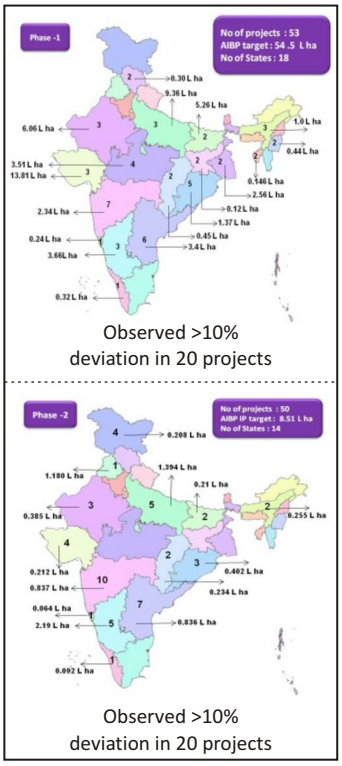
MAJOR BENEFITS

- Ground reality is captured
- Time stamping of Irrigation Infrastructure
- Identification of critical gaps
- Prioritisation of works
- Compliance monitoring
- Effective project implementation
- Irrigation Potential Creation assessment

MONITORING IRRIGATION INFRASTRUCTURE

SATELLITE-BASED ONLINE MONITORING OF AIBP PROJECTS





AIBP monitoring web page: http://bhuvan3.nrsc.gov.in/applications/aibp/aibphome/aibp.html

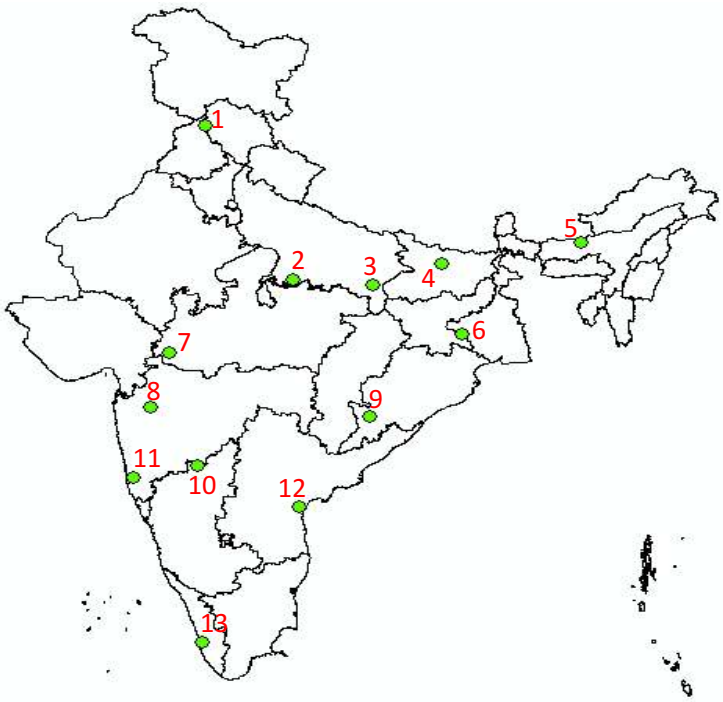
Highlights

- Simple web-based monitoring system
- Controlled access by field, regional, central monitoring offices of CWC and MoWR
- Geo-tagging of ground truth photographs using mobile application
- Online digitisation, editing tools and physical and financial progress tables
- Facility of viewing temporal progress

Implementation

- Decision taken by MoWR for implementation of satellite-based monitoring of all AIBP projects in a phased manner
- Currently, CWC is implementing in 13 AIBP projects with the help of NRSC/ ISRO

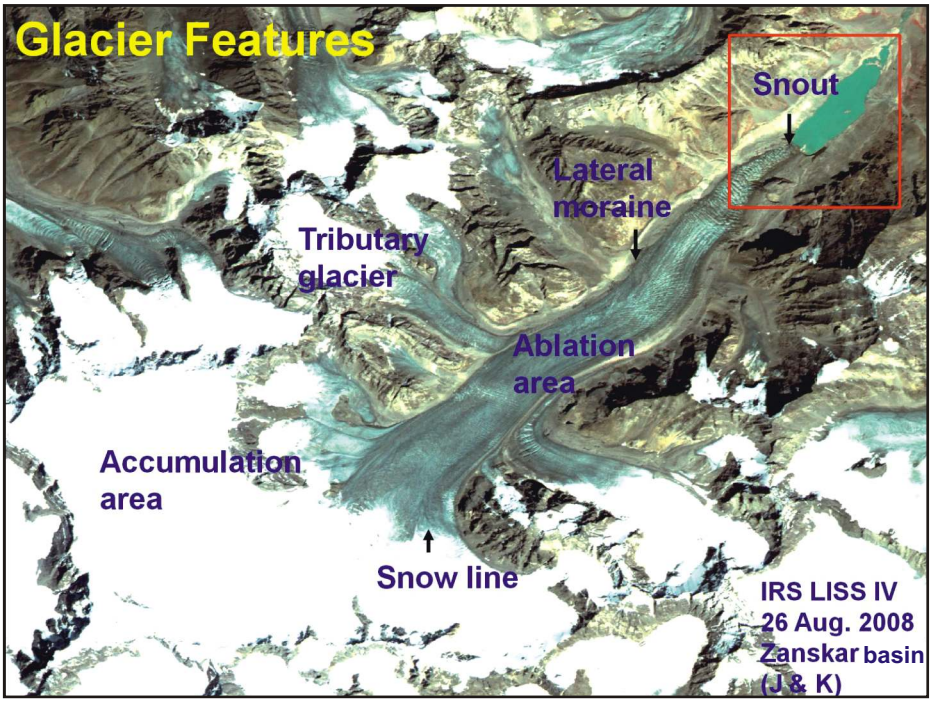
Locations of Satellite-based Online Monitoring of AIBP Projects



MONITORING HIMALAYAN GLACIERS

The great northern plains of India sustain on the perennial melt of snow and glaciers of Himalayan region meeting the water requirements of agriculture, industries, domestic sector even in the months of summer when large tracts of the country go dry. Therefore, it is important to make an inventory, monitor and assess the state of snow and glaciers and to know the sustainability of glaciers in view of changing climate and to ensure water security of the nation using space-based observations. Satellite images obtained from Indian Remote Sensing Satellite (IRS) have been used for making an inventory and monitoring of Himalayan glaciers on 1:50, 000 scale and also to carry out mass balance studies.

IRS LISS-IV Image of Zanskar Area Showing Glacier Features
(Date of image acquisition: 26 August, 2008)



Glacier morphology features such as accumulation area, ablation area (ice-exposed and debris-covered) have been mapped for 34,919 number of glaciers covering 75,779 km^2 glaciated area in the Indus, Ganga and Brahmaputra basins.

Study Period: 2004-2008

Partner Institutions: R&D Institutions, State Remote Sensing Centres & Universities

ACHIEVEMENTS

- Inventory of Himalayan glaciers in GIS environment on 1:50, 000 scale using IRS data
- Monitoring the changes in Himalayan glaciers and associated glacial lakes
- Glacier mass balance estimation

FUTURE PERSPECTIVE

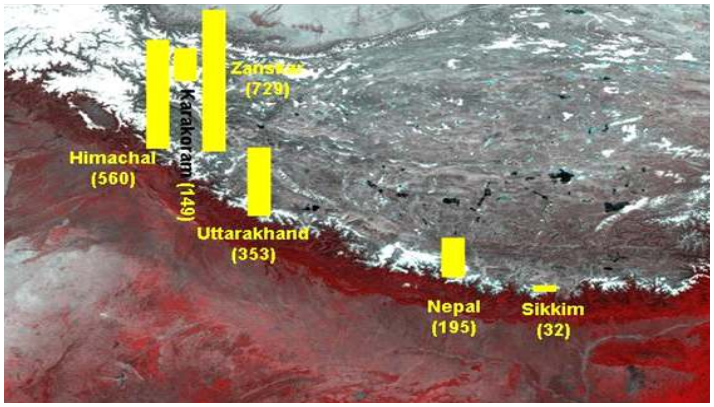
- Glacier inventory and monitoring glacier changes at large scale (1:10,000) using high-resolution satellite data
- Synergistic utilisation of optical and SAR data for glacier mapping
- Improvements in glacier mass balance estimation and validation using field-based measurement
- Photogrammetry, SAR Interferometry, GPS and GPR based studies for glacier dynamics

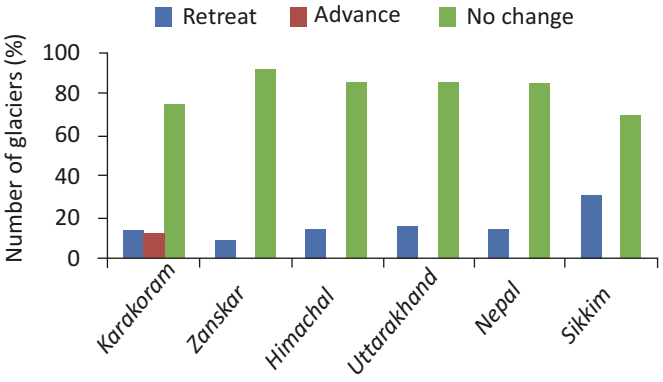
MONITORING HIMALAYAN GLACIERS

Advancement & Retreat of Glaciers

The advance and retreat of 2018 glaciers have been studied during 2001 - 2011 period.

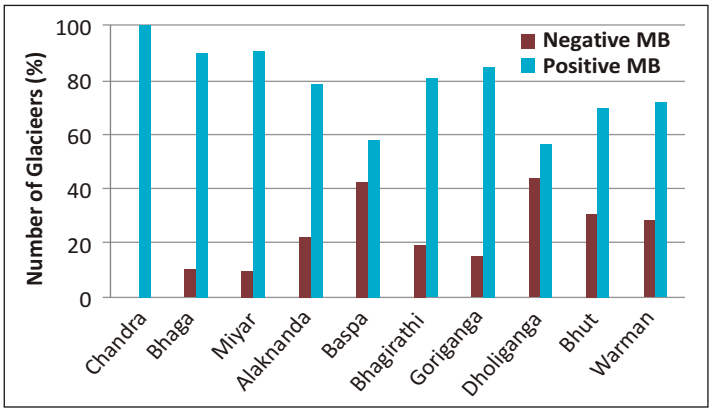
It is observed that 1752 glaciers show no change, 248 glaciers show retreat and only 18 glaciers show advancement.





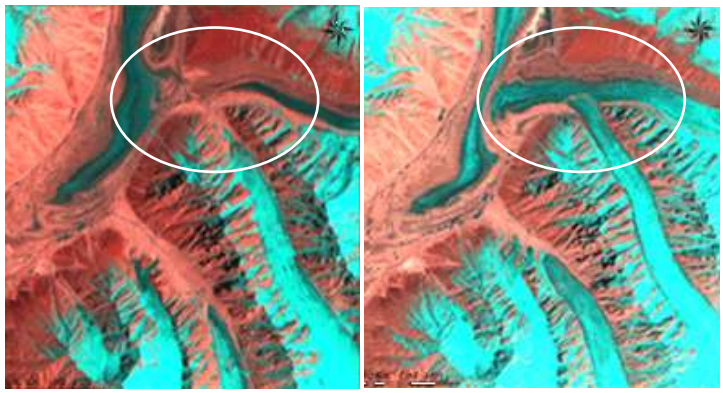
Glacier Mass Balance

The mass balance study of glaciers provides estimation of relative increase or decrease in mass of glacier over a period of time. The gain or loss in glacier mass is measured as positive or negative mass balance and relates to the health of glacier.



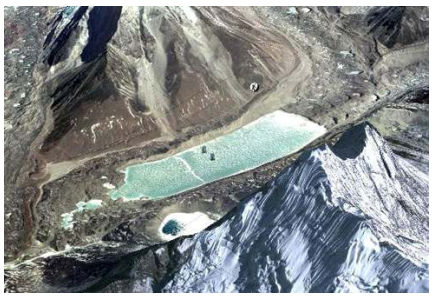
	2012	2011	2010
No. of Glaciers	1037	843	733
Negative	478	151	148
Positive	559	692	585
SMB		+34cm	22cm

IRS LISS-III Images of 2001 (left) and 2010 (right) Showing Advancement of Panmah Glacier, Karakoram Region



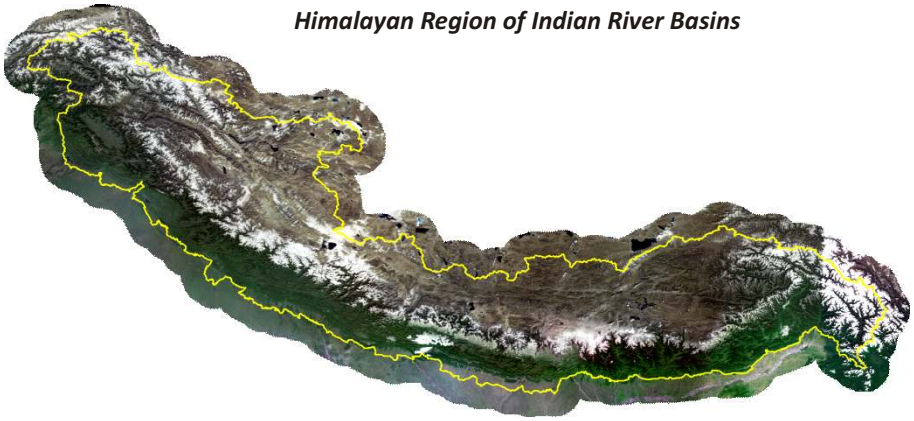
Monitoring of Himalayan glaciers using medium to high resolution satellite data and glacier mass balance studies depict the present status and likelihood future scenario towards water security and climatic variations in the country.

INVENTORY AND MONITORING OF GLACIAL LAKES

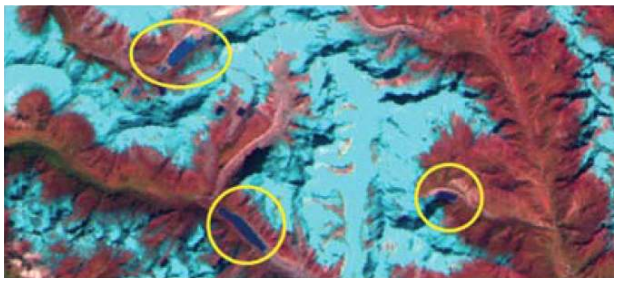


Glacial lakes are common in the high elevation zones of glacierised basins. They are formed when glacial ice or moraines impound water. The moraine creates topographic depression in which the melt water is generally accumulated leading to formation of glacial lake. The impoundment of the lake may be unstable, leading to sudden release of large quantities of stored water. Flash floods caused by the outburst of glacial lakes, called as Glacial Lake Outburst Flood (GLOF), and water bodies formed by landslides are common phenomenon in the Himalaya. Satellite remote sensing techniques are used to map, inventory and monitor the glacial lakes & water bodies in the Himalayan region of Indian river basins.

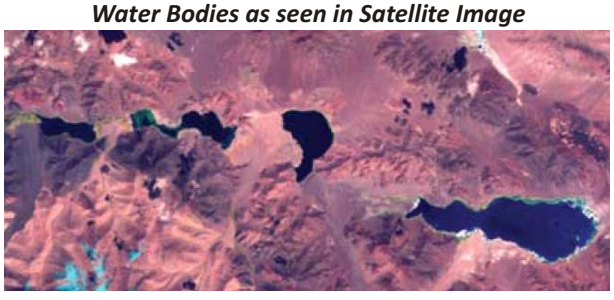
Himalayan Region of Indian River Basins



Glacial Lakes as seen in Satellite Image



Water Bodies as seen in Satellite Image



MAJOR HIGHLIGHTS

- Glacial lakes - 503
- Water bodies - 1525
- 1600 glacial lakes & water bodies have water spread area between 10 and 50 ha
- 200 water bodies have water spread area between 50 and 100 ha
- Over 50% of glacial lakes & water bodies (1169 nos.) are located within elevation range of 4,000 to 5,000 m

MAJOR BENEFITS

- Identification of potentially dangerous lakes prone for GLOF
- Prioritisation of glacial lakes for GLOF studies
- Climate change analysis

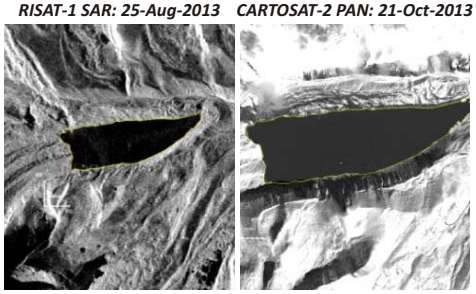
INVENTORY AND MONITORING OF GLACIAL LAKES

OPERATIONAL PRODUCTS / SERVICES

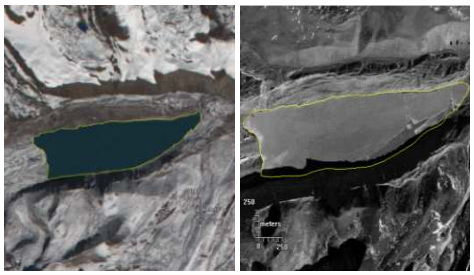
- Inventory of glacial lakes & water bodies with water spread area more than 10 ha
- Monitoring of glacial lakes & water bodies that are more than 50 ha in size: on monthly basis during June to October months for 5 years (2011-2015)
- Regular monitoring of two lakes (Lhonak lake in Sikkim and Pareechu lake) with high-resolution satellite data carried out during 2013
- Information on inventory & monthly changes hosted in *Bhuvan* & *India-WRIS* portals
- Useful for identification of potentially dangerous lakes prone to GLOF

South Lhonak Lake, Sikkim

RISAT-1 SAR: 25-Aug-2013 *CARTOSAT-2 PAN: 21-Oct-2013*

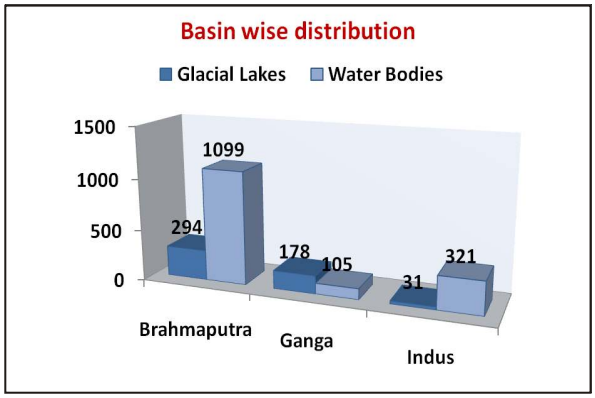


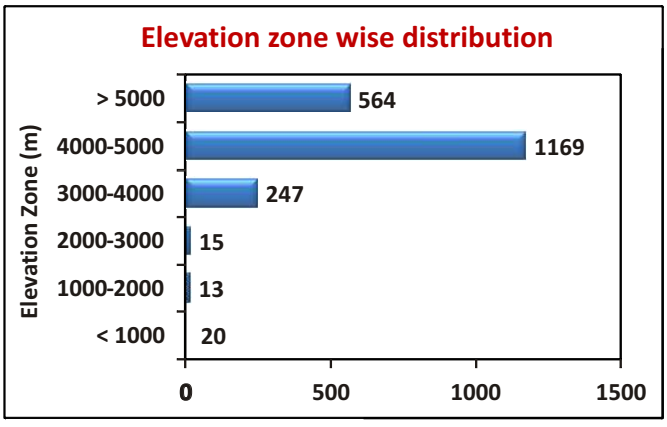
RESOURCESAT-2 LISS IV MX: 04-NOV-2013 *CARTOSAT-2 PAN: 01-Jan-2014*

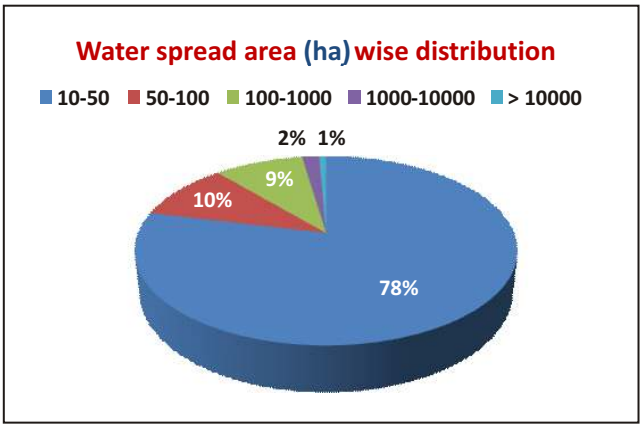


Elevation Zone-wise Distribution of Glacial Lakes

Elevation Zone (m)	Number of Glacial Lakes as per Water Spread Area (ha)					
	10- 50	50-100	100-1000	1000-10000	>10000	Total
< 1000	5	3	4	5	3	20
1000-2000	6	3	3	1		13
2000-3000	11	2	1	1		15
3000-4000	205	21	19	2		247
4000-5000	929	104	104	24	8	1169
>5000	439	68	52	2	3	564
Total	1595	201	183	35	14	2028

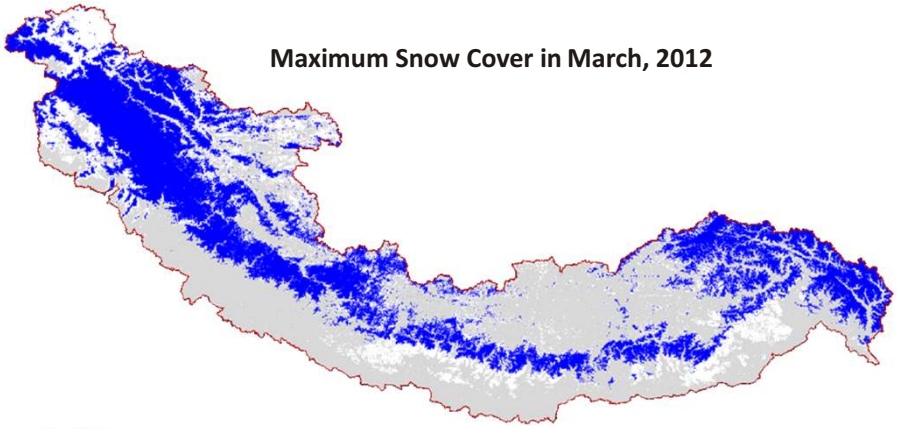


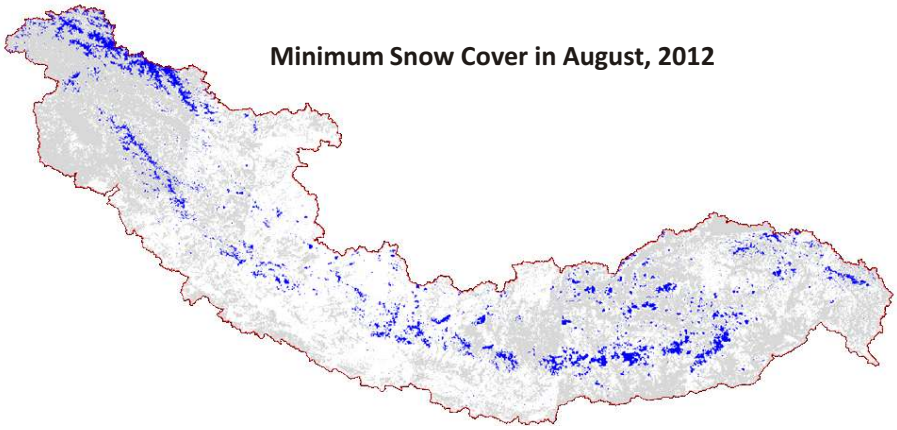




SNOWMELT RUNOFF MODELING

Snow is an important natural reservoir of fresh water resources. The snowmelt runoff occurring mostly during April to June months due to increased energy input from solar radiation, constitutes a substantial part of the water resources of the major perennial rivers of India. In summer months the snowmelt runoff is of vital importance for drinking water, hydropower generation and irrigation. Therefore, correct and timely information about the volume of snowmelt runoff likely to occur is of great importance to the managers of water resources. Remote sensing is the only tool to capture snow cover dynamics for the inaccessible Himalayan region. Snow cover being highly dynamic, the spatial extent can be captured in a cost-effective manner on daily basis.





MAJOR HIGHLIGHTS

- Snow Cover Mapping
- Snowmelt Runoff Modeling
- Snowmelt Runoff Forecasting

MAJOR BENEFITS

- Estimation and Forecasting of Snowmelt Runoff
- Water Allocation for Drinking water, Irrigation and Hydro-power generation
- Estimation of Hydel power potential
- Identification of suitable locations for Hydel Projects
- Climate Change Studies
- Winter sports Planning
- Infrastructure Planning

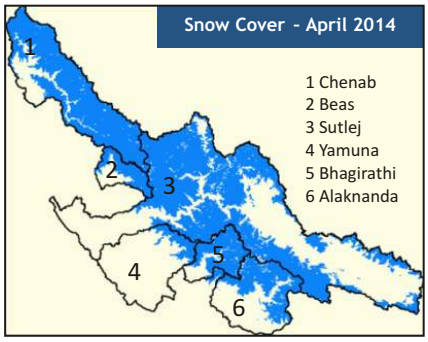
SNOWMELT RUNOFF MODELING

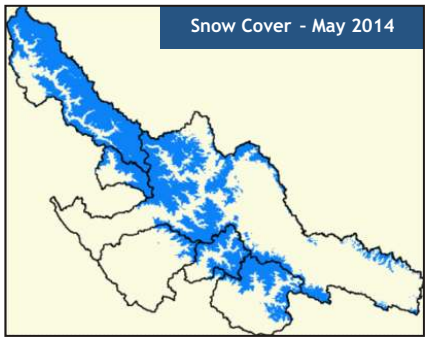
Snowmelt Runoff Forecast Models

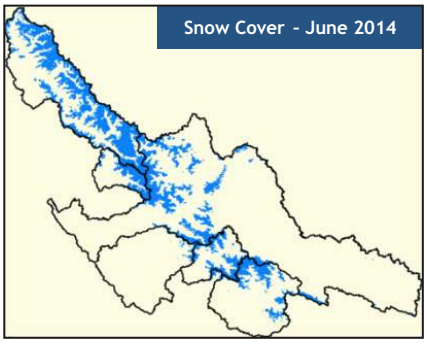
- Seasonal (April to June months)
- Short-term (16-day)

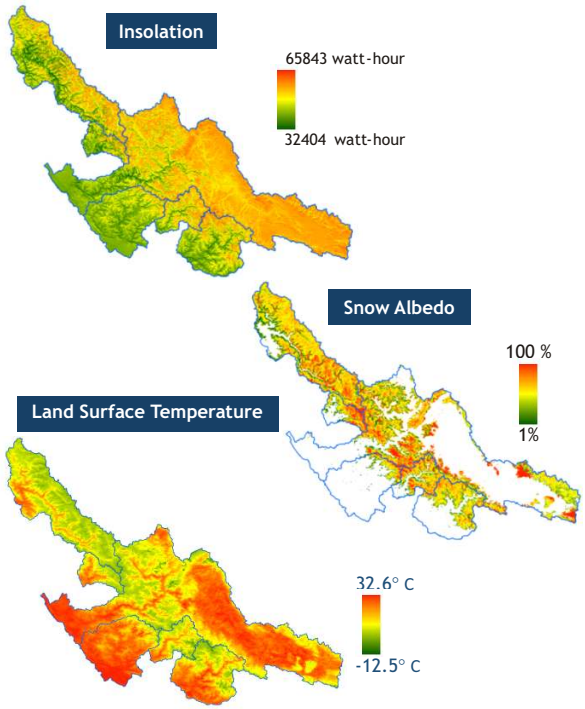
Methodology

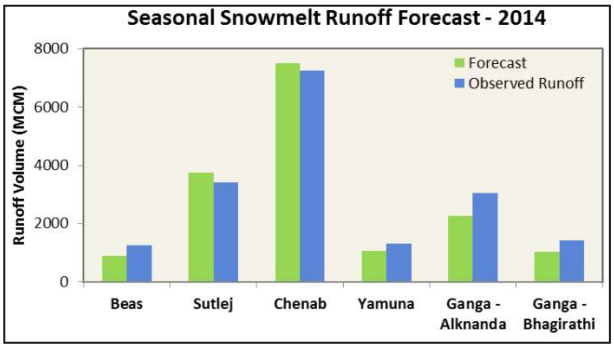
- Snowmelt runoff forecasting based on Energy Balance approach
- Physical-based model incorporates satellite data derived inputs such as snow cover, snow albedo, land surface temperature, land-use / land-cover, glacier cover, DEM
- The model incorporates atmospheric and land-cover interactions with energy components and local topographic orientation
- Snow depth is indirectly accounted by snow persistence index
- Integration of satellite derived inputs and field data such as rainfall and discharge

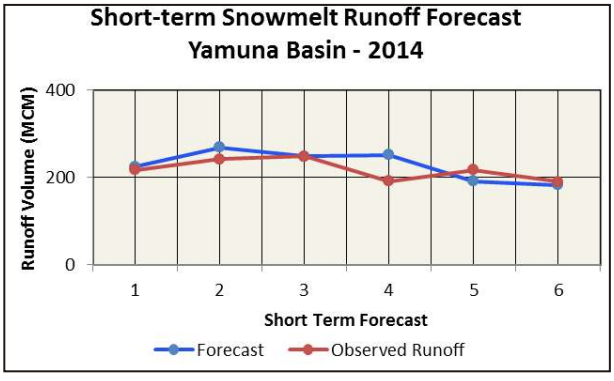






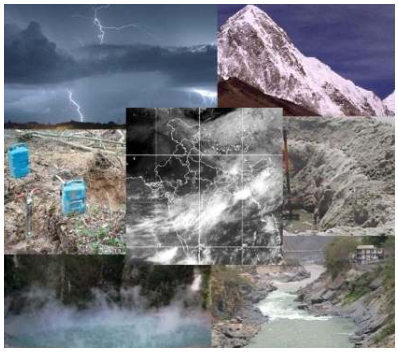






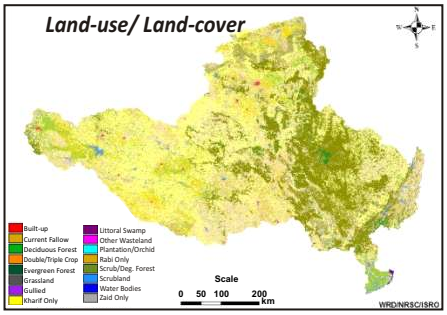
NATIONAL WATER RESOURCES ASSESSMENT

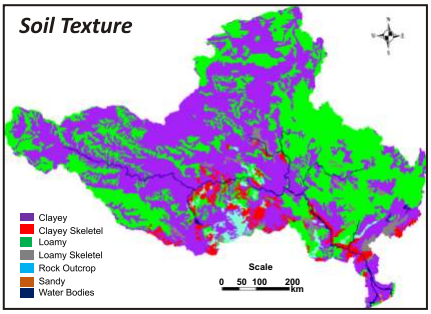
(A PILOT STUDY IN GODAVARI AND BRAHMANI-BAITARANI BASINS)

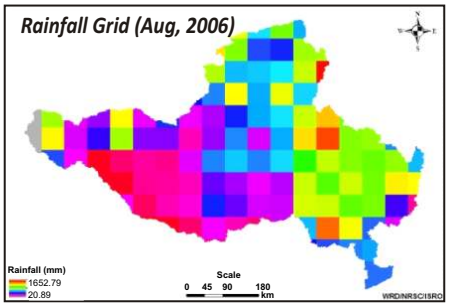


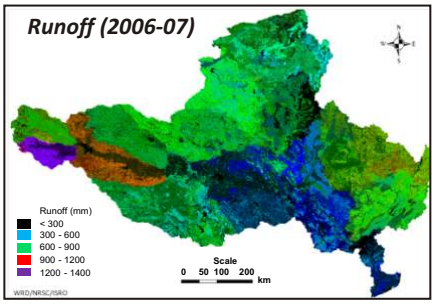
Earlier, different commissions, agencies, have estimated water resources of the country using different approaches. All these studies were based on the observed flows at terminal sites and upstream abstractions for irrigation and domestic consumptions. Limitations of these studies are: limited field data on abstractions, lumped approach, no meteorological data were taken into consideration, and no mechanism for cross-validation. Considering the importance of re-assessment of water resources availability in the country, ISRO has initiated an R&D Project titled "Assessment of National Water Resources using Space Inputs." After thorough discussions with Central Water Commission, New Delhi, a joint pilot study has been executed by NRSC and Central Water Commission (CWC) in the Godavari and Brahmani - Baitarani Basins.

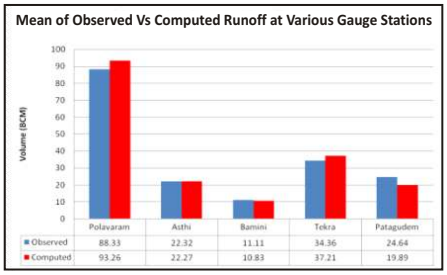
The Godavari Basin

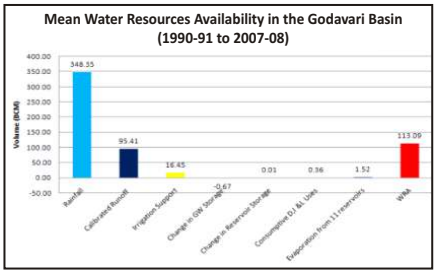












MAJOR HIGHLIGHTS

- Assessment of annual water resources during 20 years (1988-89 to 2007-08) at basin scale using space inputs through distributed hydrological modelling approach
- Assessment of water resources in extreme maximum and minimum rainfall years during the last 35 years

MAJOR BENEFITS

- Latest update on water resources availability at basin scale
- Information on spatial variability of water resources
- More accurate as it follows a process-based distributed modeling approach

NATIONAL WATER RESOURCES ASSESSMENT

(A PILOT STUDY IN GODAVARI AND BRAHMANI-BAITARANI BASINS)

SPATIAL AND NON-SPATIAL DATABASE

Static Data: Land-use / land-cover (LULC) maps of 2004-05 to 2007-08, 1985 & 1995, Soil Texture map, Digital Elevation Model (DEM), and Command Area map

Dynamic Data: Daily rainfall and temperature grids of 20 years at 0.5 and 1 degree resolutions respectively (IMD); River discharge at various gauge locations and reservoir flux data (CWC); Groundwater flux data (CGWB); Demographic data (1991 and 2011 Census)

RESULTS

Godavari Basin

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Min.	2002-03	275.50	72.63
Max.	1994-95	435.88	178.70
Mean	1990-91 to 2007-08	348.35	113.09

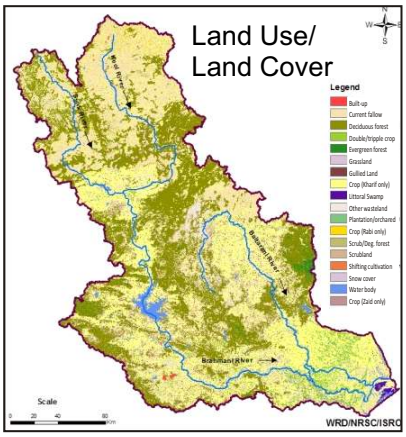
Brahmani-Baitarani Basin

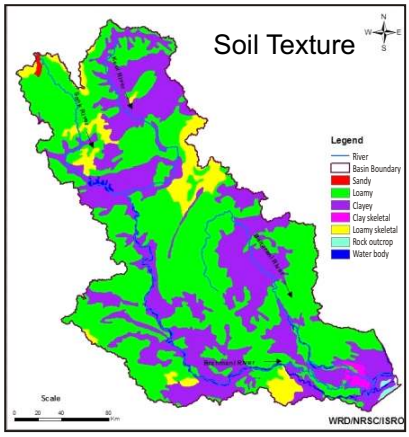
Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Min.	2004-05	42599	14421
Max.	1994-95	101932	62417
Mean	1988-89 to 2007-08	74892	35129

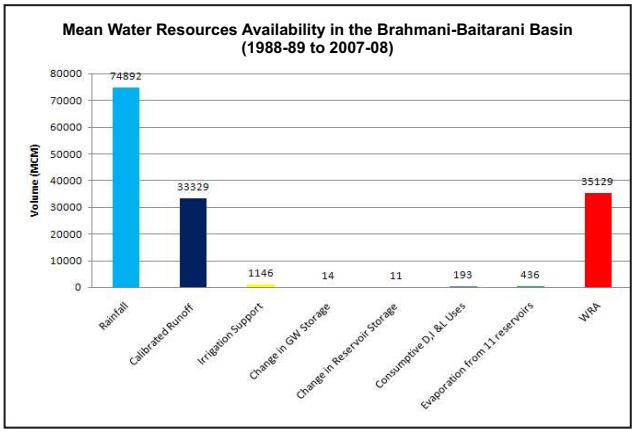
BCM: Billian Cubic Meter

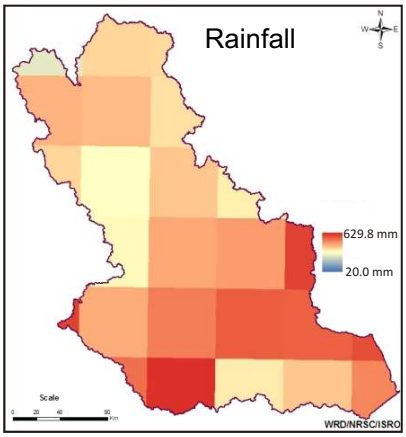
*mean rainfall of 1971-72 to 1984-85

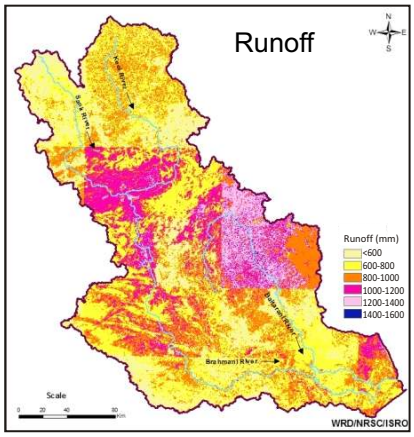
Brahmani-Baitarani Basin

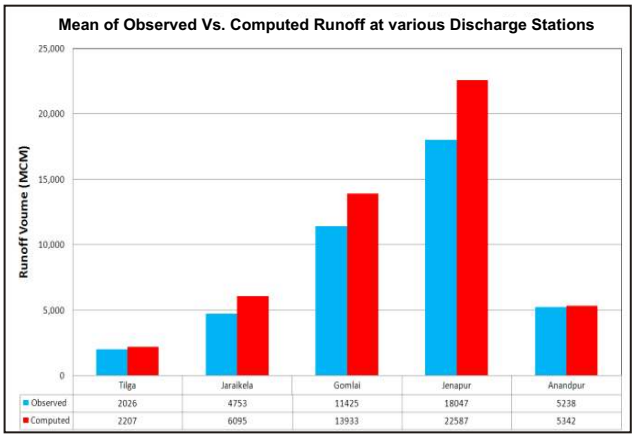












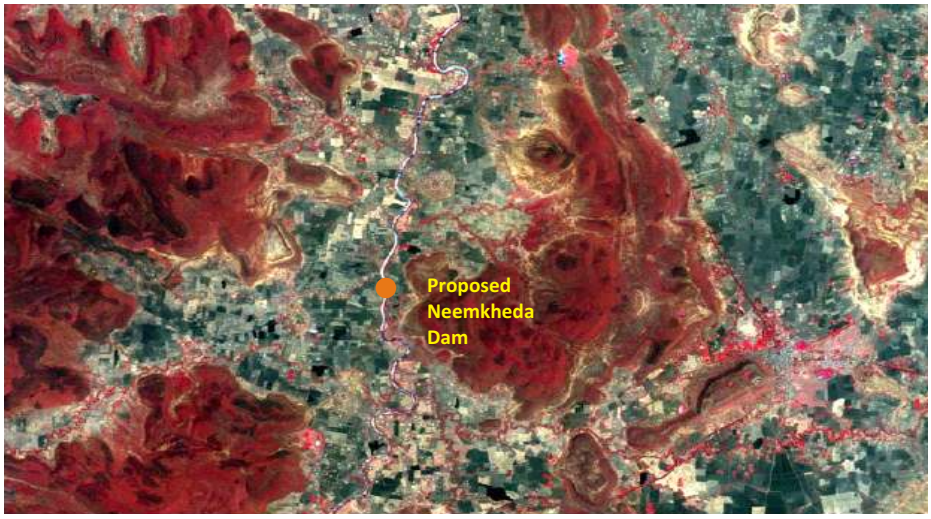
SPACE INPUTS FOR INTERLINKING OF RIVERS

Space technology plays a critical role in meeting the information requirements for efficient planning and management of the water resources systems.

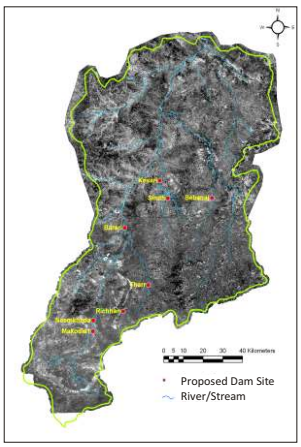
Remote sensing data from space have demonstrated their operational capability towards mapping and monitoring of many water resources projects. Cartosat-1 & Resourcesat LISS-IV data provide suitable inputs and information for proposed new projects. ISRO has carried out a few studies to provide inputs for feasibility studies conducted for Interlinking of Rivers. There is a huge scope for such studies in the light of proposed projects under Interlinking of Rivers in India.

Ken-Betwa River Linking Project

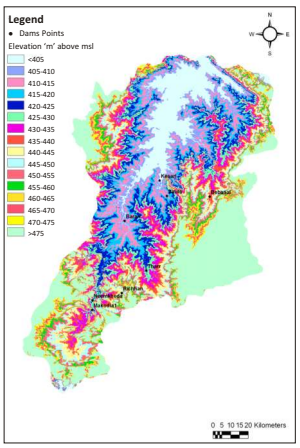
Location of Proposed Dams in Ken-Betwa River Link Project



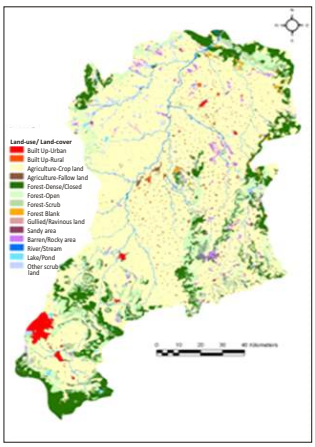
Cartosat Data



Digital Elevation Model



Land-use / Land-cover



MAJOR HIGHLIGHTS

- Generation of close contour information
- Land-use/Land-cover Information
- Dam submergence area analysis and identification of irrigation commands
- High-resolution satellite data
- Design for canal alignments
- Maps generation at required scales

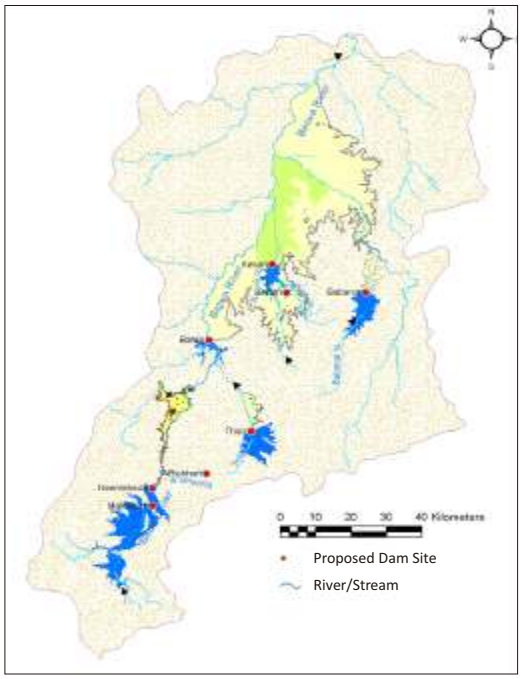
MAJOR BENEFITS

- Information for decision support for planning new water resources projects
- Time saving in preparation of feasibility reports
- Objective assessment of resources
- Better understanding for dealing Rehabilitation & Relocation (R & R) aspects

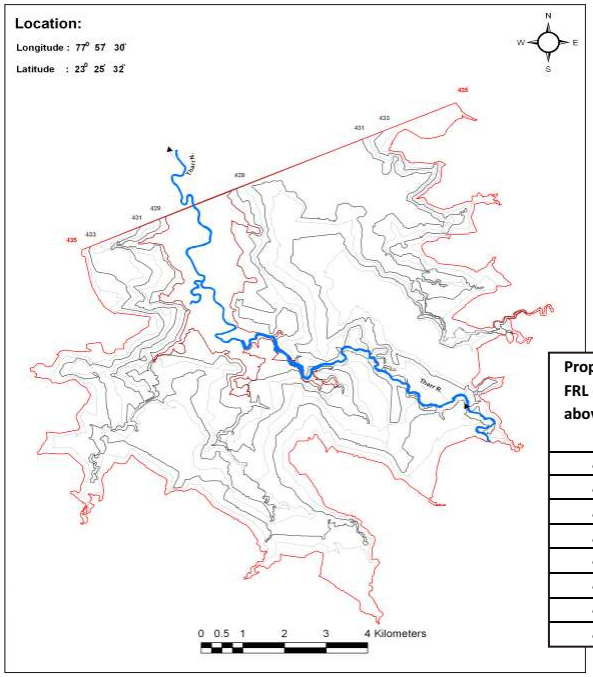
SPACE INPUTS FOR INTERLINKING OF RIVERS

Deliverables

Proposed Submergence and Irrigation Commands in Ken - Betwa River Link

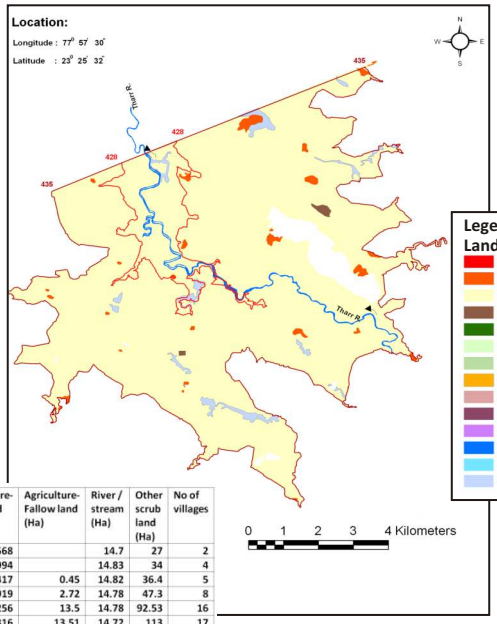


Contours Interpolated from Cartosat Data (minimum to maximum proposed FRLs): Tharr Dam

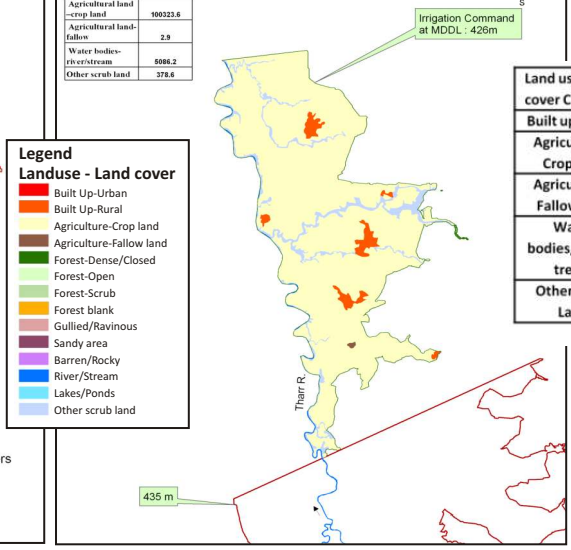


Proposed FRL (m) above MSL	Total Submergence Area (Ha)
428	611
429	1049
430	1480
431	1997
432	3420
433	4501
434	5587
435	6698

Proposed Dam Submergence and Irrigation Command Area



Land Use- Land Cover	Area in ha.
Built up-built up (rural)	98.7
Agricultural land –crop land	100323.6
Agricultural land-fallow	2.9
Water bodies-river/stream	5086.2
Other scrub land	378.6



Land use Land cover Class	Area (Ha)
Built up (rural)	98.7
Agricultural-Crop land	100323.6
Agricultural-Fallow land	2.9
Water bodies/river/stream	5086.2
Other Scrub Land	378.6

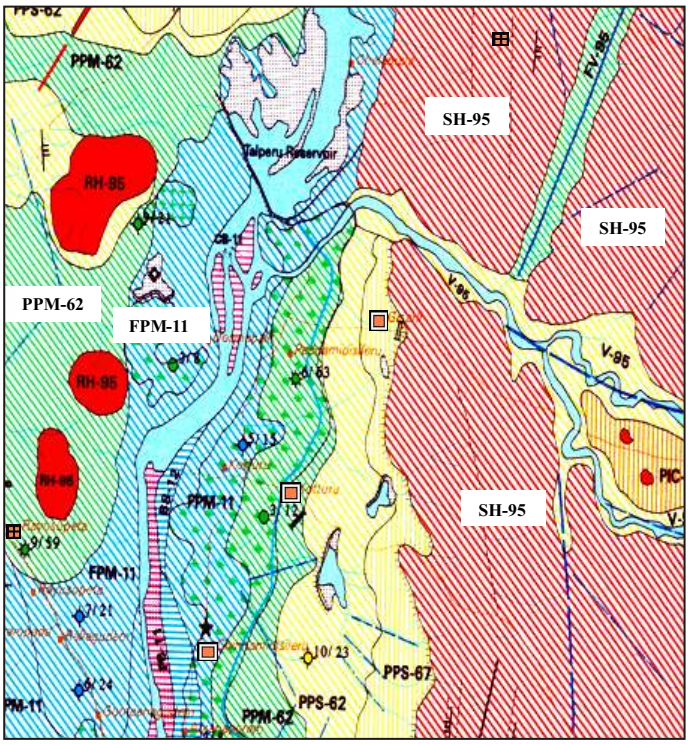
Proposed FRL (m)	Cumulative Storage (Cu.m)	Total Area (Ha)	Builtup (Rural) (Ha)	Agriculture-Crop land (Ha)	Agriculture-Fallow land (Ha)	River / stream (Ha)	Other scrub land (Ha)	No of villages
428	16.29	611	0.8	568		14.7	27	2
429	24.50	1049	6.8	994		14.83	34	4
430	37.08	1480	11	1417	0.45	14.82	36.4	5
431	54.40	1997	12.3	1919	2.72	14.78	47.3	8
432	81.17	3420	3.1	3256	13.5	14.78	92.53	16
433	120.65	4501	52.7	4316	13.51	14.72	113	17
434	170.99	5587	59.95	5381	13.51	14.68	118	20
435	232.33	6698	86.3	6456	13.61	14.67	129	25

GROUND WATER PROSPECTS MAPPING

Timely and reliable information about the occurrence of ground water is a pre-requisite to meet its growing demand for human use. In India, satellite images are being used for over three decades for ground water targeting. In early 1999, a major initiative to generate scientific database towards addressing the drinking water problem in the country was taken up by the Ministry of Rural Development, under the Rajiv Gandhi National Drinking Water Technology Mission (RGNDWM). Under this initiative, ISRO, was entrusted with a responsibility of preparing 'Ground Water Prospects' (GWP) maps at 1:50,000 scale using Remote Sensing & GIS technology. Initially, only five States were taken up; the programme was later extended to cover the entire country. The GWP maps show:

- *prospective zones of ground water occurrence; and*
- *tentative locations for constructing recharge structures.*

The GWP maps are being used by the State Line Departments across the country to address issues towards providing safe and sustainable ground water sources.



Ground water prospects map of a part of Khammam District (A.P.). The colour and hatching patterns depict the ground water prospects in terms of expected yield range and depth range of wells (for details, refer next page). The map is prepared by integrating lithological, geomorphological, structural and hydrological information derived from satellite imagery, ground data and existing maps/ literature.

MAJOR HIGHLIGHTS

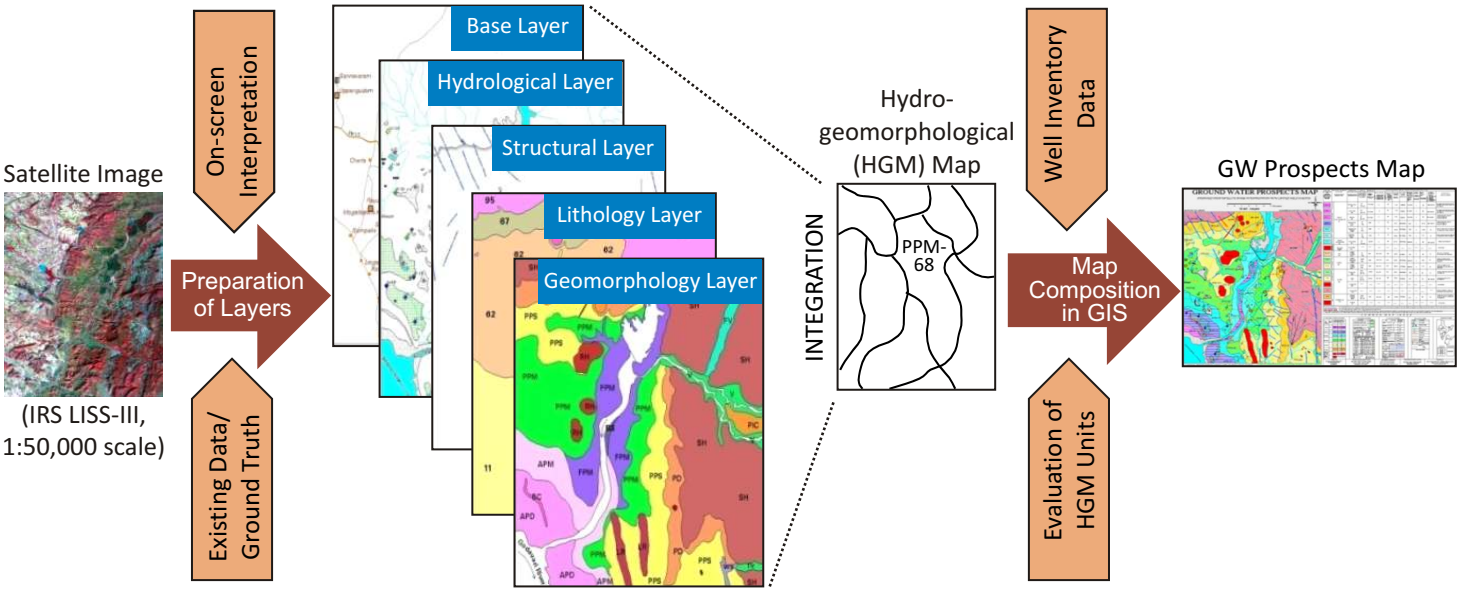
- Ground Water Prospects (GWP) maps are prepared for entire country (4,898 maps) at 1:50,000 scale
- GWP maps show prospective zones of ground water occurrence and tentative locations for putting up recharge structures
- About 2,000 officials of State Line Departments are trained to use these maps for scientific source finding

MAJOR BENEFITS

- GWP maps are being used extensively by the State Line Departments, both for selection of sites of water wells and for putting up recharge structures
- Feedback from the Line Departments of the State Govt. indicates significant improvement in Success rate of wells, especially in hard rocks
- GWP maps facilitated selection of sites for thousands of recharge structures in different States

GROUND WATER PROSPECTS MAPPING

METHODOLOGY

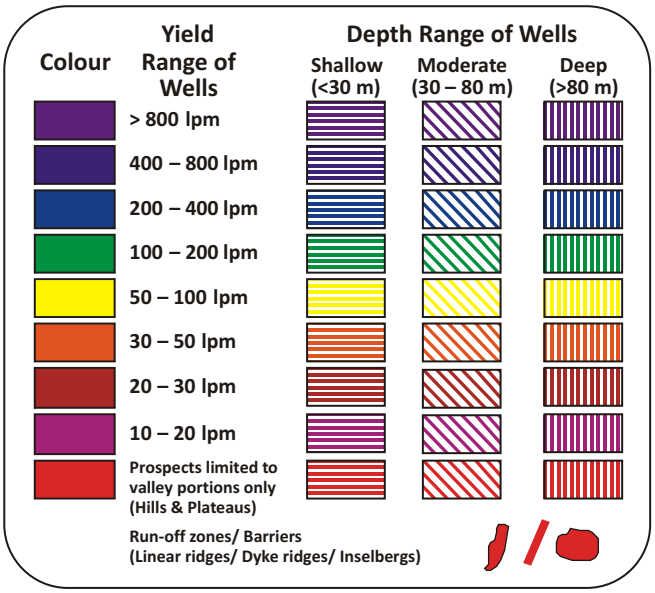


Hydrogeomorphic (HGM) units are depicted in the GWP map as alpha-numeric codes (e.g. PPM-68); alphabetic code represents geomorphology, while numeric code represents lithology. Geologic structures are depicted as line features in GWP maps. The prospects and tentative locations of recharge structures & their prioritisation are indicated for each HGM unit based on its nature, recharge conditions, exploitation status, and well data.

CONTENT OF THE MAP

- Hydrogeomorphic Unit (Map Unit)
- Geological Sequence/ RockType
- Geomorphic Unit/ Landform
- Depth to Water Table
- Recharge Conditions
- Nature of Aquifer Material
- Type of Wells Suitable
- Depth Range of Wells (Suggested)
- Yield Range of Wells (Expected)
- Homogeneity of Unit/ Success Rate of Wells
- Quality of water (Potable/ Non-Potable)
- GW Irrigated area (exploitation status)
- Recharge Structures Suitable & Priority
- Remarks (Problems/ Limitations)

SCHEME FOR DEPICTING GW PROSPECTS



UTILITY OF THE MAP

These maps are useful as a guide for narrowing down the target zones for detailed ground-based hydrogeological and geophysical investigations. The exact site for drilling of wells and for putting up recharge structures should be identified based on follow-up ground surveys/ exploration.

FUNDING MINISTRY & PARTNER INSTITUTIONS

Funding Ministry: Ministry of Drinking Water & Sanitation, Govt. of India (formerly Ministry of Rural Development)

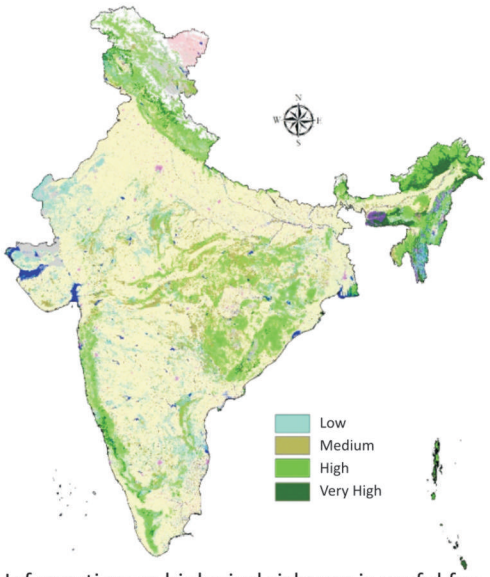
Partner Institutions: State Remote Sensing Centres; R & D Institutions; Universities; Geospatial Industry

FOREST AND ENVIRONMENT

FOREST AND ENVIRONMENT

Conservation and management of forest cover, biodiversity and wildlife require reliable, regular and updated information about their status and condition in spatial domain. Space-based inputs have immensely contributed towards sustainable management of environmental resources required for maintaining ecological balance, supporting the livelihood of dependent communities and for national development.

Biological Richness at Landscape Level



Information on biological richness is useful for bio-prospecting and conservation prioritisation

A nation-wide study on Biodiversity Characterisation at Landscape level (BCLL) during 1997-2010 was taken up by Department of Space and Department of Biotechnology, Government of India.

Major outputs:

- Vegetation type
- Fragmentation status
- Disturbance index
- Biological richness

(http://bis.iirs.gov.in)

These databases are vital for developing future strategies for biodiversity conservation.

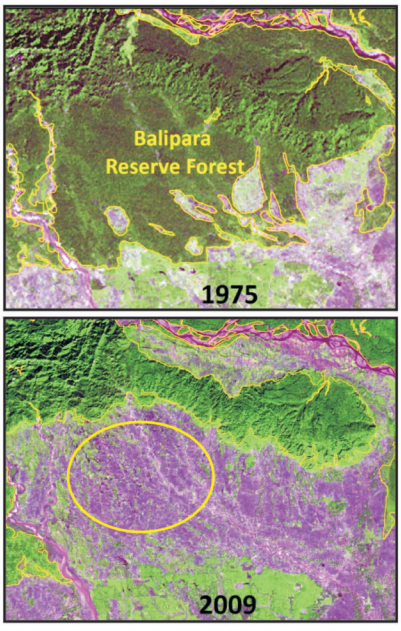
MAJOR HIGHLIGHTS

- Forest Cover Monitoring
- Biodiversity Characterisation at Landscape Level
- Biomass and Carbon Accounting
- Biosphere and Wildlife Habitats Mapping
- Eco-sensitive Zonation
- Forest Fire Detection and Burnt Area Assessment

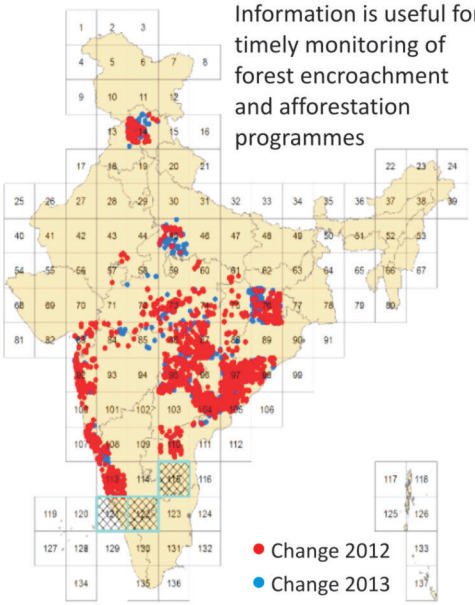
MAJOR BENEFITS

- Sustainable Management of Forest Resources
- Joint Forest Management
- Biodiversity Conservation and Protection
- Wildlife Conservation
- Forest Fire Control and Mitigation
- Strategic Environmental Impact Assessment

Large-scale Deforestation in Assam between 1975 and 2009



IRS AWiFS based Annual Forest Cover Loss Locations (Currently operational for 8 states)



Information is useful for timely monitoring of forest encroachment and afforestation programmes

FOREST AND ENVIRONMENT

OPERATIONAL PRODUCTS / SERVICES

- Biennial Forest Cover Status*
- Automated Annual/Sub-annual Forest Cover Change (currently functional for 8 States)
- Inputs to Biodiversity Conservation Planning at Landscape Level
- Forest Type Mapping
- Indian Forest Fire Response & Assessment System *(http://bhuvan.nrsc.gov.in/)*
- Inputs for Forest Working Plan Preparation & Protected Area Management Planning
- Wildlife Habitat Evaluation

**by Forest Survey of India*

RESEARCH AREAS

- Assessment of Afforestation at Early- Growth Stages
- Assessment of Carbon Source and Sinks through Eddy Flux Towers and Upscaling to Regional-level using Remote Sensing
- Forest Structure and Growth Modeling through Microwave and LiDAR Sensors
- Forest Health Assessment using Hyperspectral Sensors
- Monitoring Forest Phenology and Desiccation
- Inventory and Assessment of Non-Timber Forest Produce
- Long-term Ecological Studies

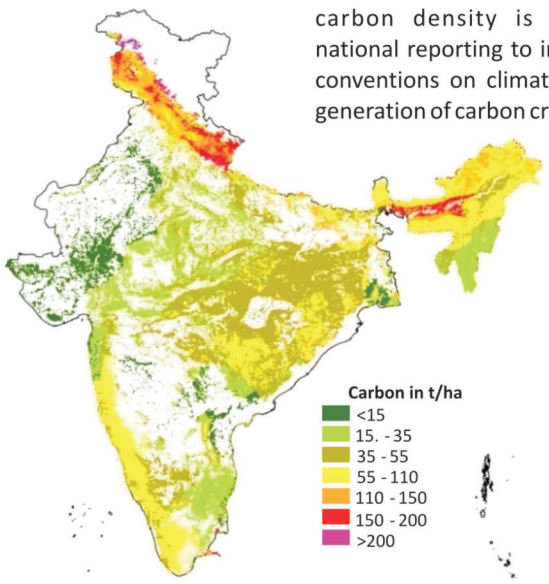
National Carbon Project

An initiative for Carbon Accounting

The study aims to quantify the exchange of carbon, mass and energy between the terrestrial environment and the atmosphere using remote sensing, geospatial analysis and process-based models.

Phytomass Carbon Density (2010)

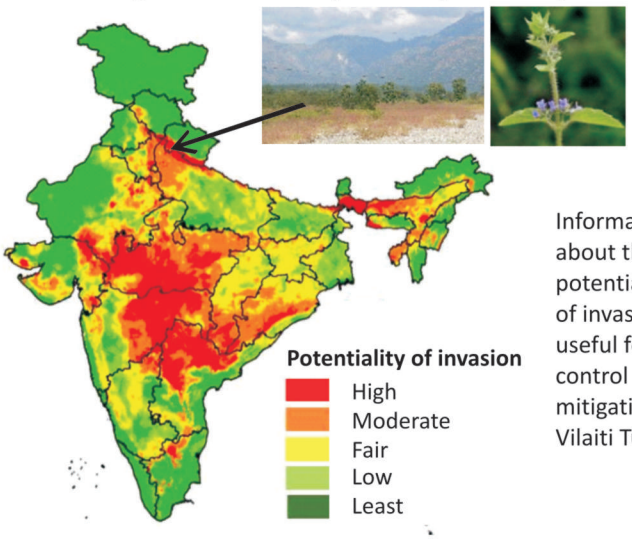
Baseline information on phytomass carbon density is useful for national reporting to international conventions on climate change & generation of carbon credits



Estimated Carbon Pool: 4368 TgC

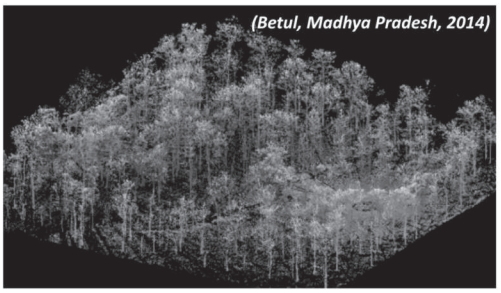
Possible Areas for Invasion of Vilaiti Tulsi (Hyptis suaveolens)

Vilaiti Tulsi is a rapidly spreading alien plant species in India and causing loss of biodiversity and ecosystem change



Information about the potentiality of invasion is useful for the control and mitigation of Vilaiti Tulsi

3D Structure of Teak Forest as seen by Terrestrial Laser Scanner



Information is useful for estimating forest carbon stock and monitoring forest growth & disturbance

PROTECTED AREA MONITORING

Biosphere Reserves

- Biosphere monitoring under UNESCO-MAB (Man and Biosphere) is critical for verifying conservation efficacy.
- Long-term satellite records help to address conservation issues.
- NNRMS sponsored study aims at analysing Land-use / Land-cover in four major biospheres.
- Study aims to assess temporal changes using IRS data in land-use dynamics (at 5 year interval, starting from date of notification - 1990, 1995, 2000, 2005 and 2010).
- The study showed that early declared Protected Areas have better conserved habitat than the recent ones.

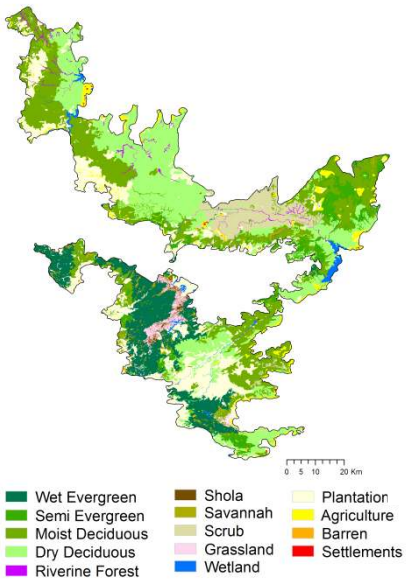
MAJOR HIGHLIGHTS

- Forest cover change
- Forest fragmentation
- Community diversity
- Decadal forest burnt area analysis
- Forest disturbance analysis
- Conservation zonation

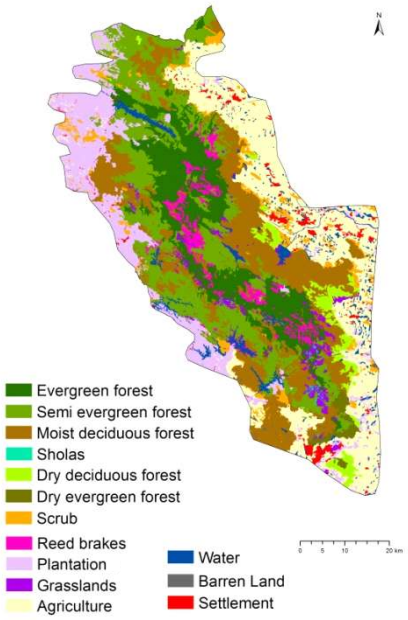
MAJOR BENEFITS

- Understanding of Conservation effectiveness of Biosphere Reserves
- Input to Protected Area management
- Prioritisation of conservation

Nilgiri Biosphere Reserve



Agasthyamalai Biosphere Reserve



Wet Evergreen Forest, Agasthyamalai

Shola Forest, Nilgiri

Wet Evergreen Forest, Nilgiri

Moist Deciduous Forest, Agasthyamalai

AUTOMATED FOREST LOSS ALERT SYSTEM

Identification of Forest Cover Loss Locations

India's forest cover, which accounts for about 21% of its geographical area, is monitored through satellite remote sensing on biennial basis. Recent concerns of the Ministry of Environment, Forest and Climate Change (MoEF & CC) has led to an initiative: Rapid Automated Detection of Forest Loss on Sub-annual/Annual basis. This information is essential if effective response to forest loss is to be put in place.

The challenges addressed for automated processing are: precise geometric registration, radiometric correction and unambiguous identification of commission areas due to cloud, cloud shadow as well as inter- and intra-annual variations in phenology, so as to identify change areas only.

IRS AWiFS data are used on a 2° x 2° tile basis for detection of forest cover loss with an area >2 ha. Computation of Normalised Integrated Forest 'Z' score is used in detection of forest loss.

Forest cover loss alerts were communicated for validation/feedback to 8 states viz., Andhra Pradesh, Chhattisgarh, Goa, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Telangana for the years 2011-12 and 2012-13.

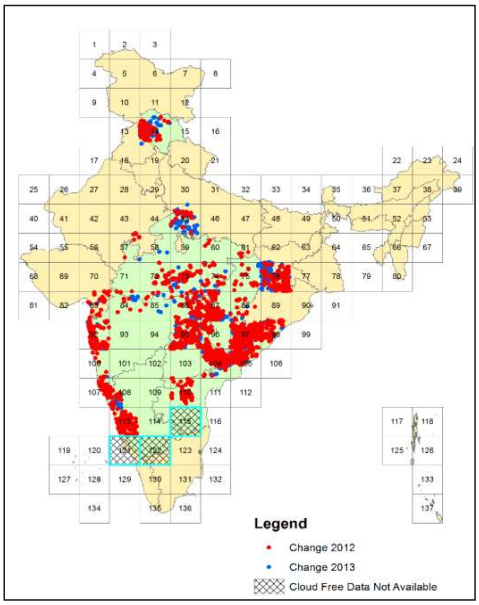
MAJOR HIGHLIGHTS

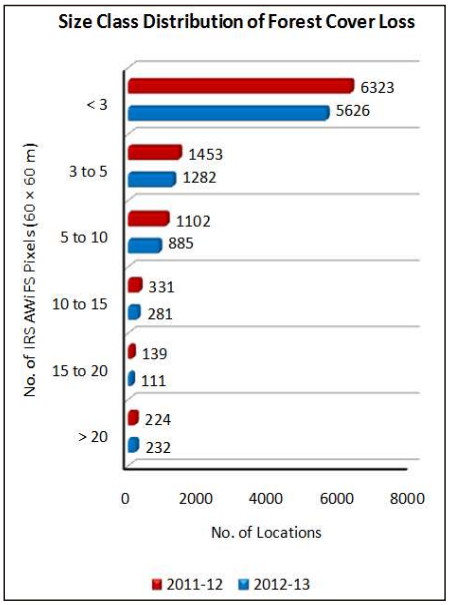
- Automated radiometric and geometric pre-processing of IRS AWiFS data
- Automated generation of cloud, cloud shadow and terrain shadow mask
- Automated identification of annual forest cover loss

MAJOR BENEFITS

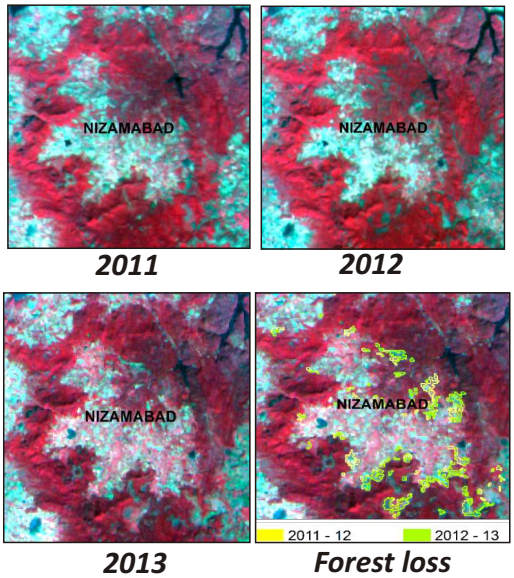
- Annual forest cover loss information to the State Forest Departments to aid in better forest management practices

Forest Cover Change Locations Across 8 States during 2011-12 and 2012-13





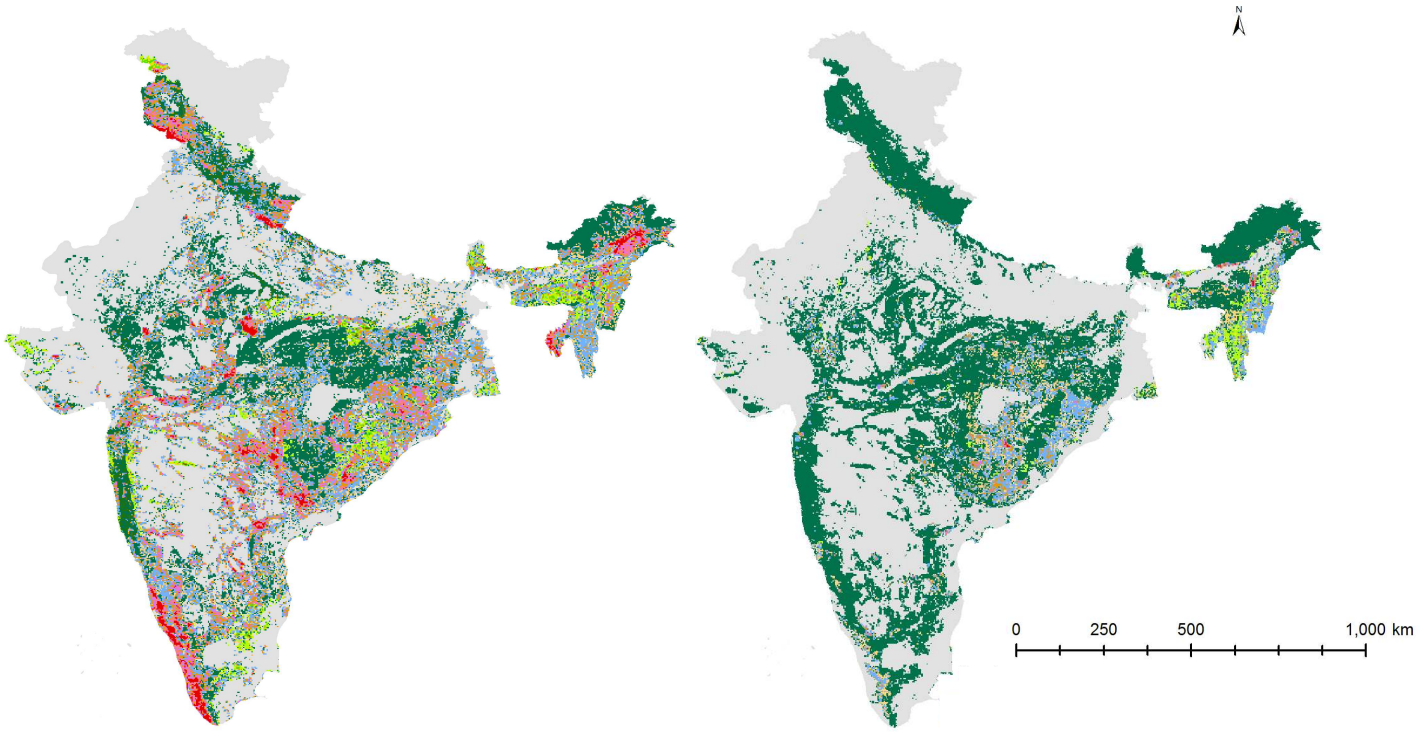
Forest Cover Loss Alerts for Parts of Nizamabad District, Telangana



LONG-TERM FOREST COVER CHANGE

Deforestation has been identified as a primary threat for the loss of biodiversity, responsible for 18% of global carbon dioxide emissions and affects the livelihoods of dependent people. As part of ISRO's National Carbon Project, a study on long-term changes in India's forest cover has been initiated. The map inputs on the forest cover loss are: (i) the 1920-1940 Survey of India topographical maps, and (ii) remote sensing data (Landsat MSS data of 1972-1975 and 1985; IRS-1B LISS-I data of 1995; IRS-P6 AWiFS data of 2005; and ResourceSat-2 AWiFS data of 2013). National level forest grid of 5 km x 5 km has been generated for time series assessment. On each spatial database, the change from year to year (1930-1975, 1975-2013, 1975-1985, 1985-1995, 1995-2005, 2005-2013) was evaluated. The annual deforestation rate of 0.63% in 1930s have come down during 2010-2011 to 0.03%.

Spatial Analysis of Long-term Forest Cover Change in India during 1930 to 2013



Change 1930 to 1975 (Grids)

Negative change	Positive change
<1 sq km loss (7866)	<1 sq km gain (849)
1-5 sq km loss (18637)	1-5 sq km gain (2013)
5-10 sq km loss (9281)	5-10 sq km gain (971)
10-15 sq km loss (4198)	10-15 sq km gain (392)
15-20 sq km loss (2213)	15-20 sq km gain (168)
>20 sq km loss (1755)	>20 sq km gain (53)

No forest change (22257)

Non forest (57712)

Change 1975 to 2013 (Grids)

Negative change	Positive change
<1 sq km loss (4752)	<1 sq km gain (611)
1-5 sq km loss (6174)	1-5 sq km gain (766)
5-10 sq km loss (1111)	5-10 sq km gain (69)
10-15 sq km loss (221)	10-15 sq km gain (13)
15-20 sq km loss (46)	15-20 sq km gain (0)
>20 sq km loss (32)	>20 sq km gain (1)

No forest change (43797)

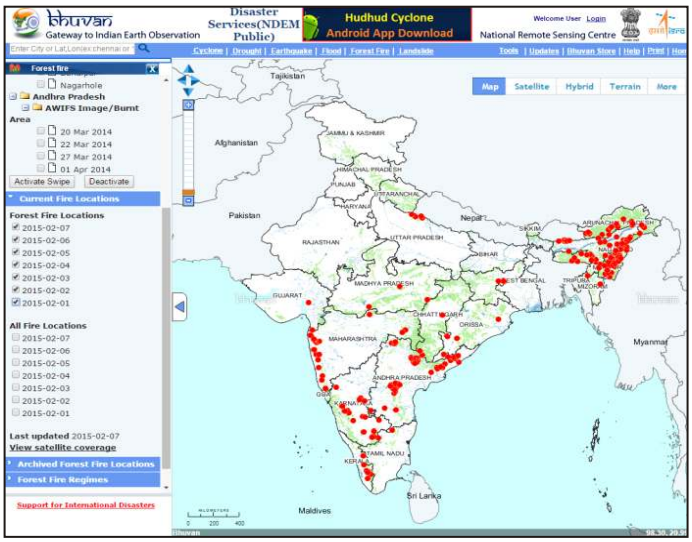
Non forest (72744)

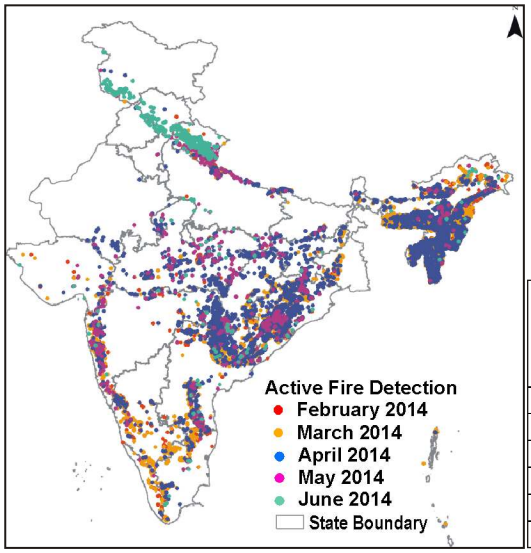
FOREST FIRE ALERT SYSTEM

INDIAN FOREST FIRE RESPONSE AND ASSESSMENT SYSTEM (INFFRAS)

- 55% of Indian Forests are prone to recurrent fires annually.
- Forest fires typically occur during January – June every year with a peak in March-April.
- Daily near real-time day & night active forest fire alerts are generated using MODIS sensors on board Terra & Aqua satellite of NASA and disseminated via BHUVAN.
- Typical satellite overpass time for MODIS is 1030 and 2230 hrs (TERRA) and 1330 hrs and 0200 hrs (AQUA).
- SMS alerts on active fires are sent to Himachal Pradesh and Karnataka.
- In-season rapid burnt area assessment is carried out using IRS AWiFS data based on user-specific request.
- Rapid burnt area assessment was carried out for Nagaland, Karnataka and Andhra Pradesh during 2014.
- INFFRAS inputs are utilised for fire mitigation and management by respective State Forest Departments.

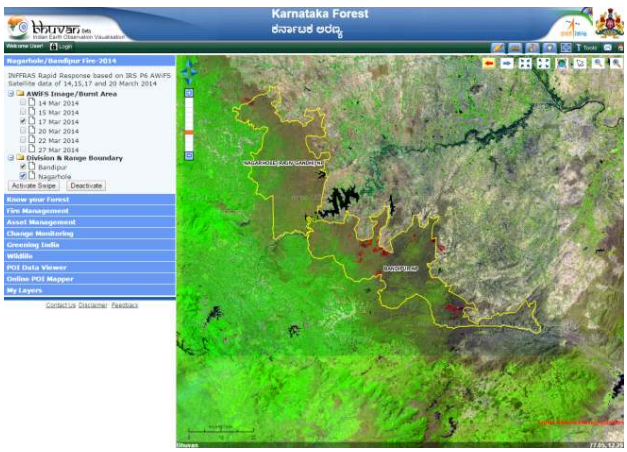
Active Fire Alerts through BHUVAN



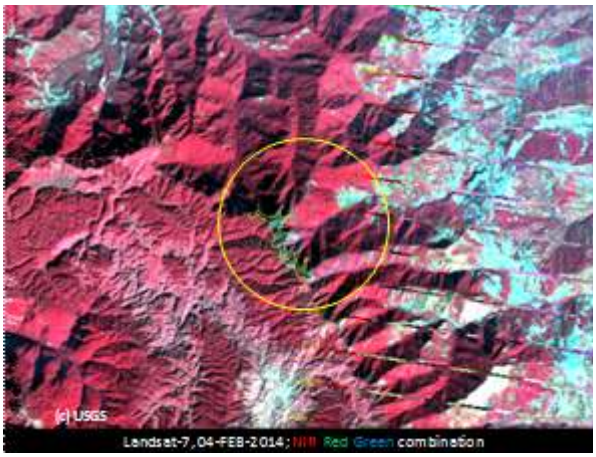


Month	No. of Active Fires
Feb	1375
Mar	12137
Apr	10471
May	1129
June	1051
Total	25037

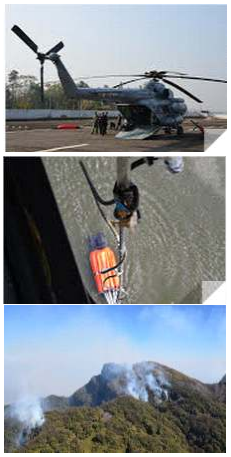
Forest Burnt Area (Karnataka) Information on BHUVAN



Rapid Burnt Area Assessment in Nagaland



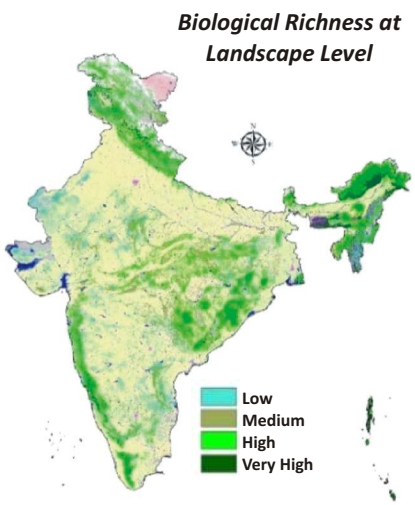
Ground Truth/Feed Back



BIODIVERSITY CHARACTERISATION

India is rich in biodiversity. Till recently, there was no systematic, scientific country-wide landscape level database on biodiversity. This prompted the Department of Space (DoS) and Department of Biotechnology (DBT) to take up a major initiative on Biodiversity Characterisation at Landscape Level (BCLL) using remote sensing and GIS. The study created a unique, nation-wide spatial database on vegetation types, degree of fragmentation, disturbance regimes and biological (plant) richness on natural landscapes in the country (1999-2005). The database generated has been shared through a web-portal called Biodiversity Information System (BIS) (http://bis.iirs.gov.in). The products and services offered by BIS are also accessible through the Indian Bio-resources Information Network (IBIN) (www.ibin.gov.in) portal.

Salient Features of Biodiversity Database



- 150 vegetation and land use classes mapped at 1:50,000 scale
- 7,761 plant species inventoried in 16,518 nationwide sample plots
- 648 endemic, 23 Rare, Endangered & Threatened (RET) species, 1879 medicinally important species, and 2803 economically important species recorded.

Partner Institutions

- 11 national institutes
- 27 universities
- 119 researchers

Database Dissemination

The database has been disseminated to a large number of organisations, including State Forest Departments. It has been used extensively for different applications like biodiversity conservation planning, bio-prospecting, climate change studies, policy making, etc.

Bramhakamal in Alpine Pasture

Deodar Forest in Gangotri

Shola Vegetation, Kudremukh NP, Karnataka

Field Sampling in a Mixed Forest, Odisha

MAJOR HIGHLIGHTS

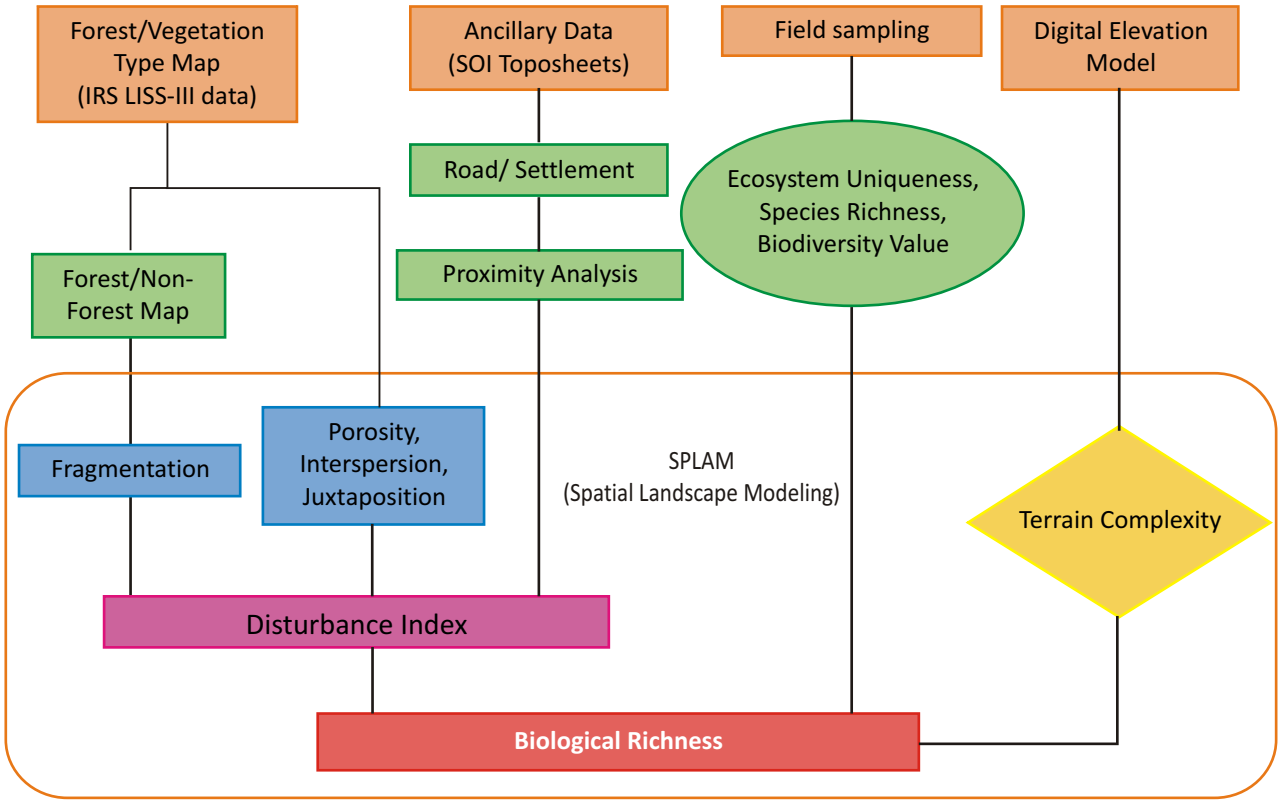
- Created nation-wide baseline database on biodiversity
- Maiden attempt to create vegetation type map of the country
- Geo-tagged species database from 16,518 field sample plots
- Entire database hosted in Biodiversity Information System (BIS) web portal
- Major outputs viz., vegetation type, fragmentation, disturbance regime and biological richness maps are freely downloadable

MAJOR BENEFITS

- Biodiversity conservation and management
- Bioprospecting of valuable gene pools
- Preparation of forest working plans
- Preparation of People's Biodiversity Registers
- Eco-sensitive zoning
- Climate change studies

BIODIVERSITY CHARACTERISATION

PARADIGM FOR BIOLOGICAL RICHNESS MODELING



BIODIVERSITY INFORMATION SYSTEM (BIS) PORTAL

(http://bis.iirs.gov.in)

Grassland inside Corbett NP

A Lakshadweep Island

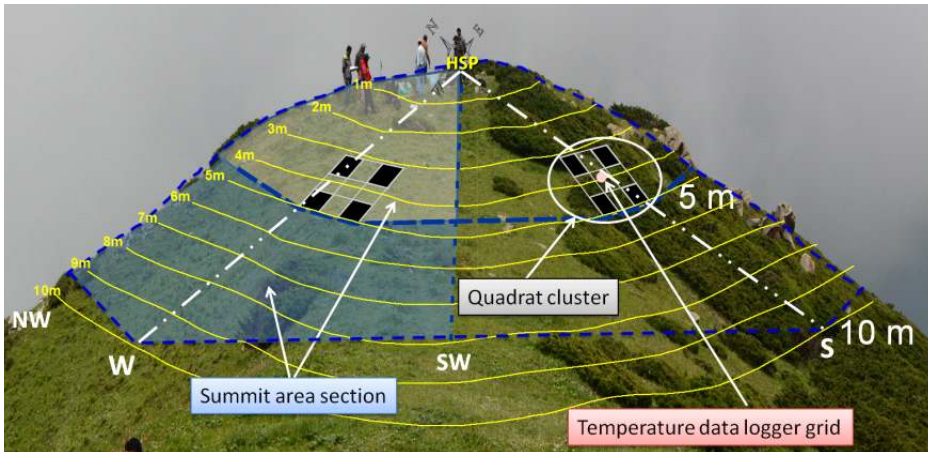
ALPINE ECOSYSTEM DYNAMICS IN INDIAN HIMALAYA

The Alpine ecotones of the Himalaya are sensitive to changing climatic conditions and hence serve as early indicators of climate change.

Upward migration of Alpine vegetation has been reported in various parts of the world. Satellite-based studies and field observations in Indian Himalaya have also indicated upward shift in tree-line in past three decades. This draws attention to the significance of the baseline data for Indian Himalaya in relation to global climate change studies.

In view of this, a multi-summit based long-term measurement network known as HIMADRI (HIMalayan Alpine Dynamics Research Initiative) has been conceptualised for long-term Alpine ecosystem monitoring to address different questions related to Alpine vegetation dynamics.

The Long-term Ecological Site in Kashmir Himalaya



Ground Photograph Showing Tree-line Position in Part of Kashmir Himalaya

MAJOR HIGHLIGHTS

- Establishment of Long-term Alpine Ecosystem Monitoring sites in Indian Himalaya
- Data collection following standard protocols
- Understanding degree and direction of change (positional shift and densification) in tree-line ecotone
- Preparation of Alpine tree-line atlas
- Filling the information gaps on alpine eco-systems for reporting to Global Alpine Watch

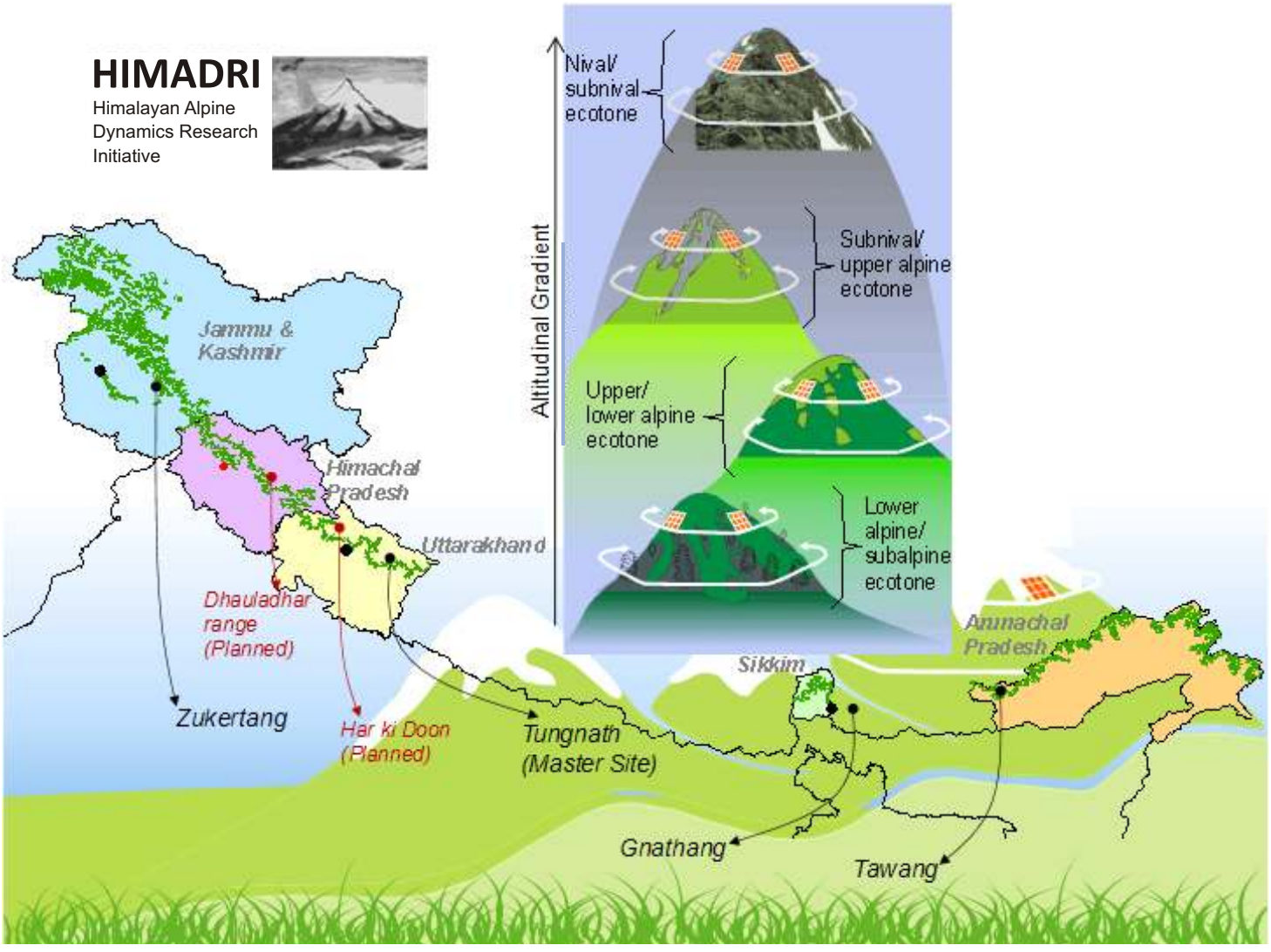
MAJOR BENEFITS

- Alpine ecosystem protection and conservation
- Long-term record (phenology, change in tree- line, densification) generation for future monitoring
- Inputs to environmental impact assessment studies

ALPINE ECOSYSTEM DYNAMICS IN INDIAN HIMALAYA

The HIMADRI network is envisaged to address the following questions:

- What are the drivers, directions and degree of current changes?
- What is the rate of actual change in tree-line ecotone?
- Are there substantial densification taking place at the existing tree-line?
- What is the rate of densification?

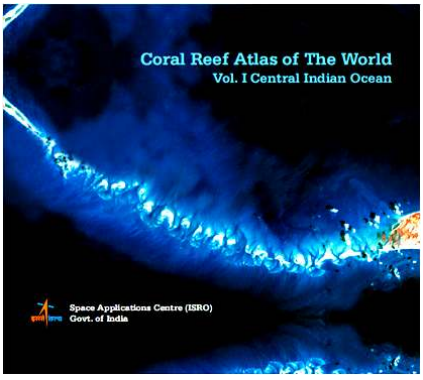


COASTAL ECO-SENSITIVE ZONES

Conservation and management of coastal environment including Mangrove and Coral Reefs require reliable, regular and updated information about their status and health in space and time. India is one among the few countries which is effectively using Satellite Remote Sensing technology for improving the understanding on key aspects of Mangrove and Coral Reefs, two important eco-sensitive zones of the coastal environment.

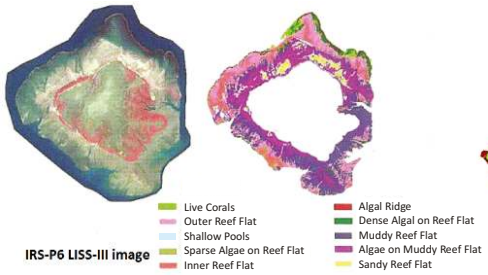
Strengthening in-situ observations and adopting geospatial techniques to forecast the future state and dynamics of these ecosystems is the current research focus.

Coral Reef Atlas (Part of Central Indian Ocean, 2010)



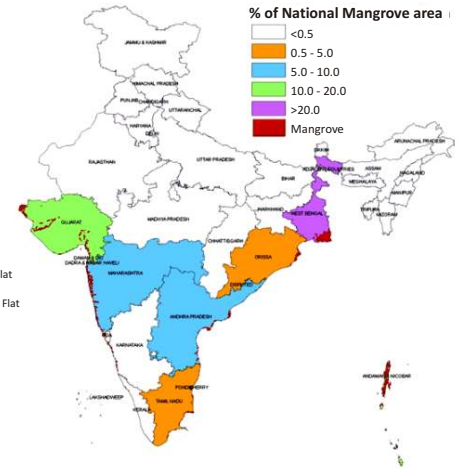
Mangrove Ecosystem

Coral Reef Zonation Map



Eco-Morphological Zones of Lalubhar Reef, Gulf of Kutch, Gujarat

National Mangrove Area (2012)



MAJOR HIGHLIGHTS

- Nation-wide Mangrove Community Zonation maps
- Development of Mangrove health model
- Study of Mangrove floristic composition
- Development of photo-synthetic rate model for major Indian Mangrove species
- Coral Reef Habitat mapping for Central Indian Ocean
- Geospatial inventory of Indian Coral Reefs
- Development of Coral Reef health model for selected Indian reefs

MAJOR BENEFITS

- Habitat-level information on two major coastal eco-sensitive zones
- Regular monitoring of coastal ecosystem health
- Understanding ecosystem level processes
- Inputs for coastal zone management

COASTAL ECO-SENSITIVE ZONES

ACHIEVEMENTS

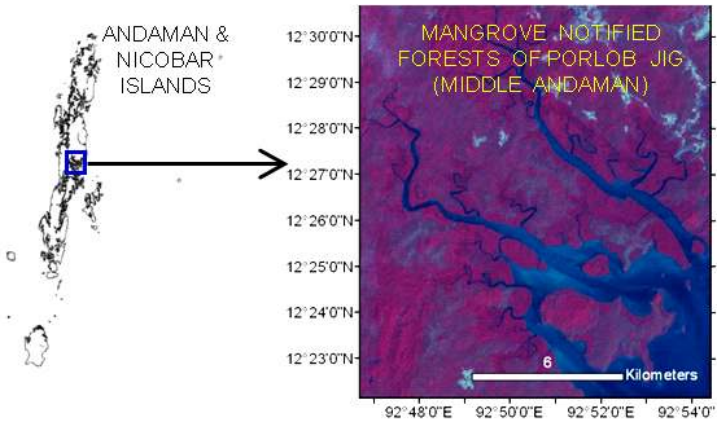
- Nation-wide, multi-temporal mapping of Mangrove
- Development of Mangrove health model based on *in-situ* and satellite observations
- Characterisation of Mangrove floristic composition based on Hyperspectral data
- Development of photosynthetic rate model for Mangrove species in response to climatic variables
- Generation of Coral Reef Habitat maps of India, Sri Lanka, Bangladesh, Maldives and British Indian Ocean Territory
- Multi-temporal mapping of Indian Coral Reefs
- Development of Coral Reef Health Model

RESEARCH AREAS/ FUTURE INITIATIVES

- Characterisation of Mangrove Ecosystem
- Productivity estimation of Indian Mangrove
- Site suitability for Mangrove plantation
- Modeling of biophysical parameters for Mangrove species
- Coral Reef Habitat Mapping for entire Indian Ocean
- Substrate-level characterisation using *in-situ* Hyperspectral observations
- Development of Coral Bleaching Forewarning System
- Understanding reef-scale processes for selected coral reef sites of India

***Rhizophora* Species with Stilt Roots**

Resourcesat-1 LISS-III Image of Mangrove



Avicennia marina

GEOLOGY AND MINING

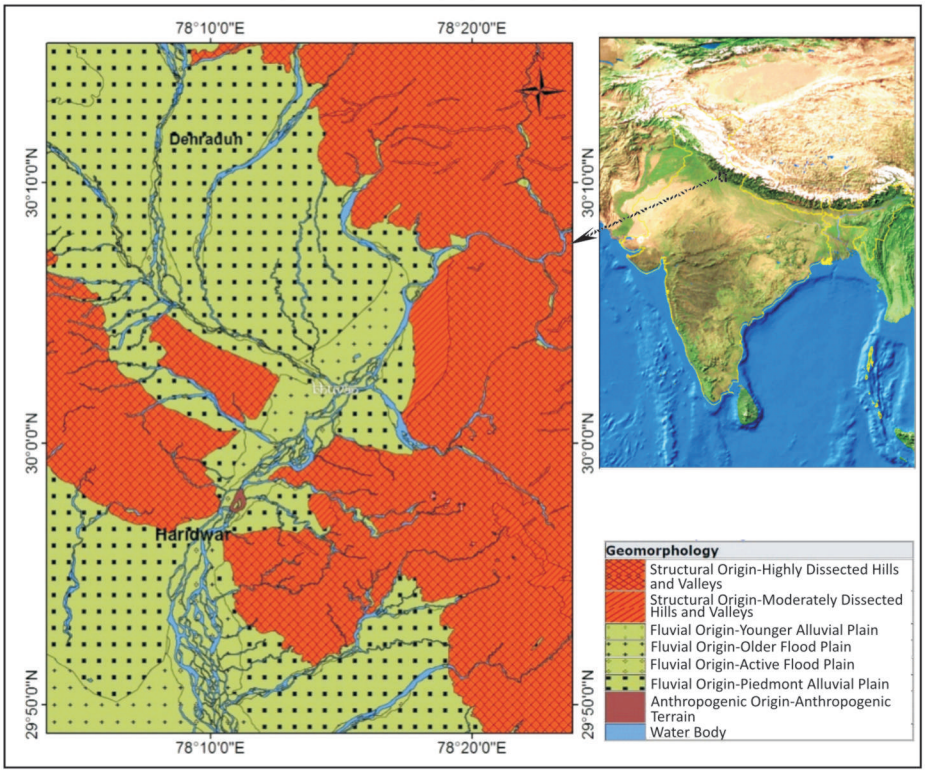
GEOLOGY & MINING

Satellite images offer a wide variety of applications in the field of Earth Sciences, e.g. geological and geomorphological mapping, hydrogeology, mineral exploration, monitoring of mining activity, engineering geology, environmental geology, geohazards, etc.

ISRO has worked in collaboration with many Central & State Government organisations to prepare geological databases and on different geological applications of remote sensing data. Today, a good number of case studies and the capacity to use space technology are available with many of the organisations related to the discipline of geology and mining.

Currently, the geologists are focusing their efforts towards exploring the potential of hyperspectral, thermal and microwave remote sensing data in identification and mapping of minerals and other features of geological interest. Geospatial modelling of remote sensing, geophysical, and ground-based observations is another area of current interest.

Geomorphological Map of a Part of Uttarakhand



This map is prepared in a national mission on 'Geomorphological and Lineament Mapping', jointly coordinated by ISRO and Geological Survey of India (GSI) in association with State Remote Sensing Centres. Geomorphology and Lineament information is vital for various geoscientific applications and is available on Bhuvan geoportal (http://bhuvan.nrsc.gov.in/).

MAJOR HIGHLIGHTS

- Basic geological inputs at varied scales for diverse applications
- National Mission on Geomorphological & Lineament Mapping
- Geological inputs for National Ground Water Prospects Mapping project
- Geological inputs for Landslide Hazard Zonation in Himachal Pradesh and Uttarakhand along important tourist and pilgrimage route corridors
- Mineral targeting using remote sensing and geospatial modeling for selected areas
- Geo-environmental impact assessment of mining, including mapping & monitoring of mine fires and land subsidence
- Feasibility studies for potential hydropower sites, road, rail & tunnel alignment
- Airborne geophysical surveys for mineral & hydrocarbon exploration (Partner Institutions: GSI, ONGC, DGH, AMD)

MAJOR BENEFITS

- Baseline geological information to support applied geological investigations and impact assessment in mining areas

GEOLOGY & MINING

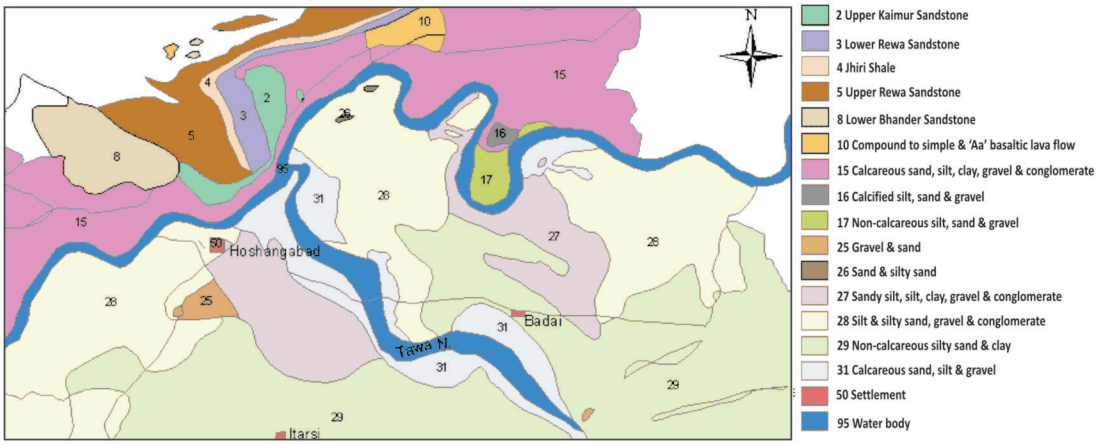
OPERATIONAL PRODUCTS / SERVICES

- Geomorphological and lineament maps of the country on 1:50,000 scale
- Geological input for site suitability analysis of Engineering Projects like hydroelectric power plants, tunneling, etc.
- Typical reflectance spectra of rocks and minerals for some of the important geological provinces of the country
- Mineral Information System for important mineral deposits and web-based Mining Information System for selected mines
- Remote sensing-based geoenvironmental monitoring of opencast mining
- Satellite-based mining induced land subsidence detection at high precision

RESEARCH AREAS / FUTURE INITIATIVES

- Upgradation of geological database using microwave SAR data and high-resolution topographic information
- Upgradation & operationalisation of Mineral & Mining Information Systems covering the entire country
- Information extraction from multi-sensor satellite data and geospatial modeling
- Innovative tools and approaches for discovery of new mineral deposits
- Spatio-temporal dynamics & impacts of mining including mining-induced land subsidence measurement & modeling
- Geodynamics of Himalaya & active tectonics studies

Reconnaissance Geological Map Based on Resourcesat Multispectral Imagery and Field Observations for Site Suitability of Shahganj Barrage

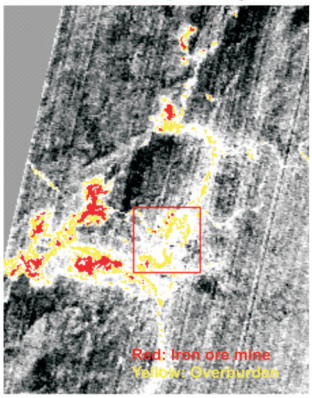


Partner Agency: Narmada Hydroelectric Development Corporation Ltd.

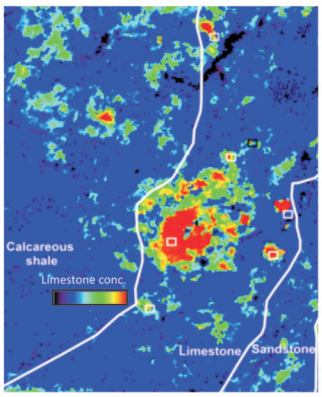
Rail Alignment along Akola–Amlakhurd Section, Maharashtra

Partner Agency: South-Central Railway

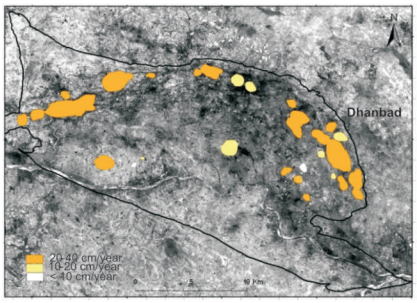
Spectral Separation of Iron Ore Mines from Overburden (Part of Odisha)



Limestone Prospecting by Spectral Separation Technique (Kolhan, Jharkhand)



Land Subsidence Areas in Jharia Coalfield during 2003-2007 Delineated using SAR Data & Radar Interferometry Technique



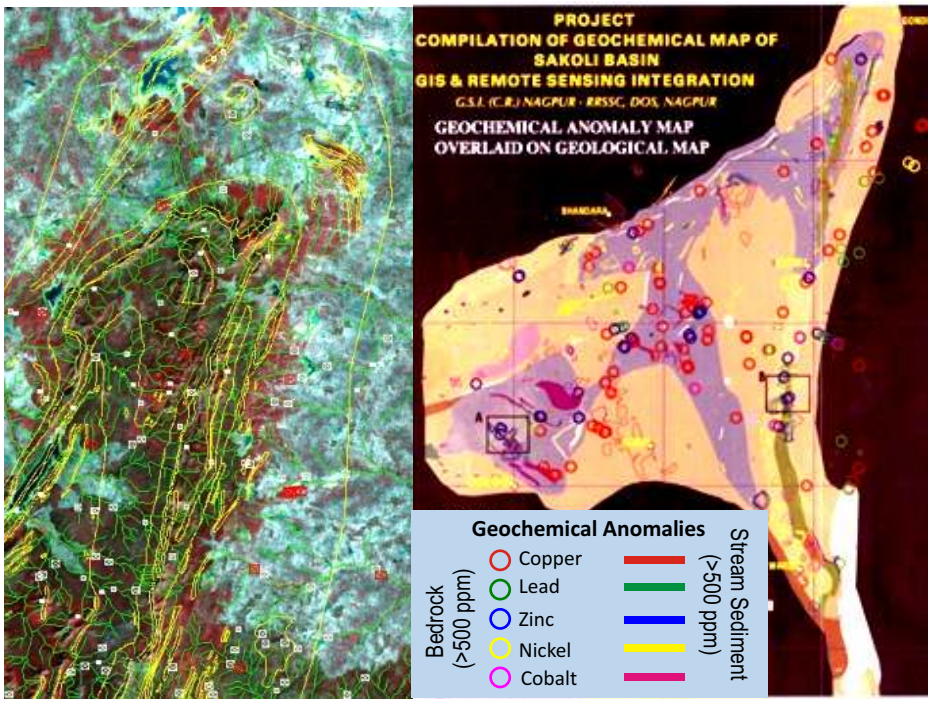
This information can be used to prevent future mine roof collapse

Partner Agencies: Coal India Ltd., CSIR & Survey of India

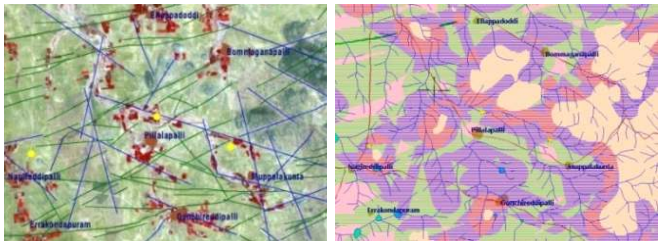
MINERAL EXPLORATION

India is a mineral rich country and ranks fourth amongst the mineral potential countries. According to Geological Survey of India (GSI), around 150 mineral belts with potential mineral zones/ deposits have been identified. However, the full mineral potential is yet to be explored and assessed, thus offering good opportunities for mineral exploration and mining development. Potential areas for exploration ventures include gold, diamond, copper, lead, zinc, nickel, radioactive minerals, coal, petroleum, etc. Remote Sensing and Geospatial Modeling techniques have been used for identifying potential areas of mineral occurrences in the country. With the advancements in remote sensing technology, the current research is focused on exploiting hyperspectral remote sensing and advanced modeling techniques in mineral prospecting.

Geochemical Mapping of Sakoli Basin for Mineral Prognostication using GIS and Remote Sensing (collaborative study with GSI and National Mineral Development Corporation (NMDC))



Geospatial Modeling for Diamond Exploration in Anantapur District, Andhra Pradesh (collaborative study with GSI and NMDC)



MAJOR HIGHLIGHTS

- Lithological, structural & geomorphological mapping using remote sensing imagery at varied scales
- Integration of geological, geophysical and geophysical data in GIS for finding potential areas of mineral occurrence
- Carried out a few demonstrative case studies in partnership with GSI, NMDC, State Mining & Geology Departments
- Hyperspectral remote sensing has the strong potential to identify and map minerals

MAJOR BENEFITS

- Identification of potential areas for further detailed exploration
- Detailed geological & geomorphological mapping of inaccessible areas
- Mineral-specific geo-environmental models help in identifying similar geo-environment elsewhere for planning detailed exploration

MINERAL EXPLORATION

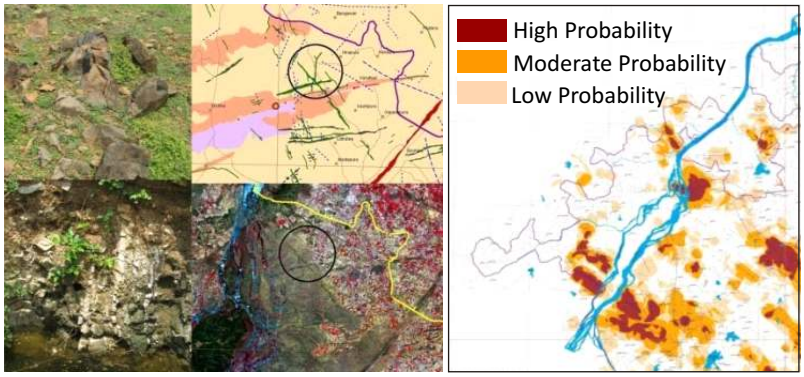
OPERATIONAL PRODUCTS / SERVICES

- Detailed lithological, structural and geomorphological mapping of mineral belts and inaccessible areas
- Creation and integration of geospatial databases and modeling for mineral prognostication to help take up detailed exploration activities
- Initiated the activities for preparation of spectral library of minerals and rocks

RESEARCH AREAS

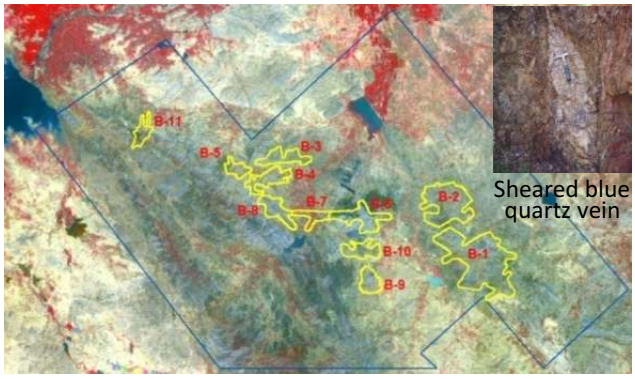
- Exploration of mineral belts of India through Hyperspectral Remote Sensing and integrated mineral-specific models capable of handling complex processes
- Exploration for Hydrocarbon through integrated exploration system
- Microwave, thermal, and high-resolution optical remote sensing data for identifying micro-mineralisation anomalies

Diamond (kimberlite) Exploration in Tikamgarh (Madhya Pradesh)



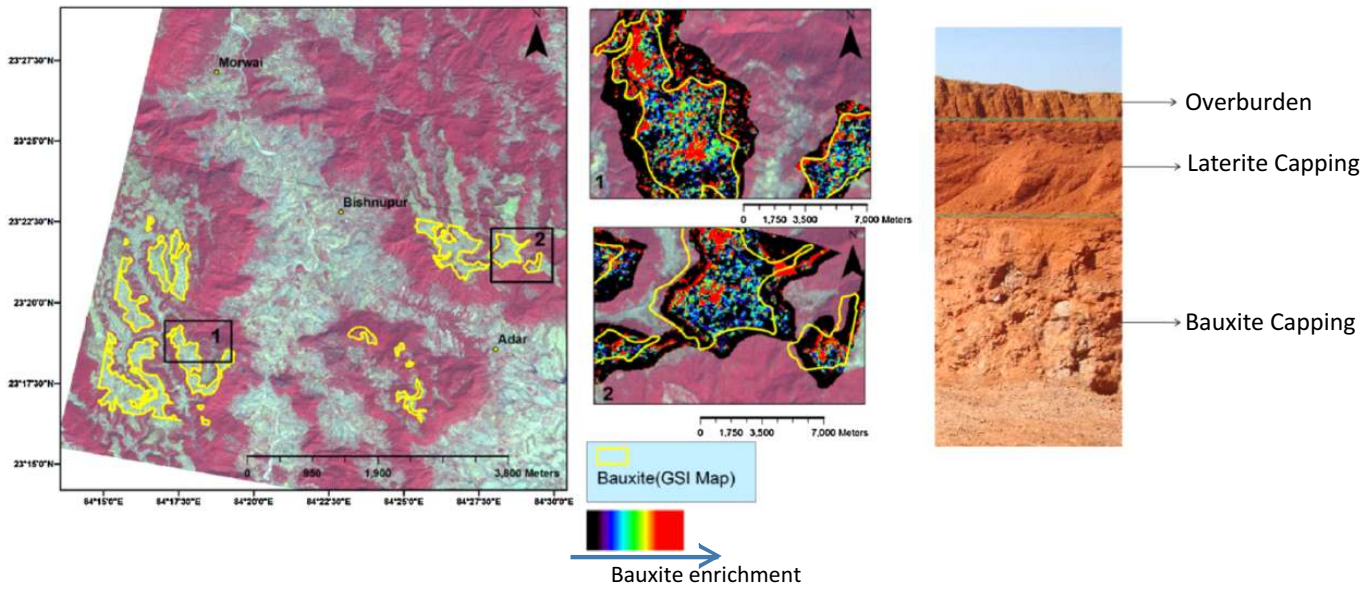
Extracting mineral-specific anomalies from satellite remote sensing and inputting to geospatial models leading to identification of potential areas for diamond mineralisation (collaborative study with GSI and NMDC)

Remote Sensing based Geospatial Modeling for Identification of Potential Blocks for Gold Exploration.



Inset shows sheared blue quartz vein in Block-1, indicator of gold mineralisation (collaborative study with GSI and NMDC)

Mapping of Bauxite Rich Pockets in Part of Ranchi Plateau (Jharkhand) using ASTER



MINING & ENVIRONMENT

ISRO has worked in collaboration with many Central & State Government organisations to prepare geological databases at varied scales for many a mineral targeting & mining applications. As a joint initiative between Ministry of Mines and ISRO, a Mining Information System has been developed and demonstrated in a pilot study for visualization and retrieval of spatial & non-spatial information related to mining for the selected mines of Chhattisgarh state.

Multi-sensor & multi-temporal remote sensing data and advanced techniques such as radar interferometry & polarimetry, and predictive modelling were found very useful for a comprehensive geoenviromental appraisal of mining.

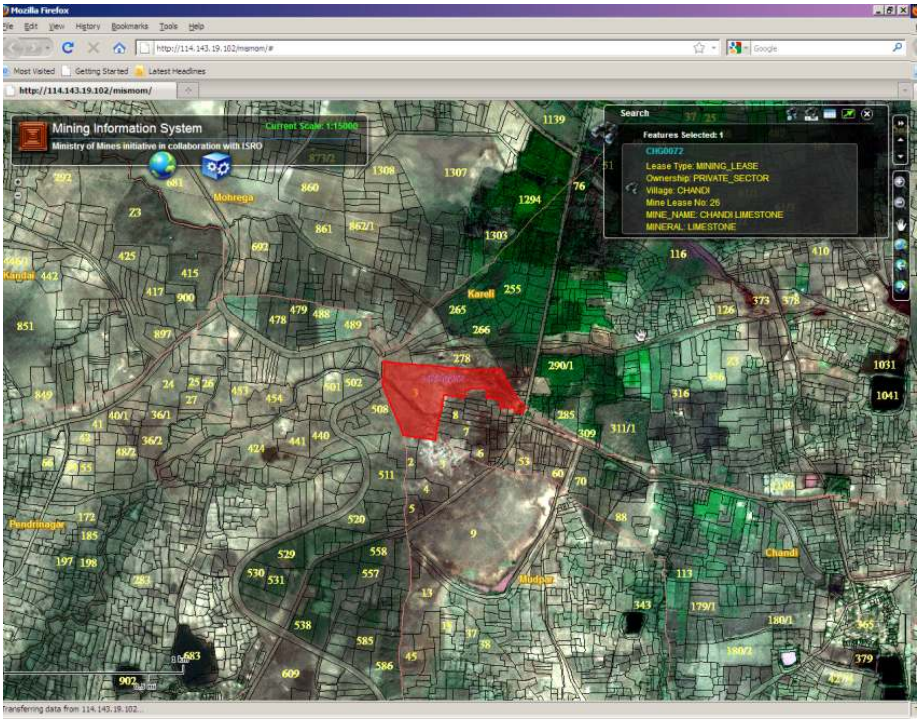
MAJOR HIGHLIGHTS

- Generation of regional geological database and development of mining information system for selective mines.
- Monitoring of mining and impact assessment including mine subsidence.

MAJOR BENEFITS

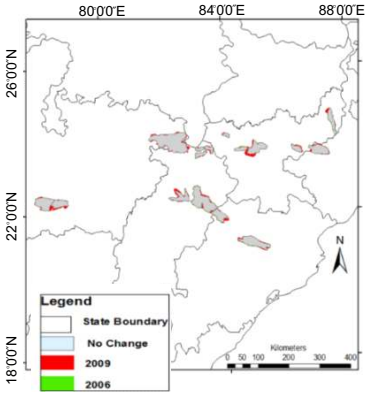
- New and/or extension of existing mineral deposits for evaluation of mining prospects.
- Geoenvironmental impact assessment of mining.

Mining Information System Web Portal for Selected Mines in Chhattisgarh



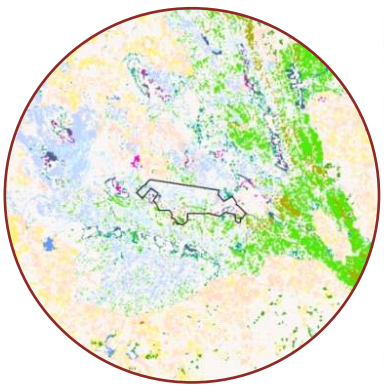
(Partner Institute: Ministry of Mines & ISRO)

Mining Lease Areas in High Resolution Image



Spatio-temporal dynamics of major Gondwana Coalfields in India showing mining expansion & unreclaimed mines

Changes in Land Use Pattern due to Mining at KIO-Mines, Karnataka



Increase in cropland
Increase in dense forest
Increase in open forest
Forest blanks to degraded forest
Increase in afforestation/tree groves
Increase in mining area
Increase in mine surrounding
Increase in water bodies
Increase in builtup area
Dense forest to open forest
Open forest to degraded forest
Decrease in water bodies
Other changes
No change
KIOM Lease Boundary
10 KM Radius from KIOM

MINING & ENVIRONMENT

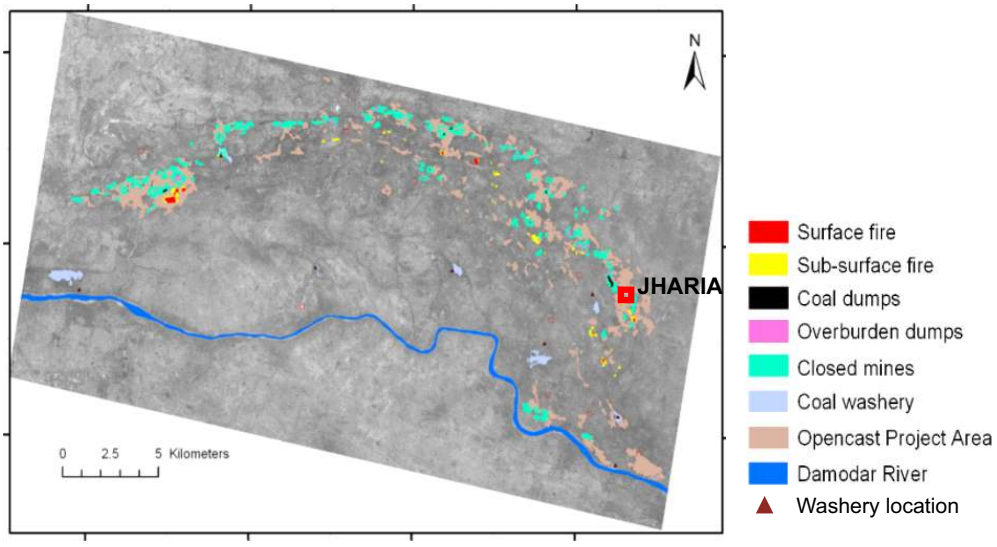
OPERATIONAL PRODUCTS / SERVICES

- Comprehensive surface plan depicting mining-related environmental indicators of opencast mines for EIA.
- Spatial Dynamics of opencast mining in the major Gondwana Coalfields of India from multi-temporal satellite remote sensing data to demonstrate mining expansion and unreclaimed mining areas.
- Availability of remote sensing based coal fire & land subsidence maps for selective coalfield(s) of the country and capability to provide such services for any of the coalfields or other underground mines in the country.

RESEARCH AREAS

- Database generation and ingestion into the Mining Information System to provide spatial & non-spatial information on national level.
- Integration of geological & mining parameters to develop newer tools & techniques for safe, efficient & sustainable mining.
- Delineation of illegal mining quarries and R&D experiment on signature building for detection of illegal underground mining.
- High precision spaceborne & terrestrial measurements coupled with ground instrumentation to address subtle issues of mining environment.

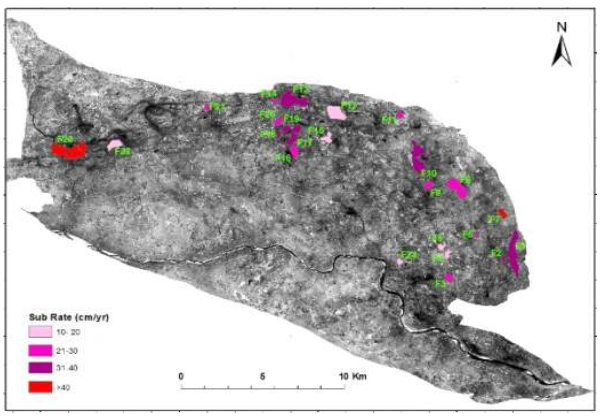
Satellite-based Geoenvironmental Surface Plan of Jharia Coal Mine Prepared from Multi-sensor Remote Sensing Data which can be used for Monitoring of Mining Activities and Environmental Impacts *(Partner Agencies: Coal India Ltd., CSIR & Survey of India)*



Unreclaimed Abandoned Opencast Mine (now Water Tank)

Coal Fire Detected in Thermal IR Data; Mining of Coal in Fire-affected Area to Save Coal & Control Fire

Satellite-based Subsiding Areas in Jharia Coalfield during 2012 Potential for Roof Collapse in Future



Land Subsidence in Angarpathar Lalten Basti of Jharia Coalfield (2014)
(Partner Agencies: Coal India Ltd. and CSIR)

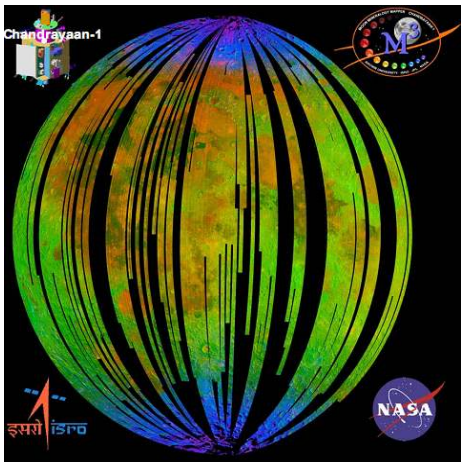
Coal Fire Induced Land Subsidence near Joyrampur Village of Jharia Coalfield (2007)

PLANETARY GEOSCIENCES

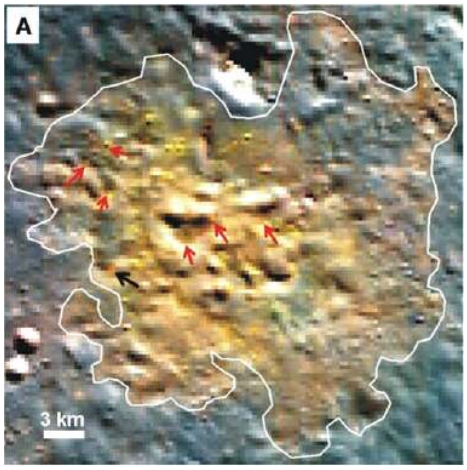
Observing and studying planets, stars and various other celestial objects towards understanding the fundamental questions about the origin, evolution and formation has been an exciting field of science. Space technology has played a pivotal role in changing our understanding about our celestial neighbors since the second half of the 20th century.

Indian Space Research Organisation (ISRO) is actively involved in planetary science and exploration. India's first planetary mission, Chandrayaan-1, has contributed significantly to enhance knowledge about the Lunar surface processes and its chemical and mineralogical composition. With the recent successful Martian insertion of Mars Orbiter Mission (MOM) spacecraft, India has become the only country to achieve this rare feat in its maiden attempt.

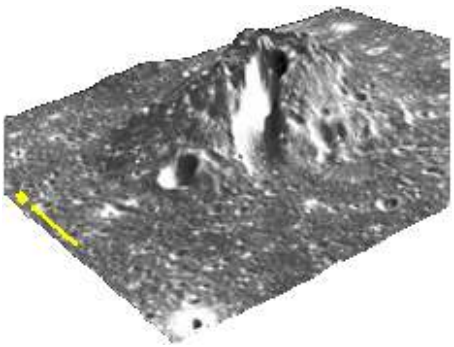
Global Distribution of Water/Hydroxyl ion on the Moon as Revealed by Chandrayaan-1 M^3 (Moon Mineralogy Mapper) Data



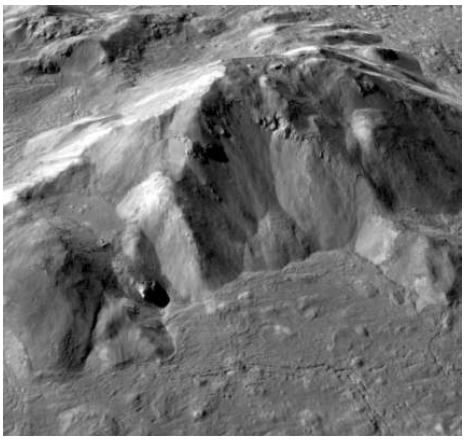
Presence of Magmatic Water in Compton-Belkovich Volcanic Complex Highlighted by Yellowness in Chandrayaan-1 M^3 Data



Depiction of High-resolution Topography of Lunar Surface (Marius hill) by Chandrayaan-1 Terrain Mapping Camera (TMC)



High-quality Topography of the Lunar Surface (Central Peak of Tycho Crater) Derived from Chandrayaan-1 TMC Data



MAJOR HIGHLIGHTS

- Chandrayaan-1 was India's first step to develop technological capability for interplanetary mission
- Chandrayaan-1 addressed simultaneous science objectives: chemical, mineralogical and topographic mapping of the lunar surface
- Discovery of water of both exogenic and endogenic origin on the Moon
- With Mars Orbiter Mission (MOM), India became the first Asian country to reach Mars
- Five sensors on-board MOM are investigating the Martian morphology, surface temperature, presence of methane, neutral gas composition of Mars' exosphere, D/H (Deuterium/ Hydrogen) ratio in the upper atmosphere of Mars

PLANETARY GEOSCIENCES

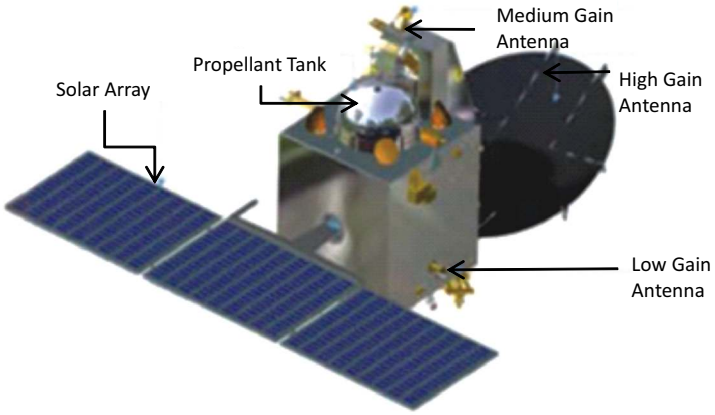
OPERATIONAL PRODUCTS / SERVICES

- Science data from Chandrayaan-1 mission instruments are available at Indian Space Science Data Centre (ISSDC) (www.issdc.gov.in)
- Chandrayaan-1 calibrated data are also available for Hyperspectral Imager (HySI) and Terrain Mapping Camera (TMC)
- TMC-derived higher level products such as Digital Elevation Model (DEM) and Ortho-images are available now including 3D Atlas of the Moon

RESEARCH AREAS

- Planetary crustal processes with special emphasis to Moon and Mars
- Mapping of lunar surface composition using hyperspectral data from Chandrayaan-1
- Study of lunar volcanism and major tectonic elements (grabens, faults) using high-resolution data from Chandrayaan-1
- Study of water/hydroxyl ion on the Moon using the data from recent lunar missions
- Mineralogical and geomorphological mapping of the Mars
- Study of Martian and lunar analogs in India

Deployed View of Mars Orbiter Mission (MOM)




Full Disc View of the Red Planet as Seen by Mars Colour Camera (MCC) - MOM


White Streaks on Mars as Captured by MCC- MOM

Future Mission: Chandrayaan-2

- Second Lunar Exploration Mission
- All are indigenous payload
- Orbiter, Lander and Rover
- Orbiter Payloads
  - L and S band mini-SAR
  - Imaging IR spectrometer
  - Neutral mass spectrometer
  - Terrain mapping camera
- Rover payloads
  - Laser induced breakdown spectroscopy
  - Soft X-ray spectrometer & alpha particle induced X-ray spectroscopy
- Expected launch 2017

OCEAN AND ATMOSPHERE

OCEAN AND ATMOSPHERE

The advent of satellite remote sensing has initiated a new era of monitoring the Earth's atmospheric and oceanic processes. The satellite sensors provide vital information to study and understand the important constituents of the atmosphere and ocean and their dynamics.

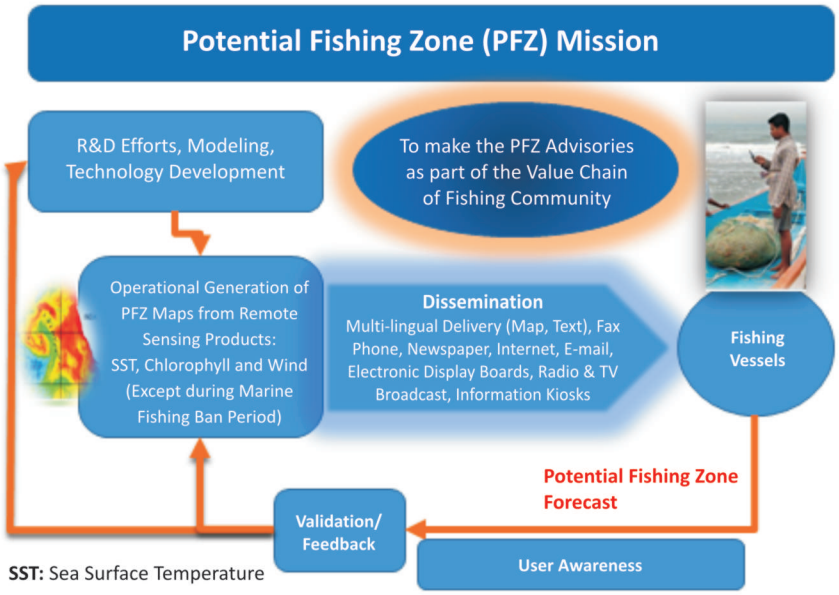
The satellite data products are operationally used by India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), Indian Institute of Tropical Meteorology (IITM) and Indian National Centre for Ocean Information Services (INCOIS) for providing information and advisory services on weather, climate and ocean.

MAJOR HIGHLIGHTS

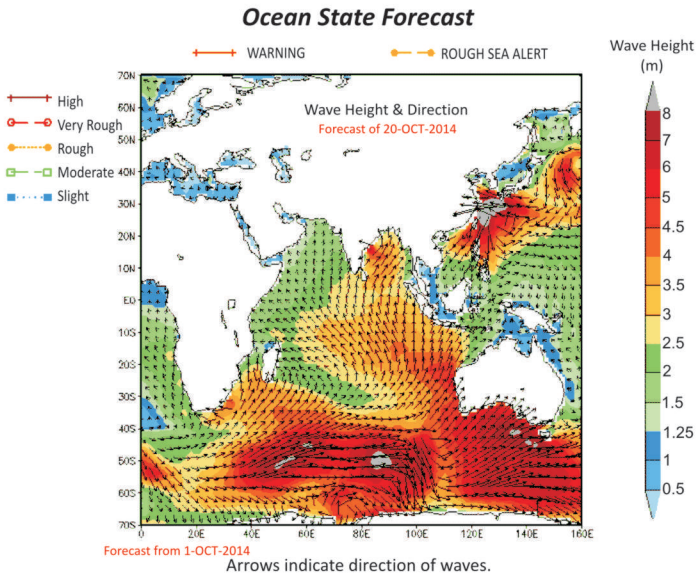
- Potential Fishing Zone (PFZ) Forecast
- Ocean State Forecast
- High-resolution Regional Weather Prediction
- Monsoon Prediction
- Tropical Cyclone & Storm Surge Prediction
- Coral Reef Bleach Alert

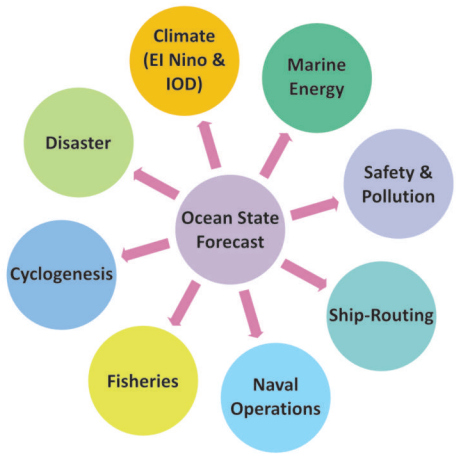
MAJOR BENEFITS

- About 40,000 users are regularly benefited through PFZ forecasts
- Space inputs have improved weather and cyclone track prediction
- Monitoring and conservation of coral reefs
- Ocean state forecast is useful for Indian Navy, Indian Coast Guard, cargo and passenger shipping agencies, off-shore oil & gas exploration agencies, fishermen and ports



SST: Sea Surface Temperature





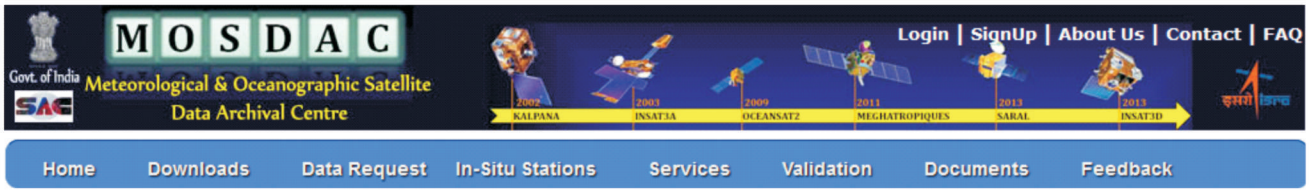
OCEAN AND ATMOSPHERE

OPERATIONAL PRODUCTS / SERVICES

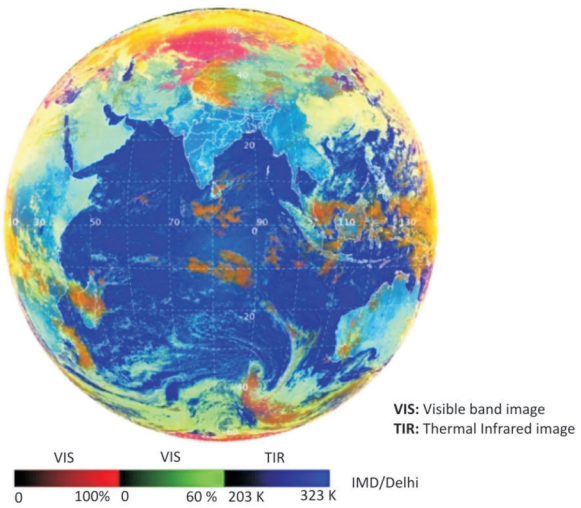
- Phytoplankton concentration, water clarity, sediment products from Oceansat
- Wind vectors over ocean from Oceansat-2
- Sea surface height anomaly/ Significant wave height from SARAL AltiKa
- INSAT-3D based meteorological & oceanic parameters, i.e. rainfall, cloud motion vector, sea surface temperature, etc.

RESEARCH AREAS

- Water quality in coastal and inland lakes
- High-resolution coastal and ocean state forecast
- Polar environment monitoring
- Prediction of high intensity rainfall events, e.g. thunderstorms
- Aerosol and cloud interaction

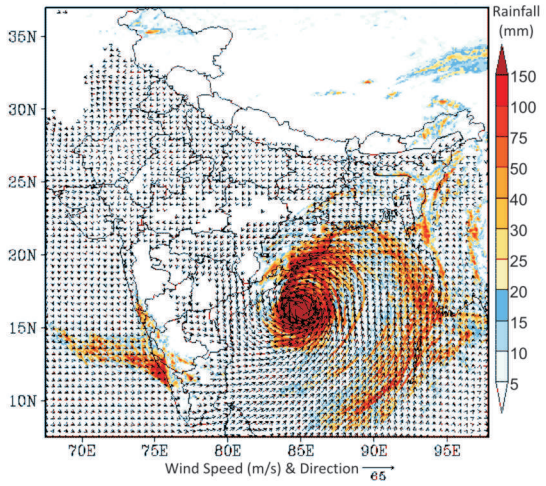


INSAT-3D RGB Composite

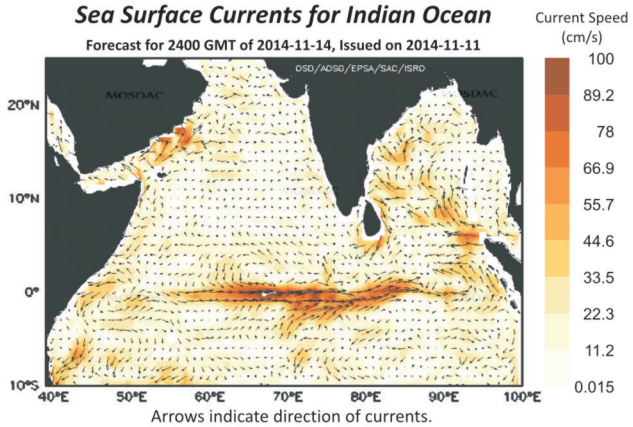


VIS: Visible band image
TIR: Thermal Infrared image

24 h Rainfall and 850 hPa Winds

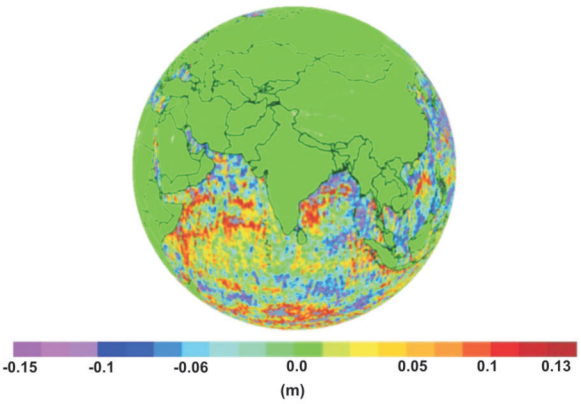


Sea Surface Currents for Indian Ocean



Arrows indicate direction of currents.

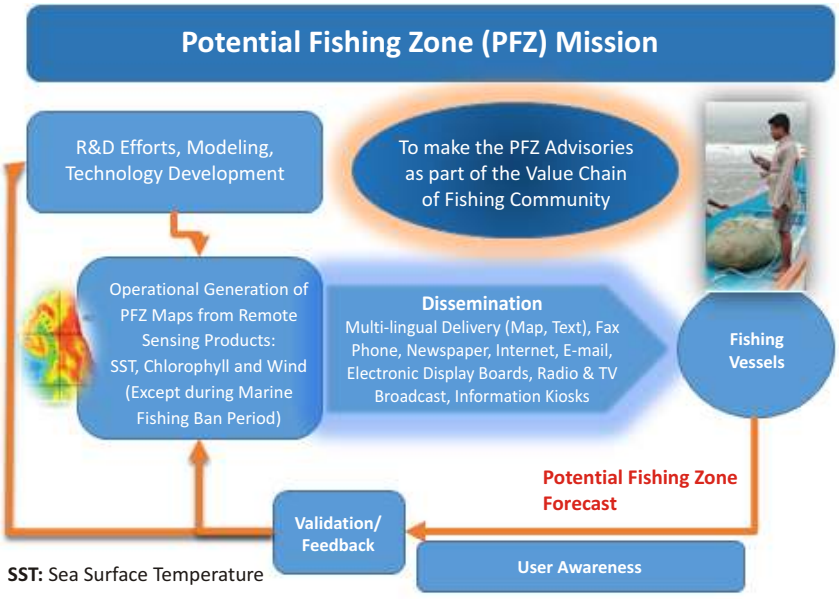
Sea Surface Height Anomaly



POTENTIAL FISHING ZONES

About 7 million people living along the Indian coastline depend on fishing for their livelihood. However, with increased knowledge and the dynamic development of fisheries, it has been realised that living aquatic resources, although renewable, are not infinite and need to be properly managed for sustainable exploitation of the living aquatic resources. Remote sensing has gained increasing importance in studies of marine systems, for extracting oceanographic information and monitoring the dynamics of oceanic environment.

Potential fishing zone information has been highly useful to the fishermen for a better fish catch. The algorithms for retrieval of sea surface temperature, coupled with ocean colour information have been standardized to indicate the locations of big fish catch. Remote sensing of fishery resources was initiated in India in early eighties with collaborative efforts of ISRO, Fishery Survey of India (MoA) and Central fisheries research institute (MoA). Presently, Ministry of Earth Sciences (MOES) is providing advisories on Potential Fishing Zones (PFZ) for entire Indian coast.



SST: Sea Surface Temperature

MAJOR HIGHLIGHTS

- Development, validation and operationalisation of Potential Fishing Zone (PFZ) methodology in partnership with Fisheries Survey of India (FSI)
- Indian National Coastal and Oceanic Information Services (INCOIS) under the Ministry of Earth Sciences (MoES) is providing operational fish forecast maps to fishing community

MAJOR BENEFITS

- Direct benefit to society
- Reduced search time, fuel cost and efforts
- Increase in profit
- Improved socio-economic status of fishermen community
- 67% success rate in PFZ
- Increase in Benefit-cost ratio (Non-PFZ to PFZ):
  - 1.27 to 2.12 for trawling,
  - 1.3 to 2.14 for gillnetting

POTENTIAL FISHING ZONES

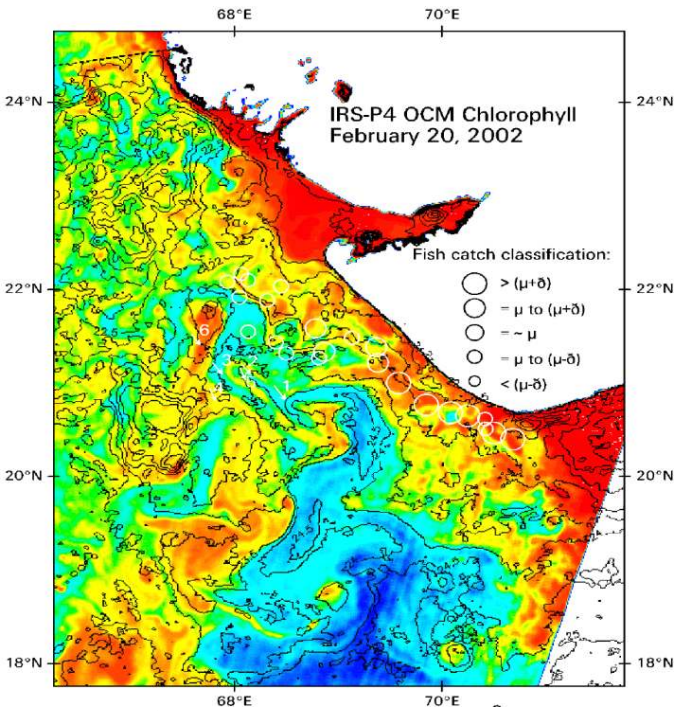
OPERATIONAL PRODUCTS / SERVICES

- Nation-wide operational PFZ forecast
- Species-specific forecast
- Zooplankton production model to identify food availability for fish seeds
- Ocean environmental parameters, e.g. chlorophyll, Sea Surface Temperature (SST), wind speed, etc.

RESEARCH AREAS

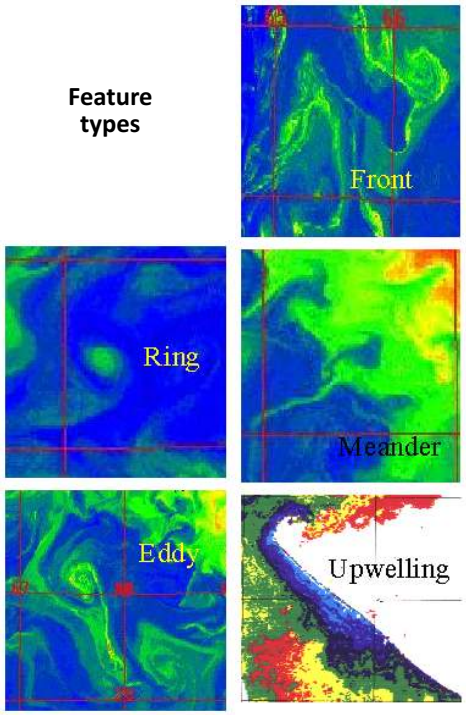
- Fishery resources exploration & management
- Integral analysis of oceanic variables and spatial predictive modeling for improving forecast
- Conservation of turtles and other endangered species
- Monitoring of ocean environment
- Remote sensing of bio-physical coupled processes
- Bloom monitoring

Integration of Ocean Colour Monitor Chlorophyll, SST and Fish-Catch Feedback Points



μ - *Mean;* δ - *Standard Deviation*

Integral Analysis of Oceanic Variables

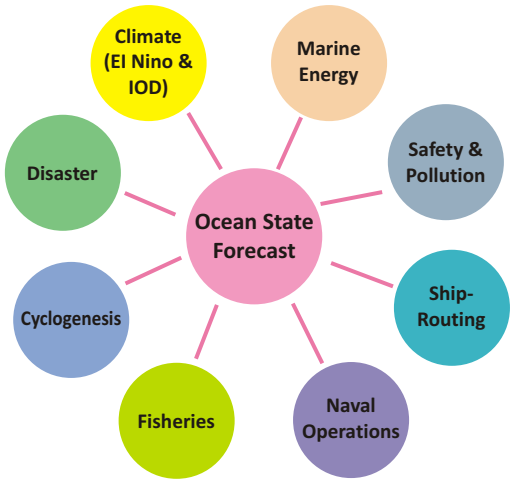


Mobile Application - Bringing Helpful Information to Rural Fishermen (Dissemination)

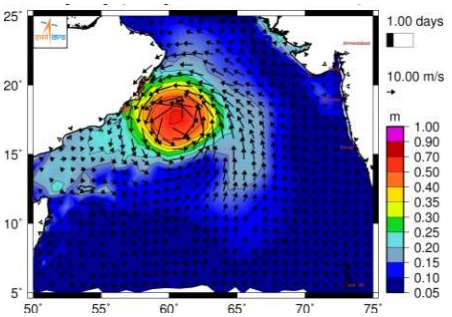
OCEAN STATE FORECAST AND OCEAN MODELS

Over 30 million people live along the coastlines of India and their livelihood is related to the Ocean in one way or the other. The marine activities range from conventional fishing to high-tech oil and natural gas exploration, transportation of goods to search & rescue operations in the high seas, naval operations to ship routing, etc.

Satellite-based parameters form an integral component of the Ocean State Forecast (OSF) models. Accurate information of ocean state parameters is, thus, vital for the well being of the countrymen as well as for the socio-economic development of the country.

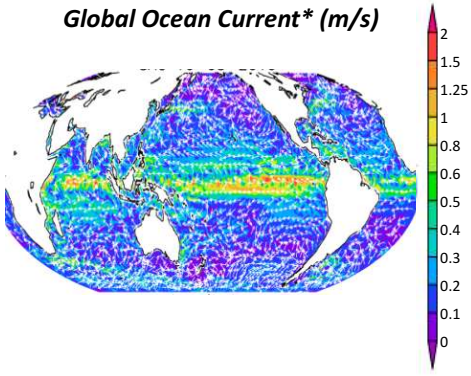


Storm Surge height (m): 28 Oct, 2014

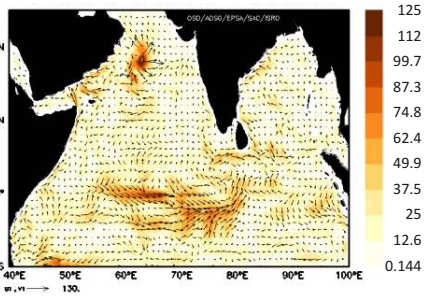


(This product is used for coastal safety during cyclonic period)

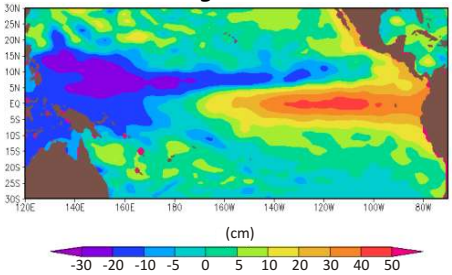
Global Ocean Current* (m/s)



Surface Current* (cm/s): 28 Oct, 2014



Model Sea Level Anomaly (cm) during El Nino*



**The above products are used to study mesoscale oceanic phenomena*

MAJOR HIGHLIGHTS

- Demonstration of satellite data for Ocean State Forecast (OSF) taken up as a pilot study during Oceansat-1 period with multi-institutional efforts
- OSF parameters were made use for Satellite Recovery Experiment
- Transfer of satellite data-assimilative models to Indian Navy
- Real-time storm surge predictions and ocean wave and circulation forecasts available on MOSDAC portal
- Wind-wave energy from model and satellite data

MAJOR BENEFITS

- Supporting Indian Navy for their fleet operations
- Potential use towards offshore installations
- Safety and pollution (oil spill tracking)
- Advance ship route planning
- Marine energy estimation (wave, tidal, current, thermal)
- Application in Fisheries resources

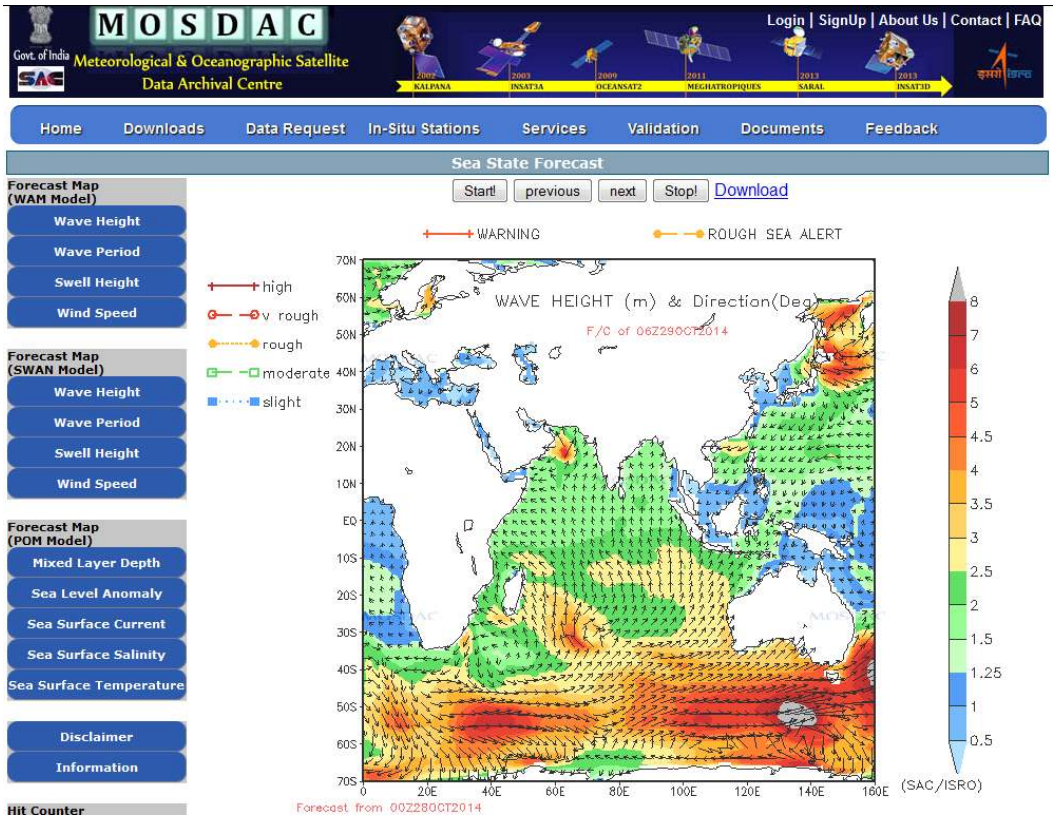
OCEAN STATE FORECAST AND OCEAN MODELS

OPERATIONAL PRODUCTS / SERVICES

- Profiles of temperature, salinity and currents (global and Indian Ocean), sea surface height anomaly from ocean circulation forecast models
- Ocean wave parameters (wave height, period, wave age) analysis and forecasts from global and regional wave models
- Automated ocean state alerts from data-assimilative ocean wave model – hosted on MOSDAC portal (www.mosdac.gov.in)
- Real-time storm-surge forecasts dynamically linked to SCORPIO on MOSDAC (www.mosdac.gov.in)
- Satellite and model based global ocean vector winds products
- The products is used by energy and shipping sector

RESEARCH AREAS

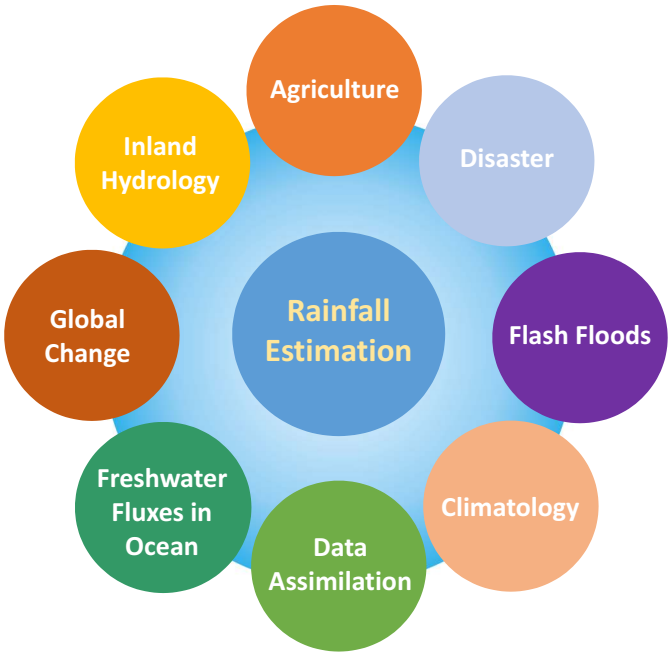
- Real-time forecasting of near-shore/coastal waters (moving from open oceans to coast)
- Experiments with mixing physics and parameterisation for fine-scale & eddy resolving models/ processes
- Coupling physics and biogeochemistry
- Advanced data assimilation for coastal regions to improve the forecasts
- Inclusion of wave-current interaction process in operational models
- Studying the effect of satellite data inclusion in storm surge model to improve forecasts
- Coupled ocean-ice modeling to understand the ice feedback
- Coastal wind-wave product from SAR & model



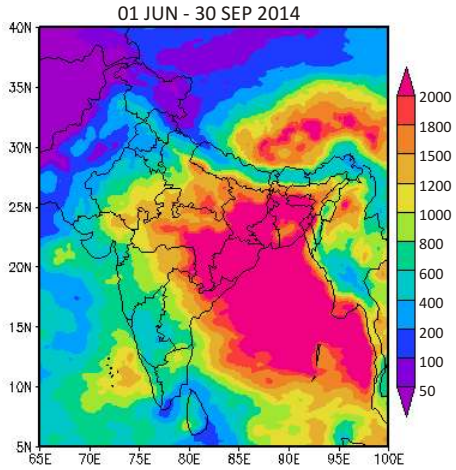
RAINFALL ESTIMATION AND APPLICATIONS

Reliable information of rainfall over the Indian region is crucial for a wide range of applications like water resource management, agriculture, disaster warning and sustainable economic growth. Rainfall estimates are also very important for the meteorological applications and validation of the weather and climate models. Ground based observations provide accurate measurement of rainfall. On the other hand, the satellites like Kalpana and INSAT-3D provide comprehensive maps of rainfall.

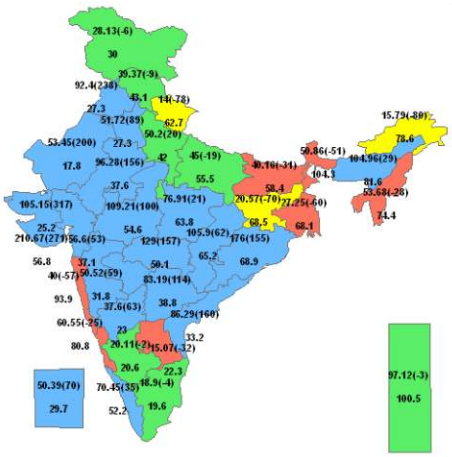
Rainfall Estimation: Science & Applications



Accumulated Rainfall (mm) during Monsoon Season (JJAS)



Rainfall from INSAT-3D on Meteorology Subdivisions



MAJOR HIGHLIGHTS

- Daily monitoring of south-west monsoon rainfall
- Assessment of monsoon performance based on daily, weekly, monthly and seasonal rainfall over India
- Mapping of rainfall over meteorological sub-divisions.
- Assessment of rainfall distribution during cyclone

MAJOR BENEFITS

- Yearly assessment of monsoon performance.
- Inputs to agriculture models for crop assessment and forecast
- Inputs to hydrological models for assessment of water resources
- Rainfall over oceanic regions for ocean models as fresh water fluxes
- Studying the impact of climate change on rainfall patterns

RAINFALL ESTIMATION AND APPLICATIONS

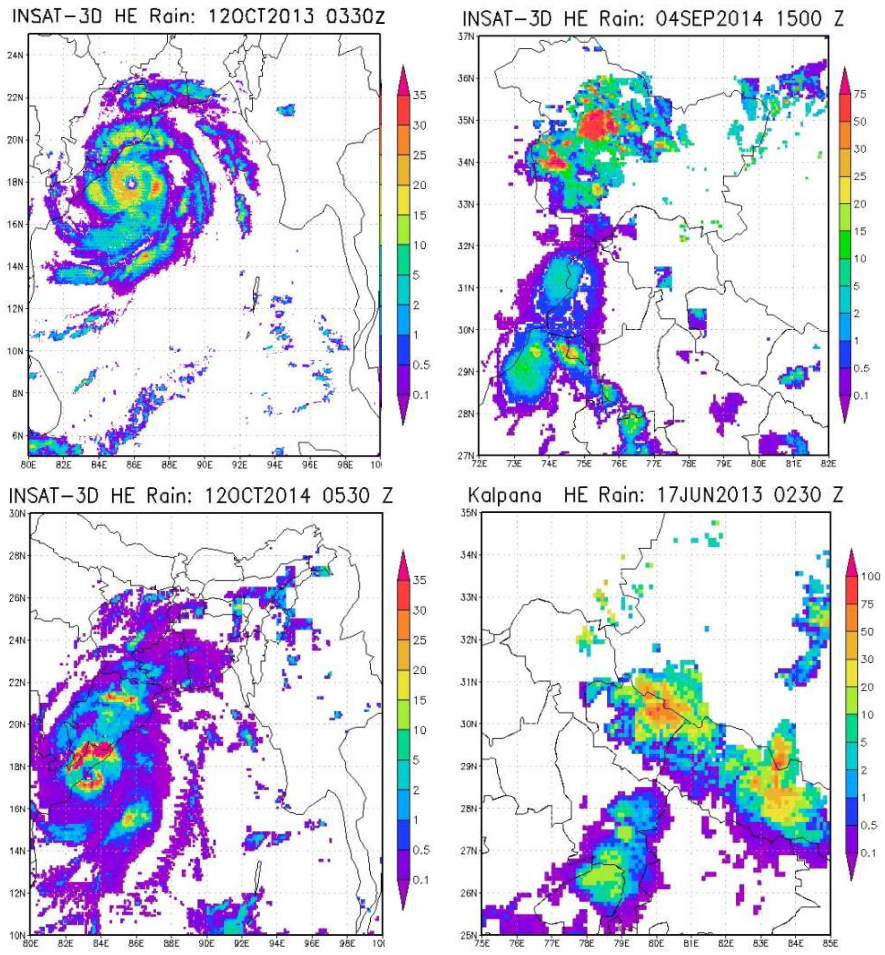
OPERATIONAL PRODUCTS / SERVICES

- Rainfall estimation from Kalpana and INSAT-3D at different temporal and spatial scales are operational at IMD
- Real-time heavy rainfall alert during the thunder storms, cloud bursts and cyclone condition are provided through MOSDAC portal (www.mosdac.gov.in)
- Monitoring performance of monsoon using various satellite products derived from measurements through Infrared and microwave remote sensing sensors

RESEARCH AREAS

- Rainfall now-casting and forecasting for 3 to 6 hours in advance
- Impact of rainfall on ocean salinity and circulation patterns
- Assimilation of rainfall in atmospheric models
- Study of impact of climate change on rainfall pattern and spatial distribution
- Synergy of rainfall measurements in association with other ocean and atmospheric variables for study of hydrological cycle

Satellite-based Rainfall Estimation (mm) using Hydro-Estimator (HE) Algorithm



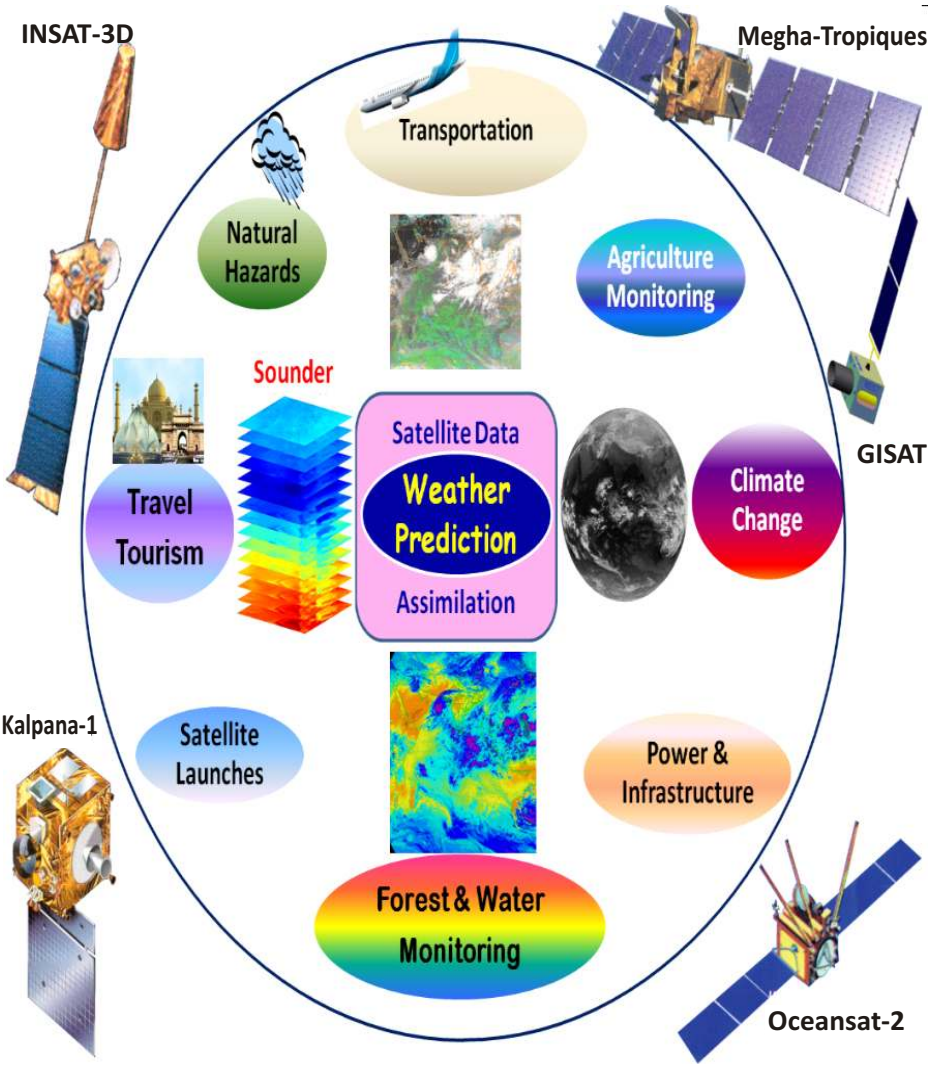
Hydro-estimator (HE) is an operational algorithm that provides half-hourly pixel-scale (~4 km x 4 km for INSAT) rain measurements by merging Thermal Infrared measurements from INSAT/ Kalpana satellites with atmospheric thermodynamic and other geophysical parameters from Numerical Weather Prediction (NWP) model derived fields.

It has immense applications in intense rain and flash flood monitoring and assessment of inundation through hydrological modeling.

WEATHER PREDICTION

Weather Prediction is the process (science, art) by which the future state of the atmosphere is determined from current weather patterns using various methods.

The problem of determining a physically consistent and accurate snapshot of the atmosphere is the central aim of the numerical weather prediction (NWP). In last few decades, with progress in both computing power and optimisation strategies, more sophisticated constraints and diverse observations have been included in NWP. The weather prediction puts a heavy demand on strong 3-dimentional database requiring a dense network of observations from ground as well as satellite platforms.



MAJOR HIGHLIGHTS

- Geophysical parameter retrieval from satellite
- INSAT Meteorological Data Processing System
- Mesoscale weather forecast using WRF model
- Nowcasting using satellite and in-situ data
- Seasonal forecast of Indian summer monsoon
- Assimilation of satellite products
- Extreme events forecast, viz. cloud-burst, storm, cyclone, etc.
- Weather prediction over SHAR for satellite launch activities
- Real-time nowcast for Uttarakhand and H.P. States
- Training/ Education/ Outreach
- Climate change studies

MAJOR BENEFITS

- Global information about the atmospheric parameters and the state of Earth's surface that can support weather forecasts
- Improved day-to-day reliability of weather prediction by providing routine observations globally
- Improving the accuracy of numerical models and under-standing of the weather processes
- Improving early warning of hazardous weather conditions leading to better protection of life and property.

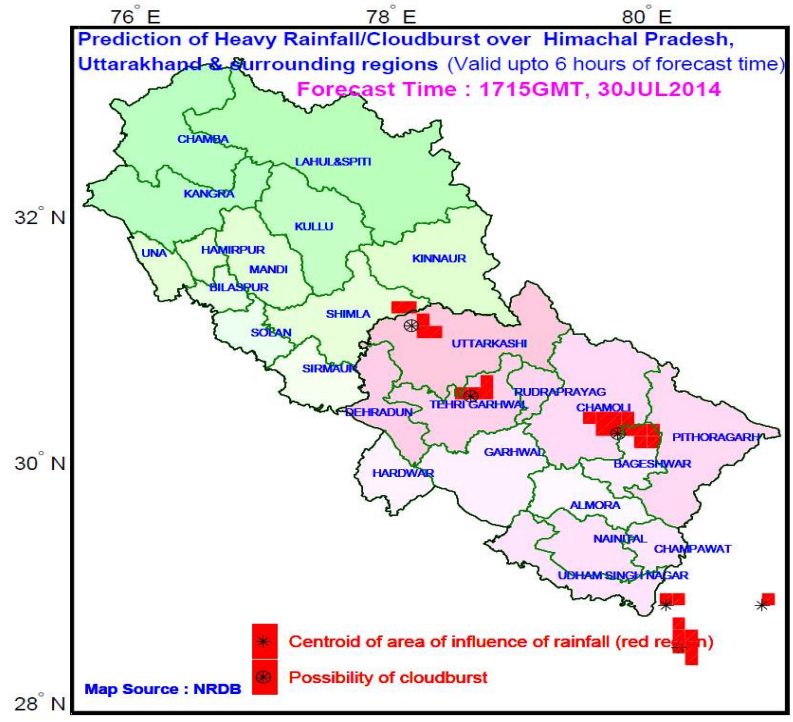
WEATHER PREDICTION

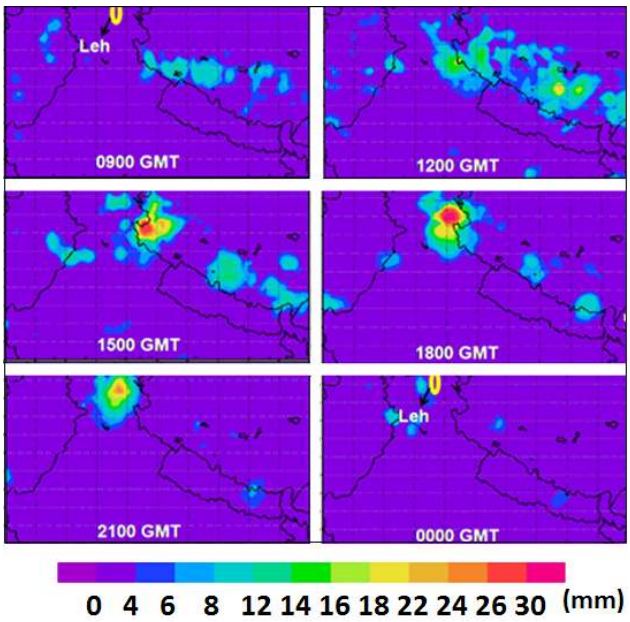
OPERATIONAL PRODUCTS / SERVICES

- Development of INSAT Meteorological Data Processing System (IMDPS) and its operational implementation at IMD and SAC
- Operational weather prediction from WRF model at high spatial resolution (5 km) using satellite and in-situ observations
- Weather forecasts are provided operationally to Karnataka State Natural Disaster Monitoring Centre
- Assimilation of INSAT-3D radiances and geophysical products in NWP models operational at ISRO (SAC) and MoES (IMD & NCMRWF)
- Input to Gujarat Weather Watch Programme with NWP model and satellite inputs

RESEARCH AREAS

- Monthly/seasonal all-India rainfall prediction using coupled climate model
- Thunderstorms forecasting using radio- sounding data over and around SHAR during satellite launch campaign
- Inter-satellite calibration of Indian geostationary satellite instruments to provide climate quality data under international GSICS programme
- Heavy rainfall alerts over Uttarakhand and Himachal Pradesh using SAC Nowcast Model (NETRA)
- Prediction of monsoon onset over Kerala using satellite data



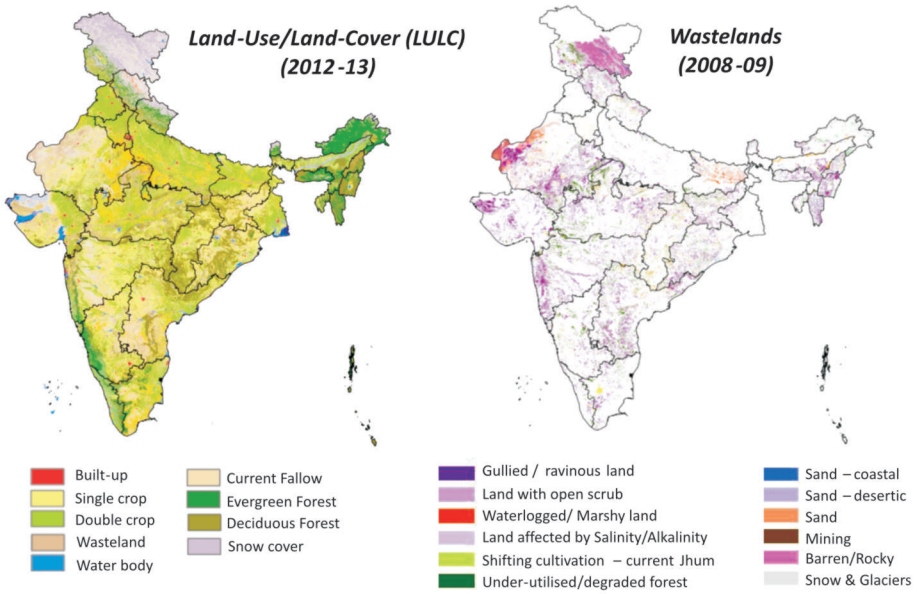


Position and intensity of the rain bands captured by the INSAT Multispectral Rainfall Algorithm (IMSRA) prior and after the cloud burst at Leh.

DEVELOPMENT PLANNING

DEVELOPMENT PLANNING

Development planning has been a central tenet of modern India's growth strategy. With the 73rd and 74th constitutional amendments, Decentralised Planning process has been adopted in the country to promote local self governance for inclusive and sustainable growth. Effective planning and decision making require reliable, periodic and updated spatial information on natural resources at varied scales. Space-based information coupled with geospatial tools facilitate creation, organisation, visualisation and dissemination of resource databases, which are vital for participatory development planning at multiple levels.



- Satellite-derived thematic databases on geomorphology, soil, LULC, wastelands, surface and ground water, infrastructure, etc. are being provided through *Bhuvan* geoportal.
- This baseline information is used to develop action plans for optimal land and water resources development and infrastructure planning.

Cadastral-Level Information from Satellite Images (Lohardaga District, Jharkhand)

- The temporal characteristics of satellite images also enable progress monitoring and performance evaluation of various developmental schemes.

MAJOR HIGHLIGHTS

- Creation, organisation and maintenance of National Natural Resources Repository
- A nation-wide initiative on Space-based Information Support for Decentralised Planning (SIS-DP)
- Sharing Earth Observation (EO) data products & services through *Bhuvan* geoportal for multifarious use by the user community
- Decentralised planning at Grassroot level enabled through a web platform, *Bhuvan-Panchayats*
- Mobile Apps for crowdsourcing of data through community participation

MAJOR BENEFITS

- Planning, monitoring and performance evaluation of developmental projects and schemes in timely and cost-effective manner
- Scientific & transparent decision making
- Opportunity for community participation in planning process

DEVELOPMENT PLANNING

OPERATIONAL PRODUCTS/ SERVICES

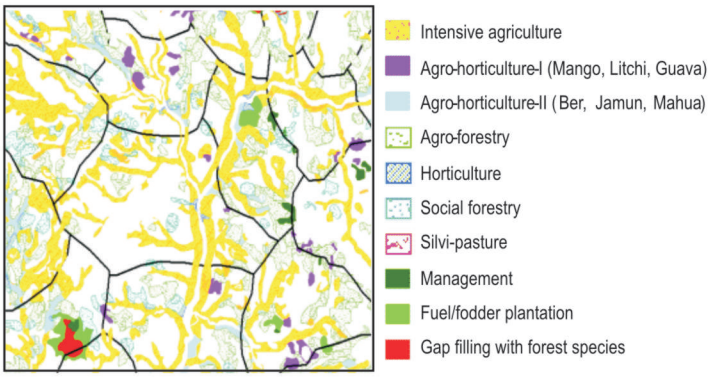
- High-resolution, ortho-rectified Satellite data and Thematic maps at varied scales (1:10,000, 1:50,000 and 1:250,000)
- LULC information on 1:250,000 (annually), 1:50,000 (every 5 years), and on 1:10,000 scales (need basis)
- Web-based tools for creation, visualisation and analysis of thematic datasets enabling community participation for societal applications

Participatory Rural Appraisal (PRA) in Wadala Micro-Watershed, Solapur District, Maharashtra

INTEGRATED WATERSHED MANAGEMENT

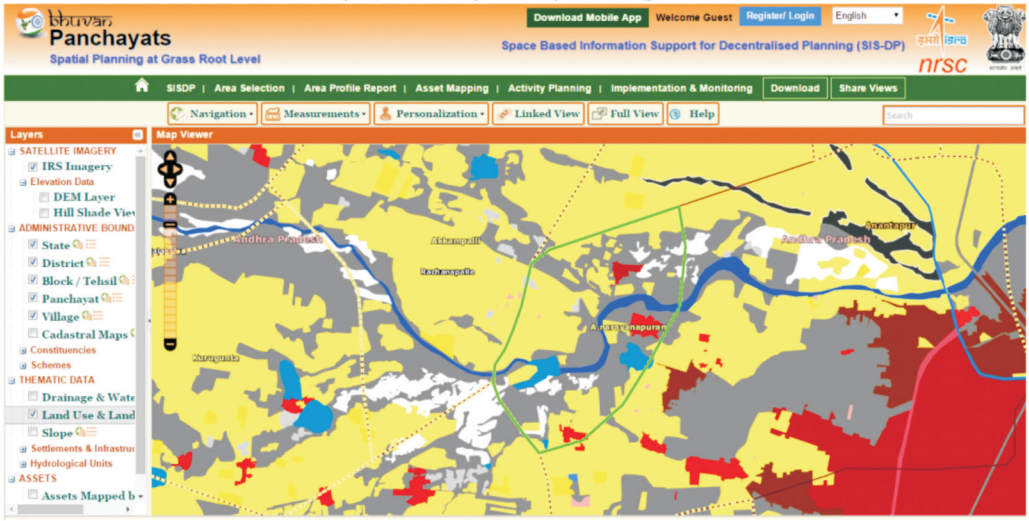
Monitoring Action Plan Implementation (Nipana Micro-Watershed, Akola District, Maharashtra)

Action Plan for Watershed Development (Part of Lohardaga District, Jharkhand)



WEB-BASED SPATIAL PLANNING AT GRASS ROOT LEVEL (*BHUVAN-PANCHAYATS* PORTAL)

http://bhuvan-panchayat.nrsc.gov.in/

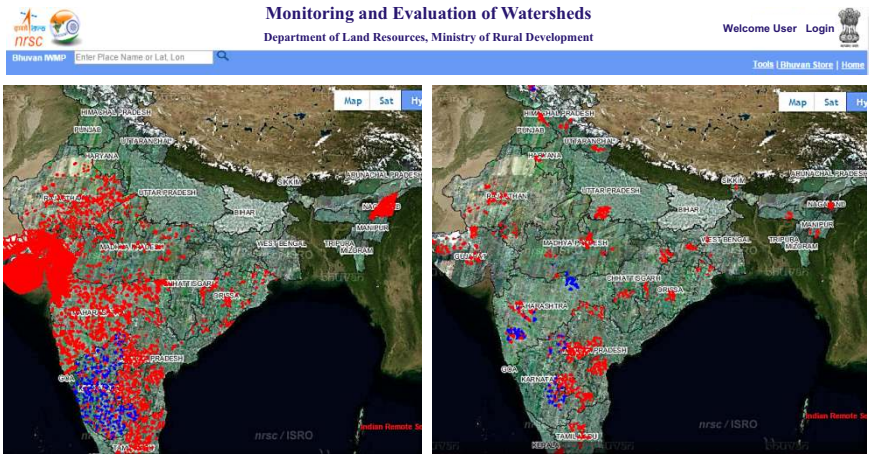


Crowdsourcing through Mobile App

INTEGRATED WATERSHED MANAGEMENT

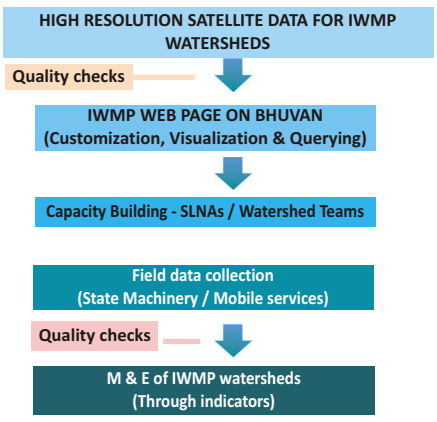
Watershed management deals with the conservation, regeneration and judicious use of available resources (land, water, plants, animals, etc.). The Ministry of Rural Development, Govt. of India has launched Integrated Watershed Management Programme (IWMP) by modifying erstwhile programmes namely, Drought Prone Areas Programme (DPAP), Desert Development Programme (DDP) and Integrated Wastelands Development Programme (IWDP) of the Department of Land Resources. IWMP is aimed towards restoration of ecological balance by harnessing, conservation and development of natural resources, especially in rainfed areas of the country.

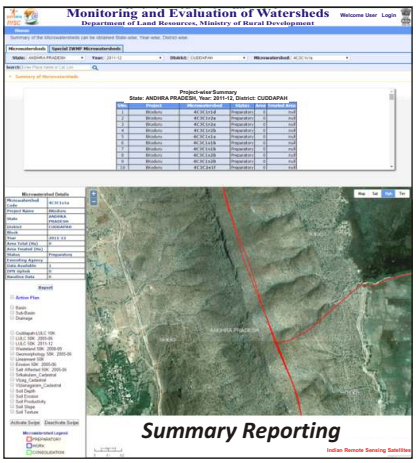
The space based remote sensing technology, especially with the availability of high spatial and temporal resolution satellite data and aided with Geographic Information System (GIS) tools could be effectively used for watershed management and monitoring activities. The geospatial technology helps in baseline survey, planning for development activities, monitoring and evaluation, apply mid-course corrections and assessing long-term effectiveness of the programme implemented.



Regular IWMP Micro-watersheds ***Special IWMP Micro-watersheds***

Approach for M&E





Summary Reporting

MAJOR HIGHLIGHTS

- Database integration at micro-watersheds scale into national framework for monitoring and evaluation
- High-resolution satellite images for impact assessment in terms of biophysical changes
- Android-based online inventory of assets created, coupled with Web-GIS based visualisation and reporting

MAJOR BENEFITS

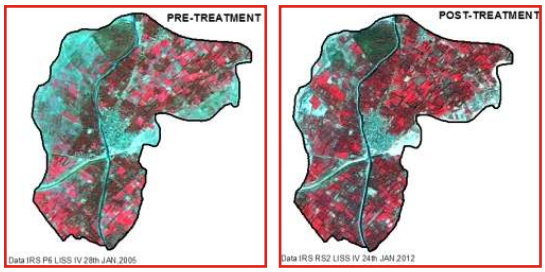
- Uniform evaluation of watershed development programme across the country using ortho-rectified high-resolution satellite image database
- Open source mapper tools for creation of future action plans using legacy/ multi-thematic layers
- Prioritisation of target areas at national level and modeling of processes

INTEGRATED WATERSHED MANAGEMENT

OPERATIONAL PRODUCTS/ SERVICES

- Employing watershed-based development framework helps to implement, regulate, correct, assess and report the interactions of man and nature for harmonious development of resources
- Monitoring and evaluation of watersheds using Remote Sensing and GIS tools enables quality implementation and mid-course corrections
- Spatial database of watersheds in 50 districts for monitoring by PMO as well as for watersheds in 10 States across country collated on *Bhuvan*

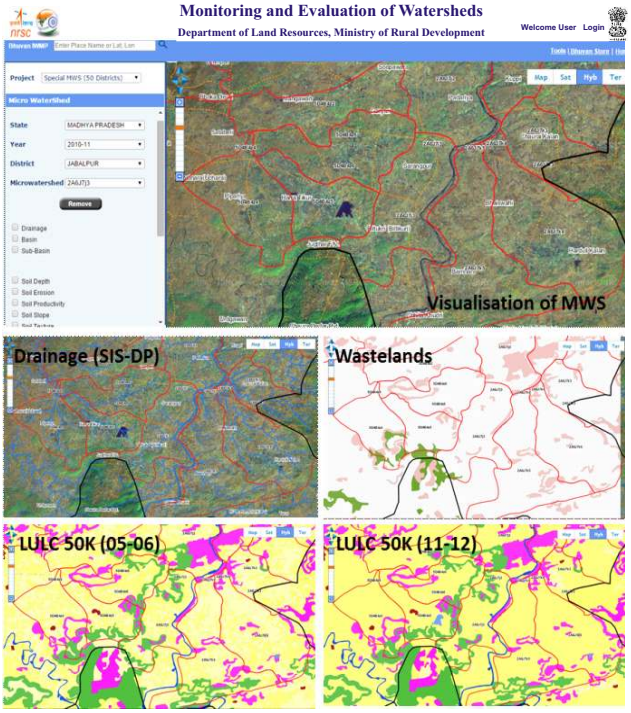
Temporal Changes in a Watershed



High-resolution satellite images at 2.5m spatial resolution, coupled with open source handheld geo-tagged field data inventory tool

Android tool

Multi-thematic Layers:
Prioritisation Inputs for Action Plans



Portal Flow

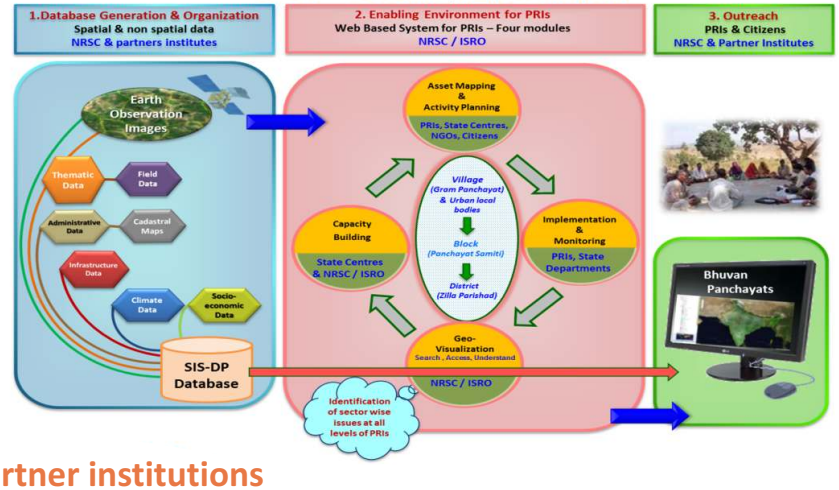
SPACE BASED INFORMATION SUPPORT FOR DECENTRALISED PLANNING

Empowering the Panchayati Raj Institutions (PRIs) and the Stakeholders with Space based Information Support for Decentralised Planning (SIS-DP) and Governance in the country

Objectives

- *To generate and provide 'Satellite Image Maps' for the entire country as base for Decentralised Planning (high resolution, true color, ortho-rectified, merged satellite data products)*
- *To prepare thematic and base layers on 1:10,000 scale using Satellite Image Maps, Slope maps using Digital Elevation Model and Cadastral maps through vectorisation and geo-referencing*
- *To create a databank of Satellite Image Maps, thematic and base maps, slope class maps; and organize census data, climate data, cadastral maps, stakeholder's data and available legacy data (thematic and base layers) on GIS platform*
- *To develop a comprehensive web portal as per PRIs and stakeholders needs for Decentralised Planning, Governance, Outreach to the citizens and data dissemination*
- *To build Capacity of PRIs and stakeholders for the use of Space Based Information in Decentralised Planning and Governance*

SIS-DP – A Conceptual Framework



Partner institutions

State Remote Sensing Centres/ State Councils for Science and Techonology of Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal, Telangana; Birla Institute of Scientific Research, Jaipur; Central Arid Zone Research Institute, Jodhpur

MAJOR HIGHLIGHTS

- Generation of true colour, ortho-rectified satellite image maps (2.5m) first time for the entire country
- 1:10,000 scale thematic maps for large parts of the country for the first time
- Web portal for planning process by Panchayati Raj Institutions (PRIs)
- Empowering the citizens by inclusion in the decision making process
- Inclusion of Centrally Sponsored Schemes for activity Planning
- Mobile based application for PRIs' Asset Mapping

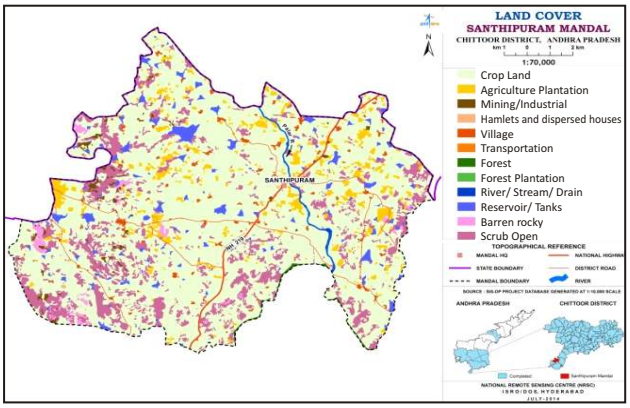
MAJOR BENEFITS

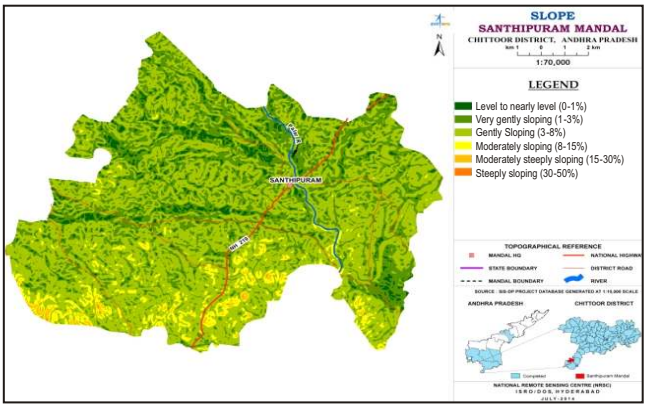
- Single Window interface for Decentralised Planning process at all three levels
- Accessibility of portal to common citizen for effective participation in planning process
- Accessibility of Climate data at Panchayat level
- Automatic Report Generation covering various socio-economic, demographic, natural, climate and infrastructure information
- Effective for decision making at Panchayat level under e-Governance

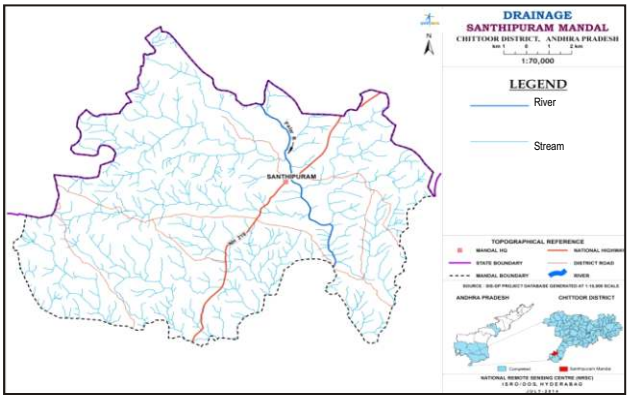
SPACE BASED INFORMATION SUPPORT FOR DECENTRALISED PLANNING

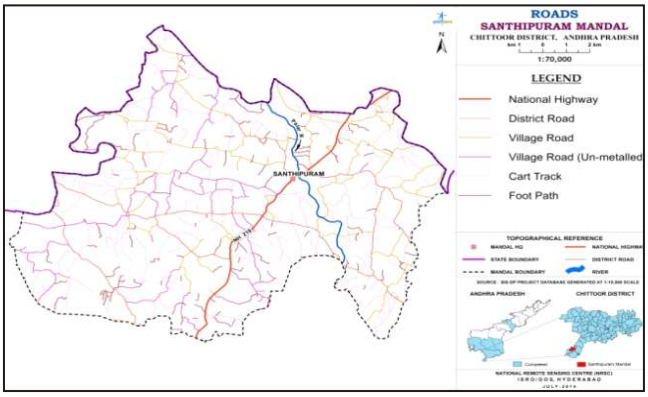
THEMATIC MAPPING AT 1:10,000 SCALE

Thematic Maps at 1:10,000 Scale for Land Cover, Infrastructure, Drainage and Slope

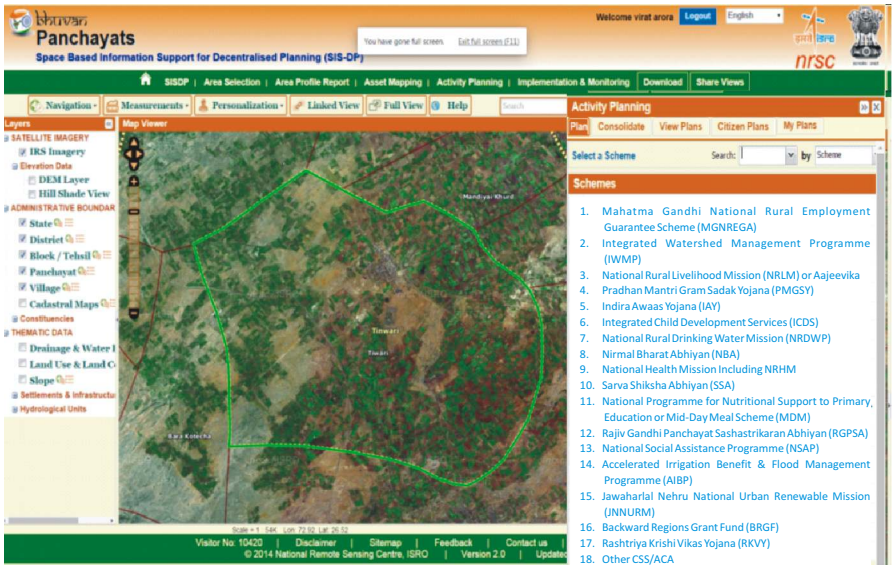








BHUVAN PANCHAYATS – SIS-DP PROJECT PORTAL



- Bhuvan Panchayats - a web portal with 2.5m color satellite images and 1:10,000 scale thematic data
- Supports Activity Planning for 17 Centrally Sponsored Schemes
- Supports mapping of 67 Assets categorized in 5 classes with 213 Attributes
- Hosts mobile app for asset mapping through smart-phones

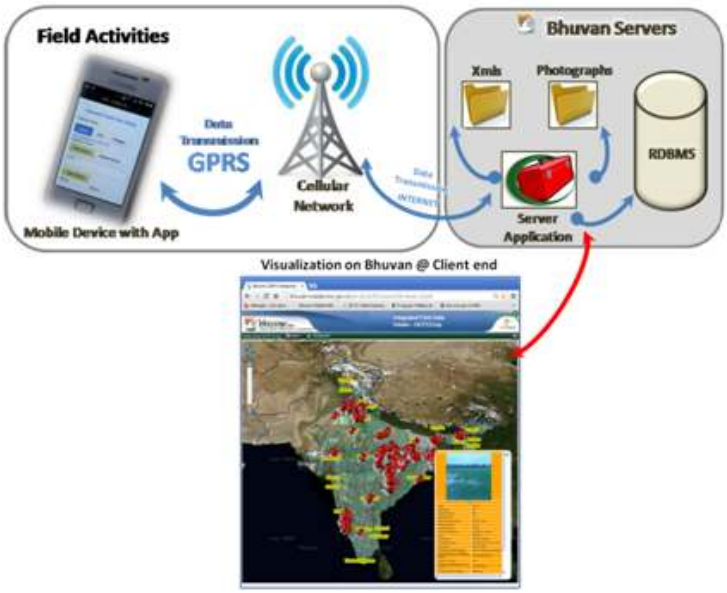
http://bhuvan-panchayat.nrsc.gov.in/

MOBILE APPLICATIONS

Data collection from field constitutes an important part in the process flows of various geospatial activities. These include collection of ground truth data, infrastructure facilities, asset mapping, disaster management, incident alerting, etc. Recent advancements in smart phones, GPS, wireless networks and WebGIS has facilitated the development of customised mobile applications for domain-specific attribute data collection with geo-tagging and field photographs.

The mobile applications not only help in standardising the data collection process but also help the user to collect the field information at ease and in a systematic manner through the rich Graphical User Interface (GUI). The collected data can be transferred instantaneously or later to the server (e.g. Bhuvan) for data management, visualisation, query and analysis.

Technological Work Flow



Requirements

Mobile device (Smart phone) with the following features: 3.5" or bigger screen, Android OS 2.3.3 or higher, built-in camera, GPS, GPRS/Edge/3G cellular connectivity, WiFi, 256 MB or higher RAM, 2GB or higher SD card storage

Training to use Mobile App

MAJOR HIGHLIGHTS

- Mobile applications have been developed for multiple and widespread end-use
- Easy and economical deployments made possible with currently available technologies
- Diverse application areas include Disaster Management, Points of Interest (PoI) & Asset Mapping, etc.

MAJOR BENEFITS

- Reduces errors inherent in manual data collection/ entry/ transfer processes
- Quick turn-around-time with near real-time data transfer, utilisation and GIS integration
- Centralised management with data sharing, reuse, protection and availability
- Huge time and effort savings

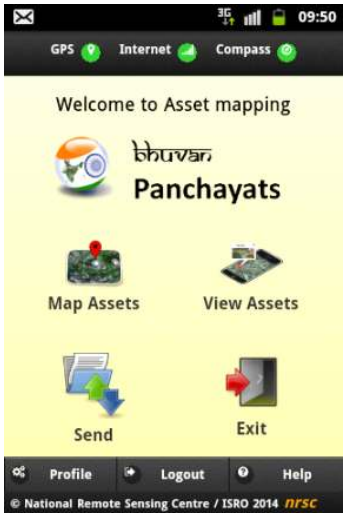
MOBILE APPLICATIONS

OPERATIONAL PRODUCTS / SERVICES

- Field Data collection on agricultural crops
- Map the Neighbourhood in Uttarakhand (MANU) for disaster damage assessment
- Accelerated Irrigation Benefit Programme (AIBP) and Integrated Watershed Monitoring Programme (IWMP)
- Basic Minimum Facilities (BMF) inventory, vehicle tracking and incident alerting applications for Election Commission of India (ECI)
- Geo-tagging of beneficiary houses for AP Housing Corporation
- Asset Mapping under Bhuvan Panchayats

SALIENT FEATURES

- Capture photographs along with location (latitude-longitude), direction and description
- User friendly addition of attribute data
- Provision to send collected data in near real-time and send later option
- Provision to edit the attribute and delete observation before sending to Bhuvan portal.
- Categories based dynamic GUI for attribute data collection
- Near real-time visualisation of collected data on web browser



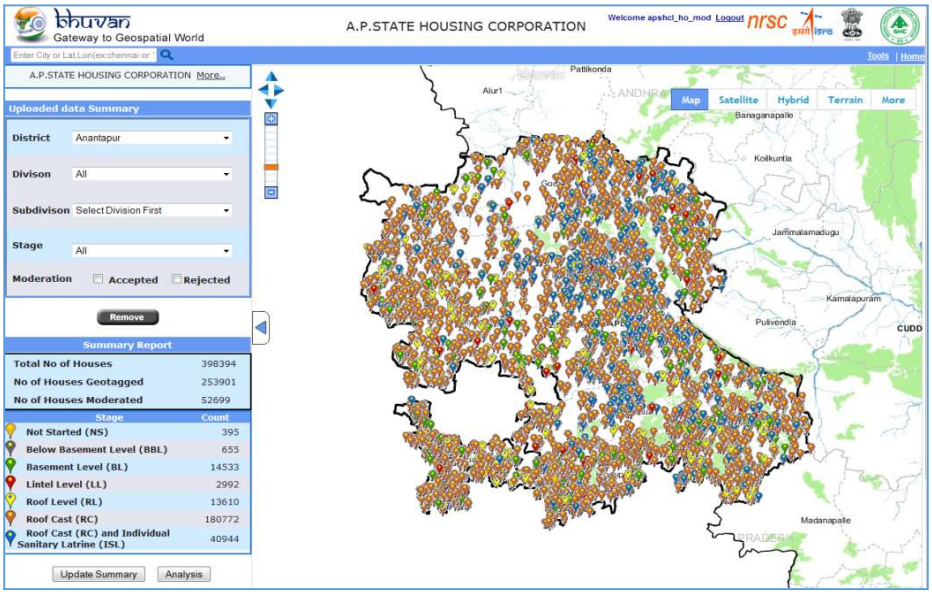
ASSET MAPPING

Asset Mapping is an extended service of Bhuvan geoportal (www.bhuvan.nrsc.gov.in). It provides Mobile-based Android Apps and Mapper applications to enable mapping in an easy and intuitive manner. Bhuvan-Mapper Applications along with the provision of rich thematic and satellite data help in building value-added maps through interactive community participation. The asset mapping datasets are hosted in Bhuvan geoportal for information dissemination and management.

Major Projects

- Specialised Android Field Data Collection & Mapper Applications developed for addressing the specific objectives of the projects, allowing for capturing assets with customised categories and detailed project specific attributes. The customisation of the categories and attributes enables embedding user-centric information.
- Android Apps developed for over 20 Projects for Andhra Pradesh State Housing Corporation (APSHC), Mahalanobis National Crop Forecast Centre (MNCFC), Map the Neighbourhood in Uttarakhand (MANU), Disaster Support during Phailin, Hudhud, etc. for Points of Interest (POI) or assets mapping.
- Mapper Applications for various projects, like Integrated Watershed Management Programme (IWMP), Karanataka Forestry Department (KFD), Maharashtra Water Resources Development Support (MWRDS), Map the Neighbourhood in Uttarakhand (MANU), etc.

A Snapshot Showing Asset Mapping Points (over 25 lakhs houses) on Bhuvan Geoportal



(Partner Institution: A.P. State Housing Corporation)

MAJOR HIGHLIGHTS

- Versatile mapping tool to collect, integrate, and disseminate geo-tagged data through Mobile-based Android Apps and Bhuvan Mapper applications
- Provision to collect project-specific attributes of Assets
- Enables Add/Edit Point of Interest (POI) option at desired Zoom Levels
- Facility to map the assets as Point or Line features as per the requirement
- Provision to overlay Administrative boundaries and other thematic datasets, e.g. Land-use/ Land-cover, Wastelands, etc.
- Seamless, ortho-rectified satellite images of 2.5 m spatial resolution available for entire country for visualisation and mapping

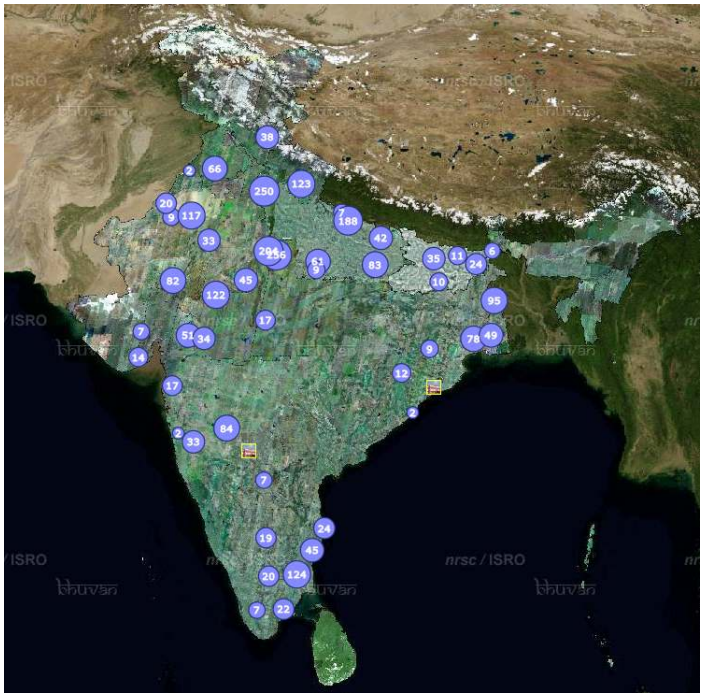
MAJOR BENEFITS

- Interactive community participation
- Facility mapping and gap analysis
- Damage assessment and mitigation strategy

ASSET MAPPING

ASSET MAPPING APPLICATIONS

A Snapshot Showing Ground Truth (GT) Point Density of Crops on Bhuvan Geoportal. GT Point includes GPS Reading, Photographs, Sketch of the Field Layout and GT Form

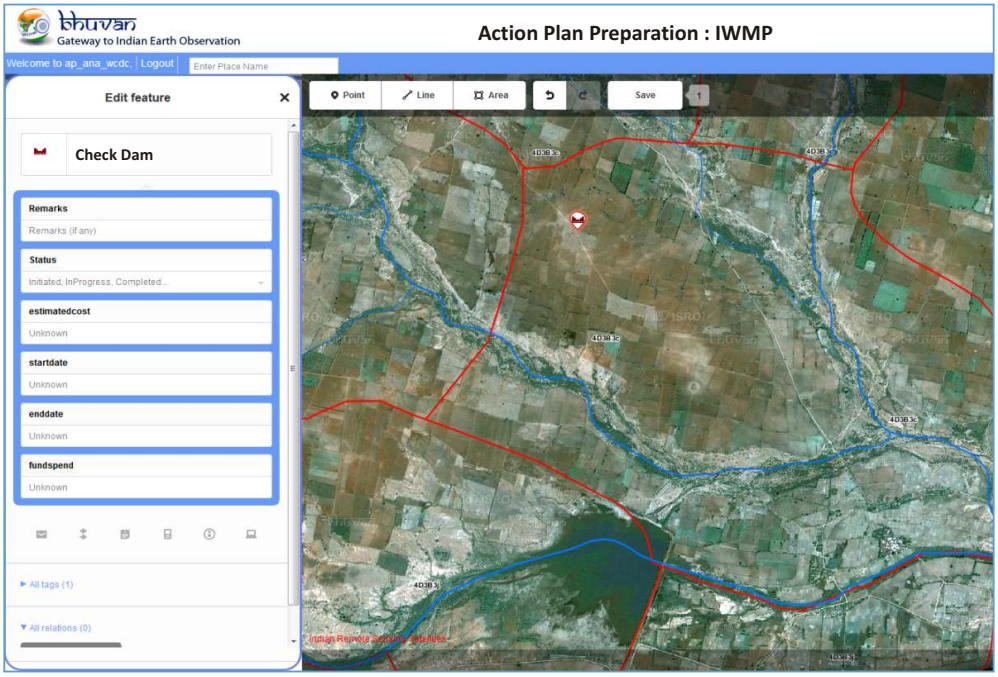


(Partner Institution: Mahalanobis National Crop Forecast Centre)

A Snapshot Showing Reservoirs and Tanks in Maharashtra

(Partner Institution: Maharashtra Water Resources Development Support)

A Snapshot Showing Bhuvan Mapper Application to make Action Plan Preparation for Integrated Watershed Management Plan



(Partner Institution: Department of Land Records)

MODERNISATION OF LAND RECORDS

Land Record Modernisation envisages deployment of modern equipments and methodologies along with the space technology to bring efficacy in survey and creation & updation of Land Records with shorter time span and good accuracy compared to old methods of survey and record preparation. The increasing availability of the High Resolution Satellite Images and Aerial images can effectively be incorporated with advanced techniques for modernisation of land records.

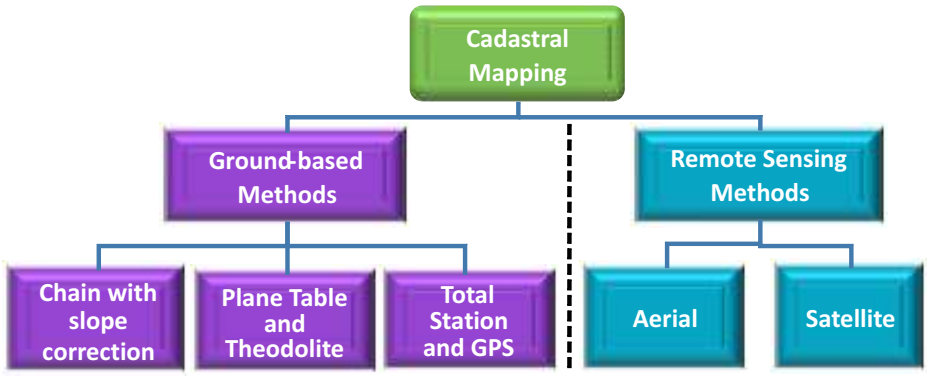
Activities

- Computerisation of Records of Rights (RoRs)
- Digitisation of maps
- Survey/ re-survey using modern technology
- Training and capacity building

Conclusive land title

- Single window
- Mirror principle
- Curtain principle
- Title insurance

Survey/ Re-survey of Cadastral Maps using Modern Technology



Factors influencing the mode of survey/re-survey

- Terrain conditions
- Settlement
- Vegetative Cover
- Parcel density
- Cost
- Timeliness

Cadastral Mapping using Ground Survey

Cadastral Mapping using High Resolution Satellite Imagery

Cadastral Mapping using Aerial Images

MAJOR HIGHLIGHTS

- Nation-wide area coverage
- Speedy and economical parcel updation through High Resolution Satellite Images
- Real-time records availability to the citizen
- Free accessibility to the records
- Web-enabled “anytime anywhere” access
- Reduce interface between citizens and the Govt. functionaries

MAJOR BENEFITS

- Rapid data processing
- Increased throughput
- Easy parcel identification on the enhanced ortho-rectified High Resolution Satellite Images
- Area prioritisation for ground survey
- Large trained manpower
- Updated land records in a single click

MODERNISATION OF LAND RECORDS

Satellite imagery

Advantages

- Economical
- Time-effective
- Mapping requires minimum Ground Control Points

Limitations

- Obscured by tree canopy
- Congested settlements
- Dynamic changes in parcels

Aerial imagery

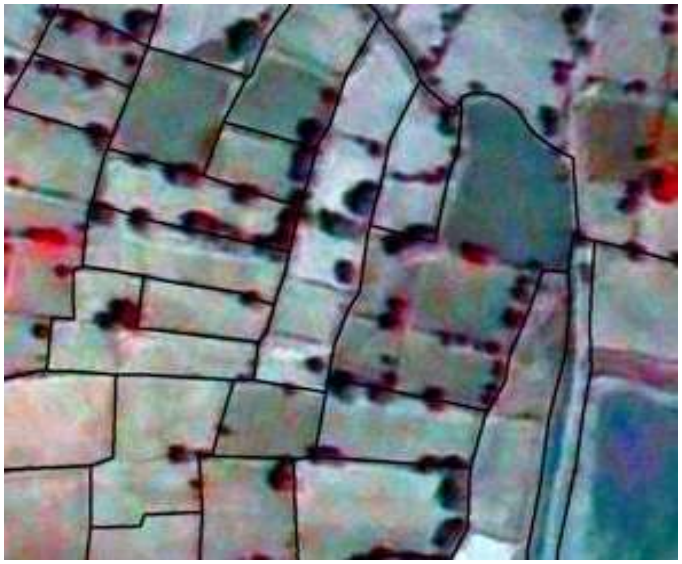
Advantages

- High accuracy
- Time-effective

Limitations

- Costly
- Weather dependent
- Procedural delay in data acquisition

Parcel Boundaries Visible in Merged Product of Cartosat-2/LISS-IV

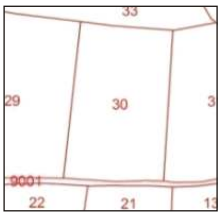


Parcel Boundaries Delineated from High Resolution Satellite Imagery

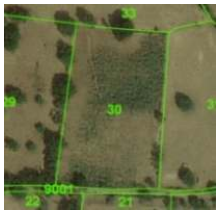
Cadastral Mapping Accuracy Analysis using Merged Product

Record of Rights (RoR)

Electronic Total Station (ETS)-GPS



HRSI

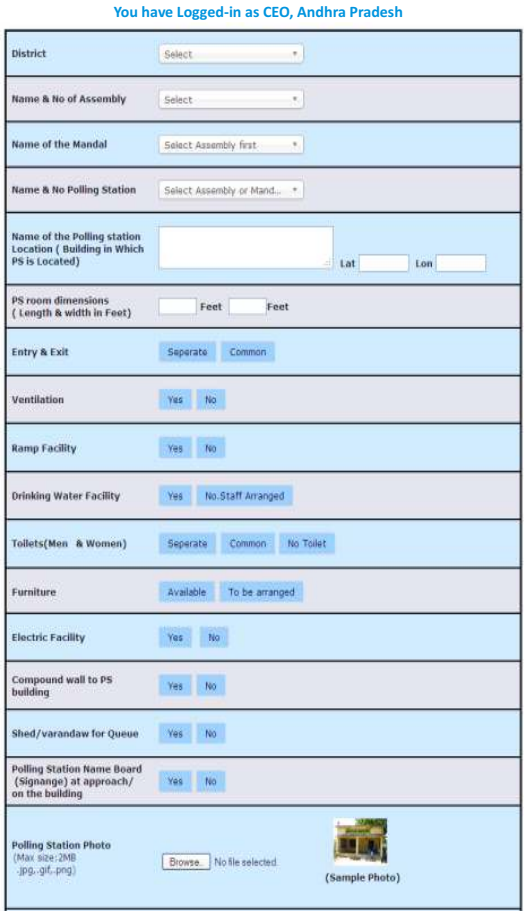


Parameter/ Parcel No.	Area (Ha)		
	Record of Rights	ETS-GPS Survey	Parcel delineated using HRSI
23	0.20	0.19	0.20
25	1.44	1.56	1.53
71	0.13	0.13	0.12

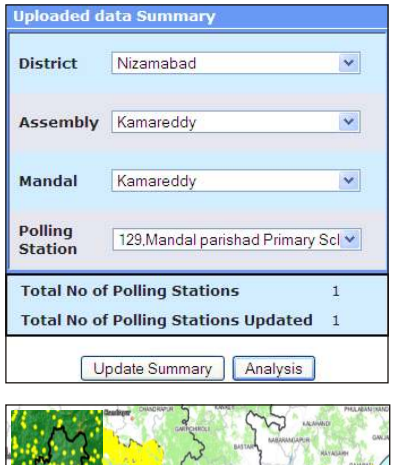
Parameters Used for Cadastral Mapping Accuracy Analysis using HRSI	Record of Rights	ETS-GPS Survey	Parcel delineated using HRSI
Area (Ha)	0.85	0.86	0.84
Perimeter (m)	384.58	381.01	378.60
Centroid shift w.r.t. ETS (m)	-	-	0.3

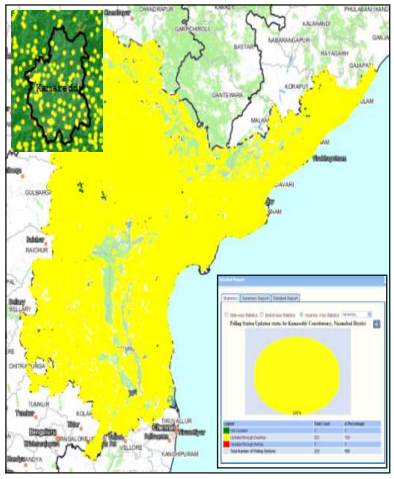
ELECTION GIS

This application is designed to provide vital information on the polling stations in terms of 17 important parameters to check the important pre- poll requirements.



Inventory of Basic Minimum Facilities at Polling Station





Total No. of Polling Stations: 69,014
Updated Polling Stations: 67,502

District Name	Total No. of P.S	Total Updated	Ventilation Non Availability	Electrification Non Availability	5AMP Sockets availability for live Webcasting Non Availability	Electric points nearby available for webcam/laptop location Non Availability	Toilets Non Availability	Drinking Water Facility Non Availability	Court-yard Non Availability	Ramps Non Availability	Compound wall to PS building Non Availability
Adilabad	2256	2256	27	375	1198	715	443	285	199	521	842
Anantapur	3310	3309	38	585	2246	1020	784	611	925	1445	559
Chittoor	3156	3156	15	353	1441	774	254	444	439	742	843
East Godavari	3982	3982	18	235	1244	712	220	142	537	838	1288
Guntur	3739	3739	40	501	1633	916	252	505	782	2380	1203
Hyderabad	3091	3085	81	124	648	585	138	686	1028	2166	157
Kadapa	2491	2491	12	362	1176	653	261	490	617	1823	631
Karimnagar	3393	3391	9	290	1369	489	207	152	334	499	435
Khammam	2259	2259	11	285	1099	539	131	120	234	240	300
Krishna	3521	3521	21	476	1760	944	141	238	349	1611	926
Kurnool	3258	3258	14	436	1031	1121	301	411	931	1227	1047

Statement showing Facilities Available in Polling Stations in Nizamabad District as on 31-10-2014

Assembly Constitution Name	Total No. of PS	Total Updated	Total Updated Non Availability	Electrification Availability	Electrification Non Availability	5AMP Sockets availability for live Webcasting Availability	5AMP Sockets availability for live Webcasting Non Availability	Electric points nearby available for webcam/laptop location Availability	Electric points nearby available for webcam/laptop location Non Availability
Kamareddy	223	223	223	204	19	150	73	202	21

Role Based Access – HQ, District (23 No.), Assembly (294 No.) login

MAJOR HIGHLIGHTS

- Monitoring of Loksabha elections - 2014 through Bhuvan portal; Andhra Pradesh was chosen as Pilot project

Basic Minimum Features

- Facility to collect 17 parameters of each Polling station by provisioning of Web Interface/ Mobile App towards smooth conducting of Polling
- Visualisation of hierarchy-wise District/ Assembly/ Polling station data

Analysis & Reports

- State/ District/ Assembly-wise Basic Minimum Facilities (BMF) statistics on Updates and Spatial View
- Download as Excel file

Training

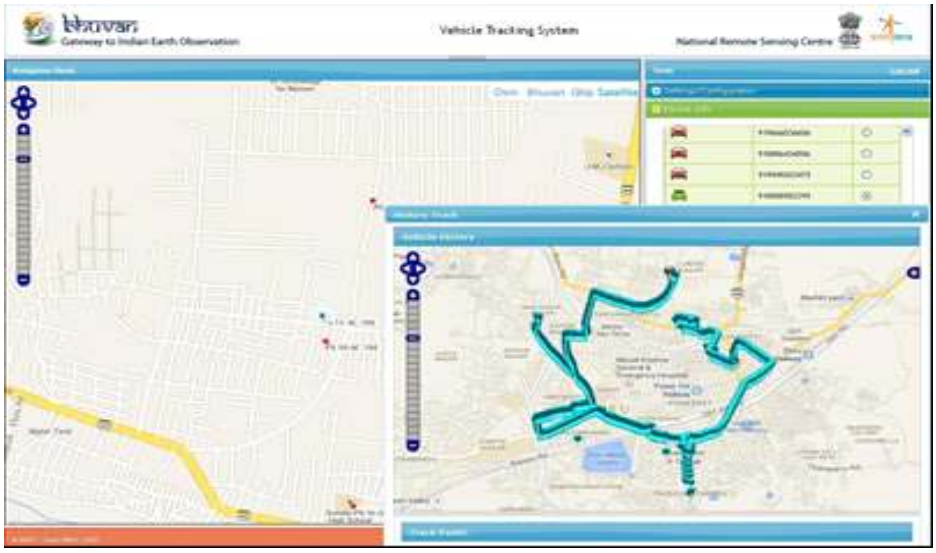
- Conducted training on BMF Module to all District and Mandal level officials through video conferencing
- Demonstrated Bhuvan Vehicle Tracking App through video conference to all District and Mandal officers

MAJOR BENEFITS

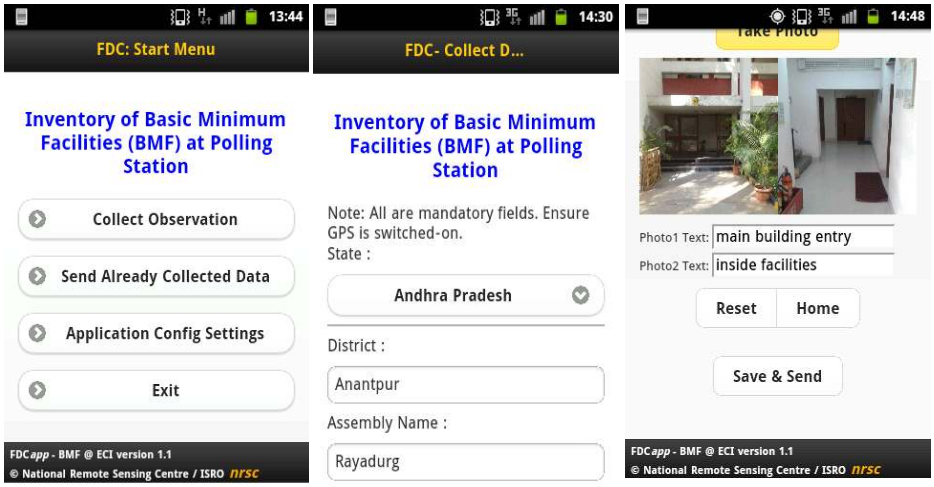
- Provides information for the smooth conduct of Elections

ELECTION GIS

Customised and Menu-driven Solution for Data Entry, Geo-tagging and Photograph Upload



Mobile Application



- Provision to capture geo-tagged photographs
- Preview of captured photographs
- Provision to save, upload to web server or to send later
- Provision to upload later/ Send Fail data
- Navigate to Collect Data Page

Vehicle Tracking

- Interface for live tracking of registered vehicles
- Visualize the track points, messages and photos received for a selected track
- 160 vehicles are active on election day out of 213 vehicles registered from 62 Assembly sectoral officers

Incident Reporting

- Based on the SMS from public, track and update the nearest squad
- Within 2 weeks of time - 99.7% data collected, an example of g-Governance, framework to replicate to any election
- Android app is designed with user friendly Form filling options with most of the data entries are based on drop down menu/choice options

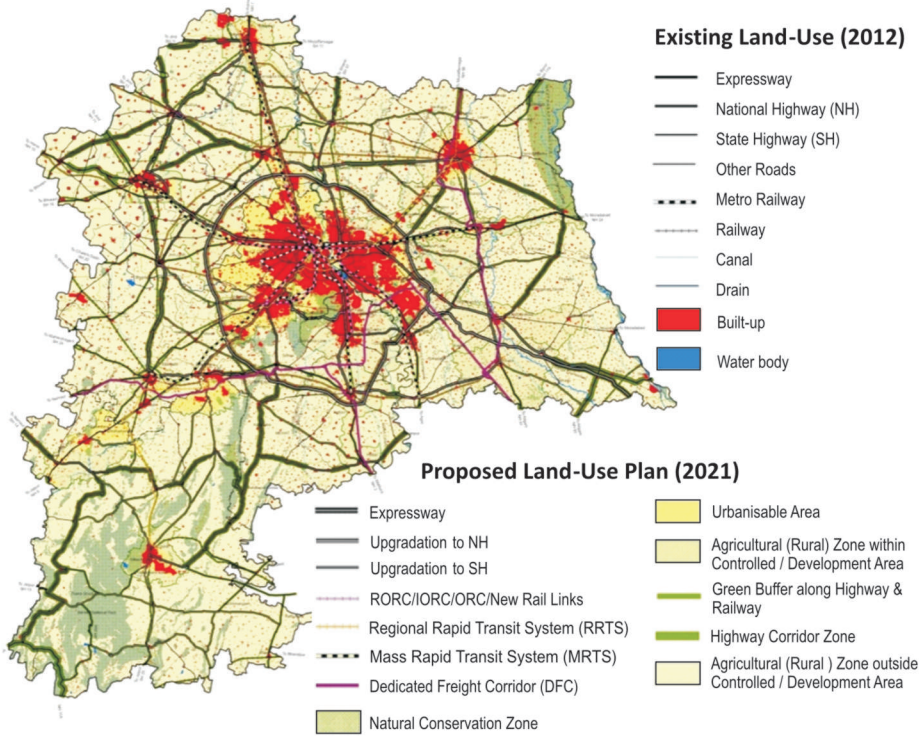
INFRASTRUCTURE PLANNING

INFRASTRUCTURE PLANNING

Infrastructure forms an integral part for growth and development of any region. Satellite images, owing to their spatial, temporal and spectral characteristics, provide valuable information about the land-use/ land-cover (present and past), existing infrastructure, terrain characteristics etc., which are vital to facilitate infrastructure planning, monitoring and management in a timely and cost-effective manner. Geographical Information System (GIS) with customised decision support tools facilitate integrated analysis of different datasets and their visualisation.

Regional Plan-2021 of National Capital Region (NCR): An Example

- NCR Regional Plan-2021 has been prepared by NCR Planning Board in association with ISRO.
- Land-use map of 2012 and Land-use change analysis map (1999-2012) prepared using satellite imagery formed the basic inputs for Regional Plan formulation.



MAJOR HIGHLIGHTS

- Satellite data provide baseline information on land-use/ land-cover, topography, vegetation cover, water bodies etc. , which are vital for infrastructure planning
- Space-based information & geospatial analysis tools support many applications like:
  - Urban and regional planning
  - Route alignment (road, rail, oil/ gas pipeline, etc.)
  - Site suitability analysis (hydroelectric project, new township, etc.)
  - Facility & Utility planning (landfill sites, schools, hospitals, etc.)
  - Environmental impact assessment
- A national mission initiated by the Ministry of Urban Development to utilise space-based inputs for preparing the Master Plans by the concerned Urban Local Bodies

MAJOR BENEFITS

- Space-based inputs along with other geospatial tools support efficient and cost-effective planning, monitoring & management of Infrastructure projects

INFRASTRUCTURE PLANNING

OPERATIONAL PRODUCTS/ SERVICES

- Primary thematic maps, e.g. present & past land-use/ land-cover (LULC), existing infrastructure, topography, geology, geomorphology, soil, etc.
- Utilitarian information from thematic maps, e.g., ground water potential, vegetation type & distribution, wastelands, etc.
- GIS-based analysis, e.g. route or corridor planning, development plans, site suitability analysis, etc.
- A web-based GIS tool available on *Bhuvan* geoportal for Urban Master Plan preparation

ONGOING/ FUTURE RESEARCH AREAS

- 3-D city modeling to assess rooftop solar potential
- Urban growth prediction and land-use/ land-cover change modeling for futuristic planning
- Effect of climate change on river basin and urban hydrology
- Geotechnical investigations and sub-surface utilities mapping using Ground Penetrating Radar
- Advanced terrain modeling (using high-resolution stereo satellite/ LiDAR data) for feasibility studies of infrastructure projects

Route Alignment & Corridor Analysis – A Few Examples

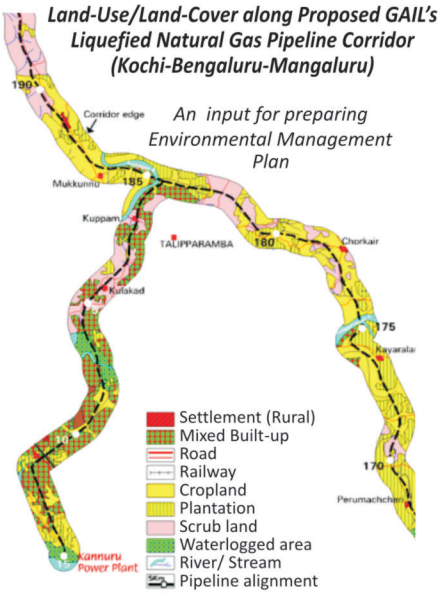
Gas Pipeline: Monitoring and surveillance of gas pipeline corridors (Kochi-Mangaluru-Bengaluru and Dahej-Vemar-Vijaipur)

Power Transmission Line: Route alignment surveys for proposed power transmission lines in Teesta–Siliguri and Dras–Kargil–Leh sectors

Rail: Corridor analysis from Farakka (West Bengal) to Lalmatia (Jharkhand)

Partner Institutions: *Gas Authority of India Limited (GAIL); Power Grid Corporation of India; Indian Railway*

Land-Use/Land-Cover along Proposed GAIL's Liquefied Natural Gas Pipeline Corridor (Kochi-Bengaluru-Mangaluru)



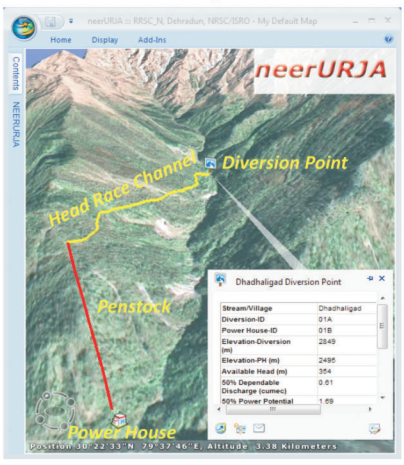
Space-based Inputs for Harnessing Renewable Energy

Hydropower: Satellite-derived Digital Elevation Model (DEM) and other thematic information (e.g. land-use/ land-cover, geology, geomorphology, etc.) in conjunction with river discharge help assessing the feasibility for locating hydropower sites, especially in inaccessible and mountainous terrain. Demonstrative studies have been carried out in Uttarakhand and NE region, wherein around 75 potential hydropower sites have been identified.

(Partner Institutions: *Government of Uttarakhand; Bodoland Territorial Council)*

Solar Energy: Satellite-derived estimates of solar radiation reaching the Earth's surface can be used to find suitable areas for harnessing solar energy. Demonstrative studies have been carried out in urban environment (Dehradun & Bengaluru) using 3-D modeling for assessing the solar power potential.

Potential Hydropower Site Selection in Birahi River Valley, Uttarakhand

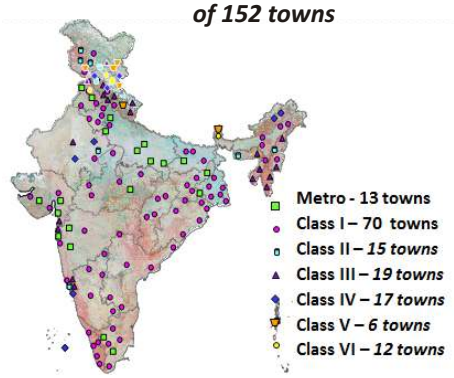


URBAN PLANNING

Urban planning helps to formulate long and medium-term objectives for the sustainable urban growth. The primary step/ phase of urban planning is the preparation of present/ existing urban land-use maps. Urban growth being dynamic in nature, periodic updation of urban land-use is required for effective urban planning. Satellite remote sensing offers excellent opportunities not only for mapping, measuring, managing, monitoring the changes or developments caused by urbanisation but also helps the Urban Local Bodies (ULBs) to enforce regulatory control measures.

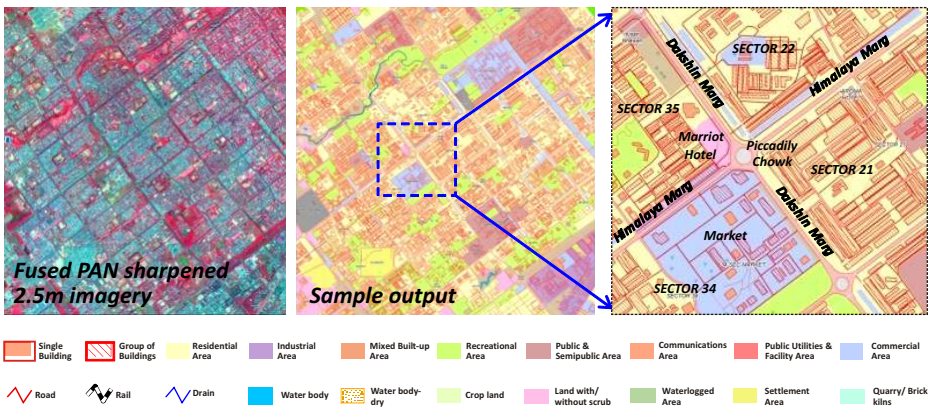
National Urban Information System (NUIS)

Distribution & Classification of 152 towns



- Preparation of Urban Geospatial Database on 1:10,000 scale for 152 Towns (covering about 50,000 sq km) using high-resolution satellite data (Cartosat-1 PAN + Resourcesat LISS-IV)
- Urban Geospatial Database contains 12 thematic layers (Urban Land-Use, Transportation, Geology, Geomorphology, Physiography, Soil, etc.) and 4 administrative/ planning boundary layers
- Hard copy maps & GIS database provided to the ULBs for preparation of Master Plans
- GIS database for these 152 towns published on Bhuvan.
- Developed open source Bhuvan-NUIS web application for preparation of Master Plans by the ULBs

Urban Land-Use: Part of Chandigarh City



MAJOR HIGHLIGHTS

- First-time National-level High-Resolution Satellite data utilisation for preparation of Large-scale (1:10,000) Urban Geospatial Database under the National Urban Infrastructure (NUIS) programme
- Standards established for preparation of large-scale space-based geospatial database
- Trained about 300 scientists from Partner Institutes (PIs) (State Remote Sensing Centres and other premier institutes) on large-scale mapping using high-resolution satellite data

MAJOR BENEFITS

- Geospatial database for 152 towns made available to Urban Local Bodies (ULBs) on Bhuvan platform formed the basic inputs for Master Plan preparation
- Benefited State Urban Departments and Partner Institutes to adopt NUIS standards and execute many State-level urban mapping projects

URBAN PLANNING

OPERATIONAL PRODUCTS/ SERVICES

- Urban land-use/ land-cover and inputs for Master Plan preparation under NUIS programme
- Urban sprawl and growth monitoring (*Bhuvan*)
- 3-D city visualisation of urban areas
- Analysis and mapping of informal settlements
- Municipal GIS, Tourism GIS
- Urban suitability analysis
- Mapping of urban green spaces
- Visualisation of cities through high-resoluton (1 m) satellite images (*Bhuvan*)

ONGOING/ FUTURE RESEARCH AREAS

- Urban growth modeling
- Impact of urban forms on urban micro-climate
- Urban environment and urban pollution
- Assessment of urban solar potential
- Vulnerability assessment of human settlements (seismic, flood, industrial, landslide, cyclones, etc.)
- Development of emergency response systems for human habitat

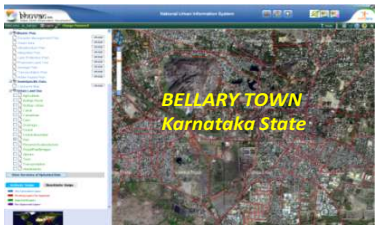
Bhuvan-NUIS

A Web-based Application for Geospatial Data Support for Master Plan Preparation

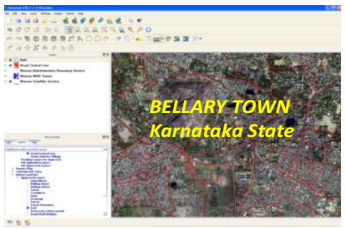
At the behest of Ministry of Urban Development, NRSC/ISRO has developed ***Bhuvan*-NUIS** web application to enable the ULBs prepare the Master Plans themselves. *Bhuvan*-NUIS is a open source GIS providing a comprehensive Geospatial framework for creation and updation of spatial and attribute data along with customised spatial analysis tools required for urban planning. Town and Country Planning professionals across the country have been trained to use this application. Many State Town & Country Planning Departments have identified towns for preparing Master Plans on *Bhuvan*-NUIS platform.

Bhuvan - NUIS Open-Source Geospatial Web Application

Bhuvan-NUIS Web Portal



Bhuvan-NUIS QGIS Plug-in



Salient Features

- ULBs can use Bhuvan-NUIS for preparing comprehensive geospatial data by creating, updating and loading town-specific spatial and non-spatial database and also archiving existing maps and GIS data
- Utilises exhaustive Remote Sensing & GIS data and open source solutions for Master Plan preparation
- Training and Capacity Building to Town Planning professionals
- Video Tutorials in Hindi and English
- Discussion forum for sharing of knowledge and experiences by Town Planners

DISASTER MANAGEMENT SUPPORT

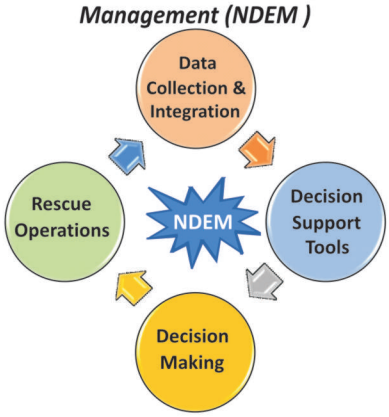
DISASTER MANAGEMENT SUPPORT

Towards supporting country's efforts in efficient management of natural disasters, ISRO has evolved a comprehensive space-based Disaster Management Support (DMS) Programme and institutionalised the same in association with concerned ministries/ agencies. Earth Observation satellites together with meteorological & communication satellites and aerial survey systems form the base for providing timely support and services for disaster management.

Satellite, Aerial and Ground-Based Observation Systems

GEO: Geostationary Orbit; **LEO:** Low Earth Orbit; **AWS:** Automated Weather Station; **DWR:** Doppler Weather Radar; **Res.:** Resolution; **Met:** Meteorological

National Database for Emergency Management (NDEM)

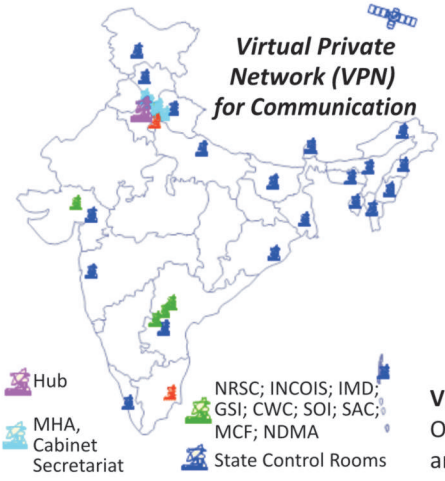


Operational Services from Decision Support Centre (DSC)

http://bhuvan-noeda.nrsc.gov.in/disaster/

- Floods
- Cyclones
- Forest fires
- Landslides
- Earthquakes

Virtual Private Network (VPN) for Communication



Emergency Communication Equipments

VPN: Linking National & State Emergency Operation Centres with Knowledge Institutions and Key Government Offices

MAJOR HIGHLIGHTS

- Nation-wide monitoring of major natural disasters like Floods, Cyclones, Landslides, Forest Fires & Earthquakes, through Decision Support Centre (DSC) at NRSC
- Establishment of satellite-based communication network linking State Emergency Operation Centres with Control Room at MHA, DSC at NRSC, other national agencies and key Govt. offices in Delhi
- Deployment of emergency communication systems during disasters
- Addressing database creation through National Database for Emergency Management (NDEM)
- Infrastructure for undertaking Aerial Surveys
- Support to International disasters
- Capacity building

MAJOR BENEFITS

- Better Disaster Response for Relief and Rescue
- Ensuring satellite-based communication during disasters
- Assessment of damage
- Mitigation planning

DISASTER MANAGEMENT SUPPORT

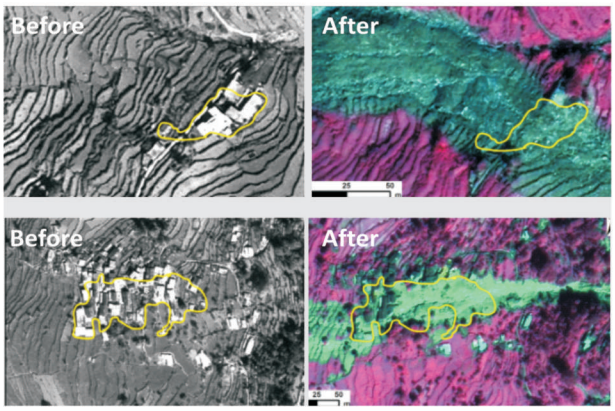
OPERATIONAL PRODUCTS / SERVICES

- Near real-time monitoring and mapping of major floods/cyclones in the country
- Flood hazard zonation in Assam, Bihar, Odisha, etc.
- Near real-time forest fire detection and case-specific burnt area assessment
- Landslide inventory, monitoring & hazard zonation
- Earthquake damage assessment
- Disaster services through NDEM public (http://bhuvan-noeda.nrsc.gov.in/disaster/) and private portals

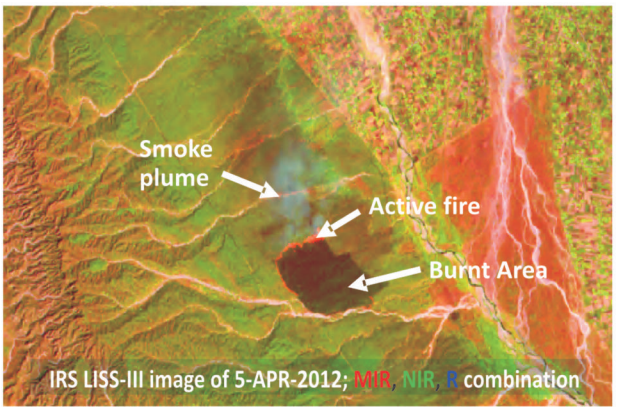
RESEARCH AREAS/ FUTURE INITIATIVES

- Flood forecasting and spatial inundation modeling
- Flood prone area assessment
- Urban flood modeling
- Modeling of storm surge inundation
- Forest fire danger rating
- Early warning of disasters
- Establishment of National Disaster Management Command Centre (NDMCC)

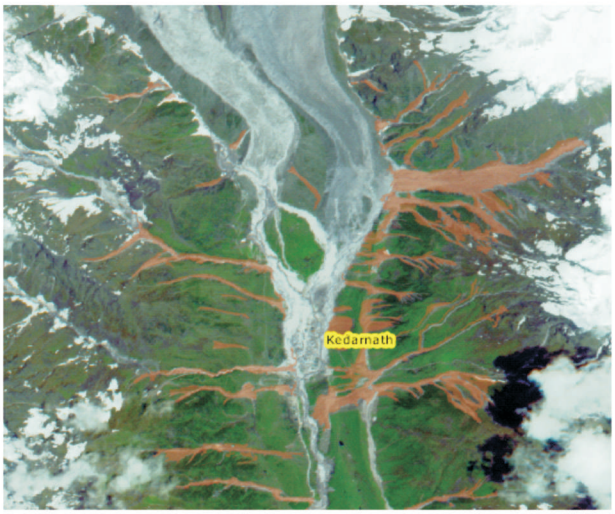
Damage to Buildings due to Okhimath Landslides-2012



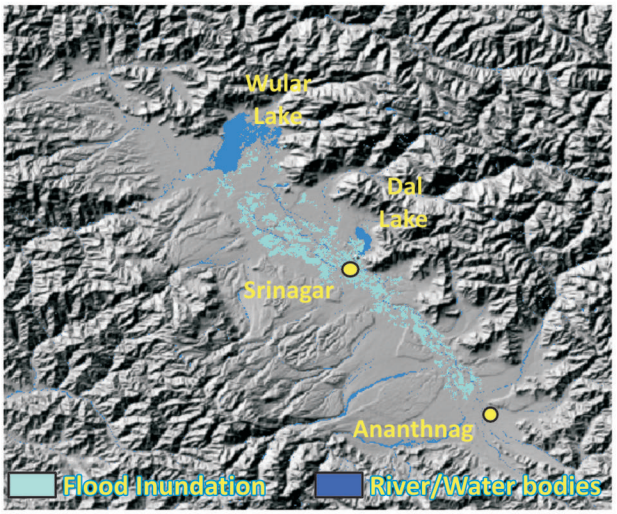
Forest Fire in Rajaji National Park, Uttarakhand – 5th April, 2012



Flood & Landslides around Kedarnath-2013



Floods in Jammu & Kashmir-2014



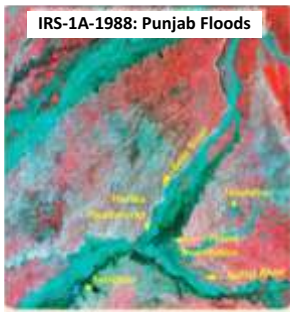
FLOODS & CYCLONES

Floods and Cyclones are the most devastating disasters affecting the country. Nearly one-eighth of the country's geographical area is prone to floods. Assessment of the extent of flood-affected areas and the damage to the infrastructure is critical to plan for relief operations.

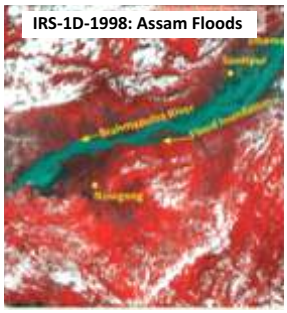
Under the Disaster Management Support (DMS) Programme, ISRO provides operational services towards delineation of flood-affected areas in near real-time for major flood and cyclone events. Flood hazard zonation is also being carried out. Flood forecast methodologies have been generated and being operationalised.

Indian Satellites for Flood Monitoring

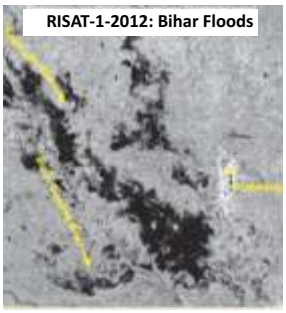
Demonstration 1980's → Operational Services 1990's → Institutionalisation 2000's



- Limited Coverage
- Less Details

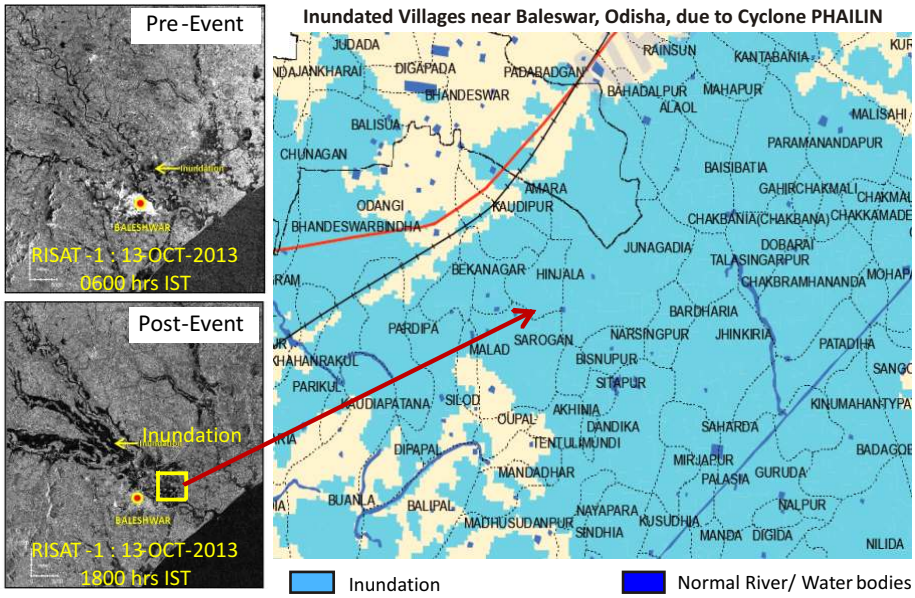


- Large Coverage
- More Details



- Day & Night Imaging
- All Weather Capability

Flood Mapping



MAJOR HIGHLIGHTS

- Nation-wide monitoring of major Flood and Cyclone events in near real-time for delineation of flood-affected areas
- Flood Hazard Zonation for selected states in the country
- Flood Early Warning and Spatial Inundation Modeling for selected rivers
- Flood prone area assessment
- Support to International Disasters through International Charter, Sentinel Asia, UN-ESCAP
- Capacity Building of Government Officials

MAJOR BENEFITS

- Better management of Relief and Rescue Operations
- Rapid damage assessment
- Planning mitigation measures

FLOODS & CYCLONES

OPERATIONAL PRODUCTS / SERVICES

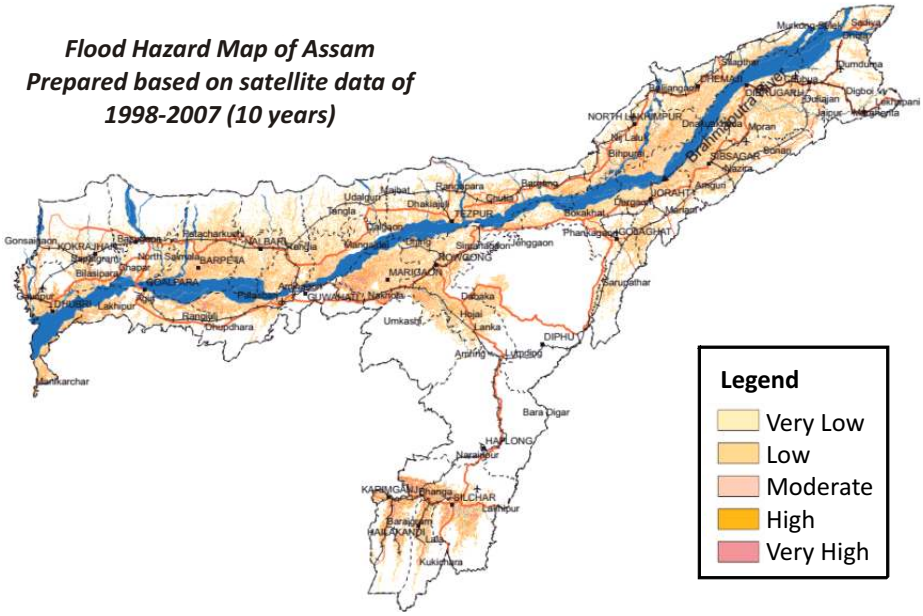
- Near real-time monitoring and mapping of major floods/ cyclones in the country
- Flood Hazard Zonation for Assam, Bihar, Odisha, etc.
- Flood disaster services through NDEM public and private portals (http://bhuvan-noeda.nrsc. gov.in/disaster/)

RESEARCH AREAS

- Flood forecasting and spatial inundation modeling
- Flood prone area assessment
- Urban flood modeling
- Modeling of Storm surge inundation

Flood Hazard Zonation

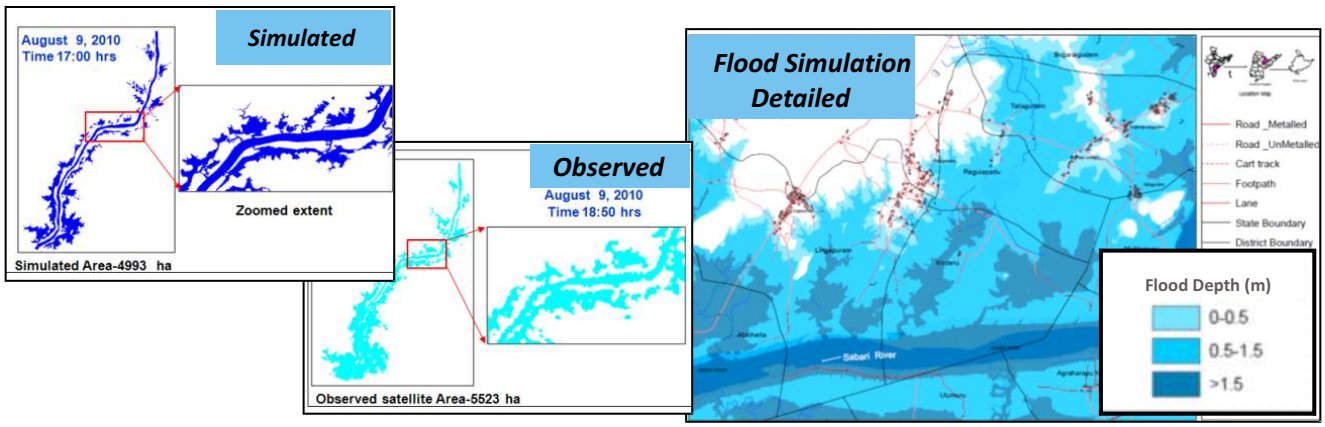
Flood Hazard Map of Assam Prepared based on satellite data of 1998-2007 (10 years)



- Based on multi-year satellite data, frequently flood-affected villages are identified in Assam and Bihar States and Flood Hazard Atlases are prepared.
- Assam Flood Hazard Atlas was released by Hon'ble Chief Minister of Assam in July, 2011.
- Bihar Flood Hazard Atlas was released by Hon'ble Minister for Disaster Management in June, 2013.

Flood Early Warning

Studies on flood forecasting and inundation simulations are being carried out for Godavari / Sabari River in Andhra Pradesh using fine-resolution elevation data. The methodology is to be transferred to Central Water Commission.



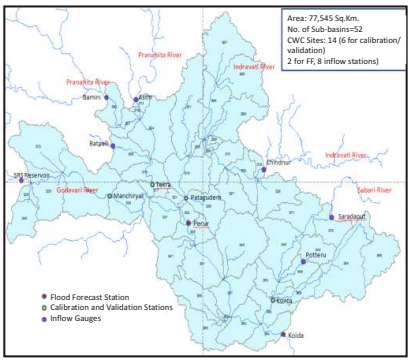
FLOOD EARLY WARNING SYSTEM AND DAMAGE MITIGATION

Flood early warning in the flood-prone areas can give sufficient time in planning flood relief and rescue operations and thus will reduce the flood damage. With the development of remote sensing and computer analysis methods, traditional techniques can be supplemented with hydrological modeling techniques for flood early warning system. Flood forecasting and alarming in spatial environment is very important for flood relief and rescue operations. Flood inundation simulations prior to the event can minimise the damage to human life and property.

A web-enabled complete flood forecasting system for flood-prone rivers with the amalgamation of hydrological models, space-based information, field hydro-meteorological data and high-resolution topographic data like ALTM is being developed. The forecast system will help in real-time flood management.

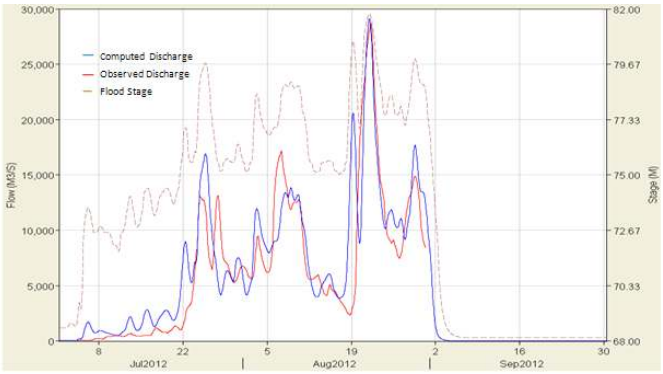
Godavari Flood Early Warning System

Hydrological Description of the Study Area



Inundation Simulation in Sabari River using ALTM DEM

Flood Forecast Hydrograph at Perur (2012)



MAJOR HIGHLIGHTS

- The approach is a complete transformation from a point-based conventional flood forecast system to the spatial flood early warning system
- Hydrological modeling and hydraulic routing approach adopted
- Used in real-time in collaboration with Central Water Commission (CWC) & India Meteorological Department (IMD)
- Godavari, Mahanadi, Ghaghara, Gandak, Kosi, Brahmani-Baitarani are identified for the study

MAJOR BENEFITS

- Useful for spatial flood alarming, flood relief and rescue operations and flood management in spatial domain
- Flood alerts were given to the concerned departments (CWC and DMSP-NRSC)

FLOOD EARLY WARNING SYSTEM AND DAMAGE MITIGATION

SPATIAL AND NON-SPATIAL DATABASE

Static Data

- Land-use/ land-cover, Soil texture, DEM of 30 m and 10 m resolution, ALTM DEM

Dynamic Data

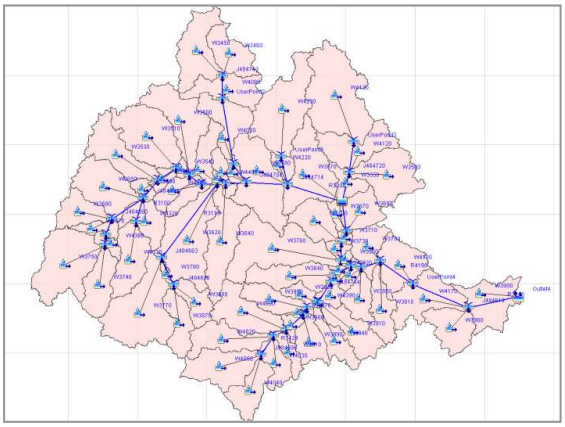
- Real-time 3 hr. discharge data from CWC
- Daily Rainfall Data in near real-time from IMD
- Evapotranspiration (ET) data and Rating curves
- Reservoir operations data

RESULTS

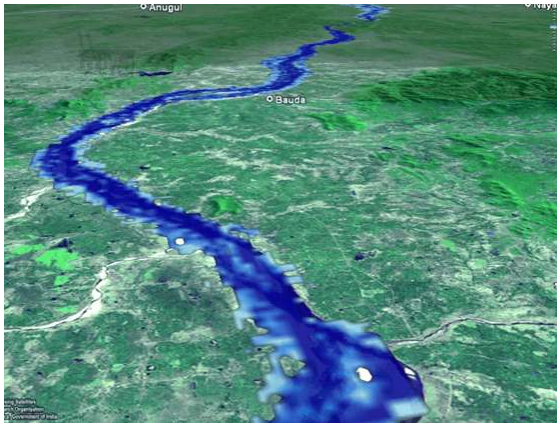
- Forecast lead time and discharge forecast accuracy is increased
- Flood hydrograph can be computed at any river confluence
- Inundation simulations match with the remote sensing images
- Integrated effect of lake burst, rainfall and steep slopes were studied, wherever applicable

Mahanadi Flood Early Warning System

Basin Model setup for Mahanadi River

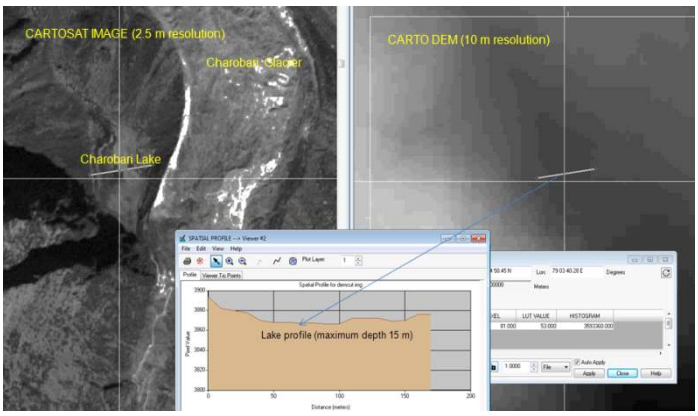


Inundation Simulation in Mahanadi River using 10m CARTO DEM

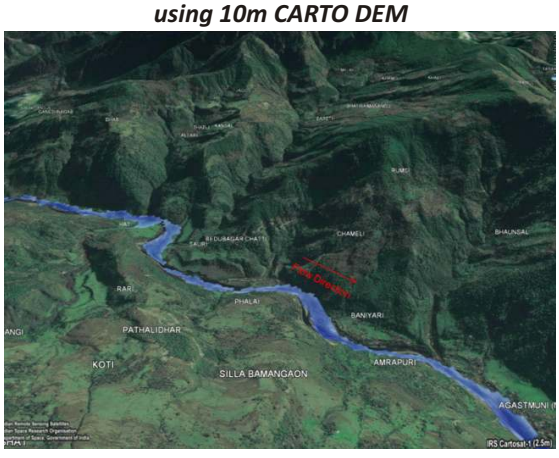


Kedarnath Flood Inundation Simulation (Mandakini River)

Chorabari Lake Topographic Profile



Inundation Simulation in Mandakini River using 10m CARTO DEM



CYCLONE MONITORING AND PREDICTION

Tropical cyclones are the major natural hazards that affect the coastal region of India. In view of the serious risk posed to life, property and infrastructure, availability of reliable and timely information about the probability of formation of tropical cyclones, their location, movement, intensification, and landfall become very crucial for disaster management and mitigation.

Using appropriate models and satellite data, ISRO is supporting the efforts of India Meteorological Department (IMD) to predict the tropical cyclone track, intensity and landfall. Satellite observations are used for continuous monitoring of North Indian Ocean basin to investigate the cyclogenesis. After the formation of a cyclone, its track is regularly monitored and predicted on an experimental basis. The information generated are regularly posted on web portal (http://www.mosdac.gov.in/scorpio/).

Cyclogenesis

- Cyclogenesis is predicted from the observations of Satellite-based Thermal Infra-red (TIR) and visible imageries and satellite onboard scatterometer derived winds.

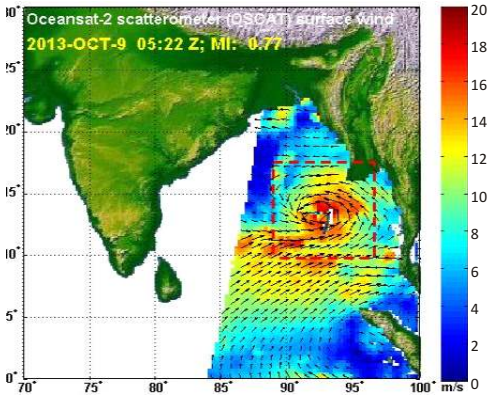
Monitoring & Geo-positioning of Cyclones

- High temporal and spatial resolution TIR and visible imageries from INSAT-3D and KALPANA play crucial role for cyclone monitoring and geo-positioning.

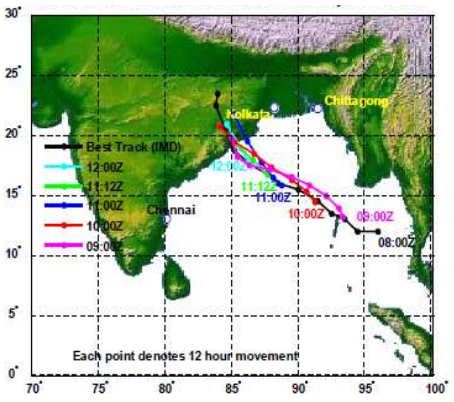
Real-time Prediction of Cyclone Track, Intensity and rainfall

- Hurricane Weather Research Forecast (HWRF) model, Lagrangian Advection Track Prediction Model developed at SAC are used for real-time cyclone prediction.

Surface Winds Observed by Oceansat-2 Scatterometer during Cyclogenesis of PHAILIN



Real-time Track Prediction of Cyclone PHAILIN



Eye of Cyclone PHAILIN in Bay of Bengal as seen by INSAT-3D

MAJOR HIGHLIGHTS

- Prediction of cyclogenesis (cyclone formation probability) over the Indian ocean (1-5 days in advance)
- Continuous monitoring of cyclone and fixing the cyclone center position (i.e. geo-positioning)
- Real-time prediction of cyclone track, intensity and rainfall on experimental basis
- Assimilation of data from Indian satellites (e.g. INSAT-3D, KALPANA, Megha Tropiques, SARAL) in the numerical weather prediction (NWP) models have improved the prediction of cyclone track, intensity, rainfall and storm- surge
- Prediction of storm surges in the coastal region in the hindcast and real-time mode
- Information disseminated to the users through a web portal, called Satellite-based Cyclone Observations and Real-time Prediction over the Indian Ocean (SCORPIO)

MAJOR BENEFITS

- Timely information helps disaster management authorities to take measures for reducing loss of life and property

CYCLONE MONITORING AND PREDICTION

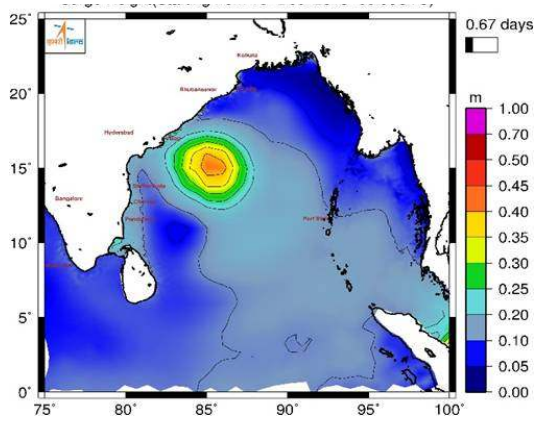
STORM SURGE

Storm surge is an abnormal rise in water column over and above the astronomical tides. Surges are mainly generated by very intense winds whirling around the eye of a cyclone associated with low pressure system. 70-90% damage during the landfall of a cyclone is caused by the storm surges. Real-time prediction of storm surges can be provided by using numerical models with meteorological inputs from Numerical Weather Prediction (NWP) models.

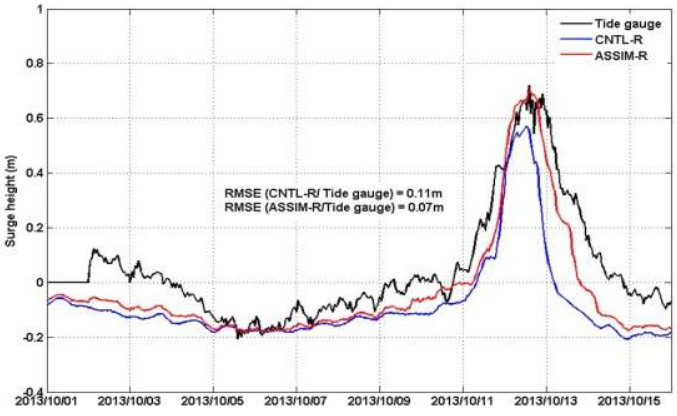
Prediction of Storm Surge

In order to predict the storm surges over the Indian coastal region during a cyclone time, ADvanced CIRCulation (ADCIRC) model has been installed and configured for the Northern Indian Ocean region. The model has been used to generate real-time predictions of surges for several cyclones during 2013-14. Extensive validations of the surge events were carried out using observations from multiple Tide Gauges maintained by Survey of India. To correct the inaccuracies related to the predicted surges, Deterministic Ensemble Kalman Filter (DEnKF) has been implemented in-house to assimilate Altimeter observations into the ADCIRC model.

Surge Height
(Starting from 10-Dec-2013-00:00UTC)



Impact of Satellite Altimeter data Assimilation in the Model



Dissemination of Forecasts

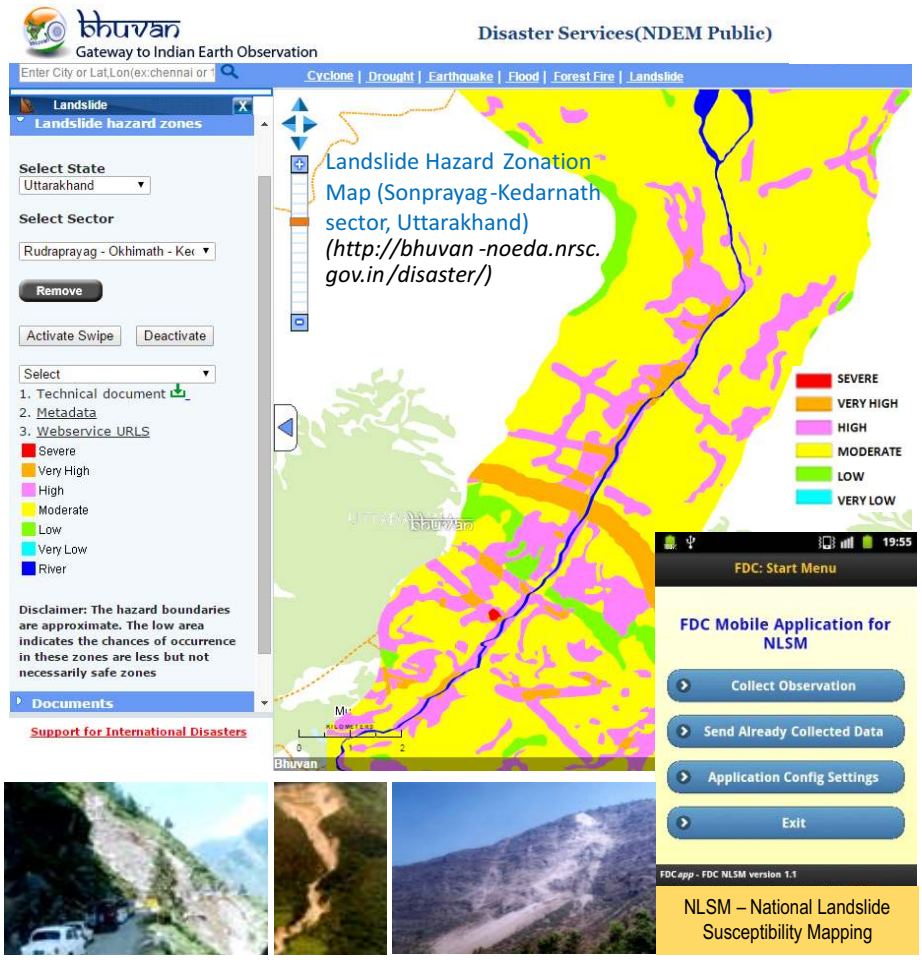
The real-time prediction results during the cyclone are being disseminated to the users from Satellite based Cyclone Observations and Real-time Prediction over the Indian Ocean (SCORPIO) website linked with Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC, www.mosdac.gov.in).

LANDSLIDES

Landslide is one of the major natural disasters that causes widespread damage and loss of life every year in mountainous areas. About 0.41 million km^2, i.e. 12.6% of the Indian landmass is prone to landslides. Remote sensing plays a pivotal role for collecting information on landslides, especially in inaccessible mountainous areas.

Predictive modeling in GIS using terrain parameters (e.g. lithology, geomorphology, topography, land use, etc.) and known landslide occurrences can be done to prepare 'landslide susceptibility' maps for demarcating the areas prone to future landslide occurrences. Very high resolution satellite data, such as Cartosat-2 (ground resolution: 1 m), can be used for mapping damage caused to roads, built-up land, agricultural land, etc. due to landslides.

Bhuvan Disaster Services on Landslides



NLSM – National Landslide Susceptibility Mapping

MAJOR HIGHLIGHTS

- Landslide hazard zonation (LHZ) mapping along tourist & pilgrimage routes (~2000 km) for the Uttarakhand & Himachal Pradesh States
- Damage assessment of a few major landslides, such as Varunawat (Uttarkashi) and Okhimath landslides of Uttarakhand (2003 & 2012)
- Landslide inventory in case of extreme events, such as Kashmir earthquake (2005), Sikkim earthquake (2011), Kedarnath disaster (2013) and J&K floods (2014)
- Landslide early warning maps available in Bhuvan portal on experimental basis

MAJOR BENEFITS

- Landslide hazard zonation and landslide management maps prepared for the States of Uttarakhand & Himachal Pradesh are useful for developmental planning, adopting preventive measures and policy making

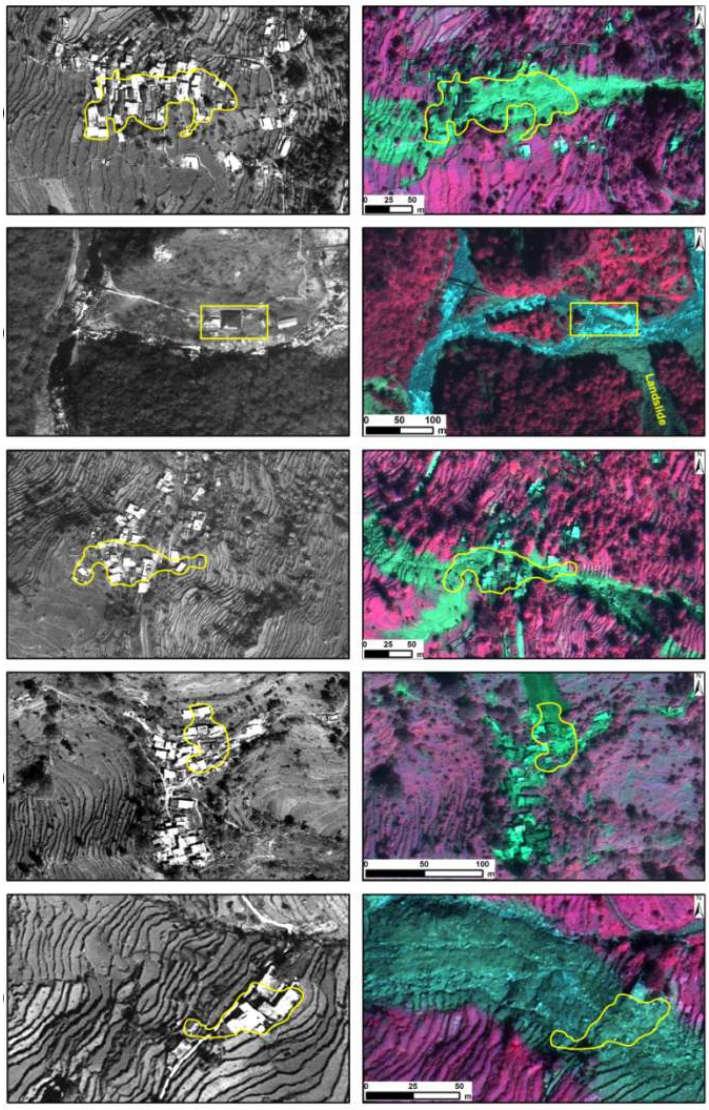
LANDSLIDES

OPERATIONAL PRODUCTS / SERVICES

- Landslide inventory in case of extreme events
- Landslide hazard zonation (Uttarakhand, Himachal Pradesh) at 1:25,000 scale
- Experimental Landslide Early Warning System for Rainfall Triggered Landslides

Damage to Habitations Assessed using Pre and Post Event very High Resolution Satellite Images

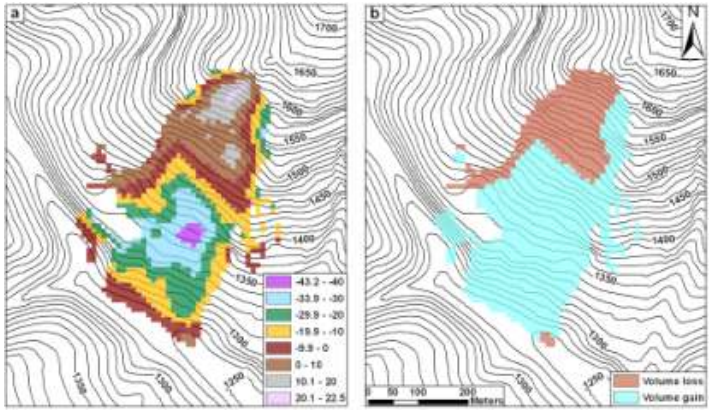
Pre-landslide Image ***Post-landslide Image***



RESEARCH AREAS

- Rapid methodology for landslide susceptibility mapping
- Debris flow modeling to find out the zone of initiation and run-out distance of landslides
- Separation of zones of depletion and accumulation within individual landslides using automatic methods
- Characterisation of landslides using multi-band microwave data
- Landslide monitoring using ground and space-based SAR Interferometry technique
- Creation of rainfall intensity vs duration regression equations in hilly areas other than Uttarakhand

Landslide Volume Estimation using Cartosat DEMs



Landslide Detection using Automated Techniques

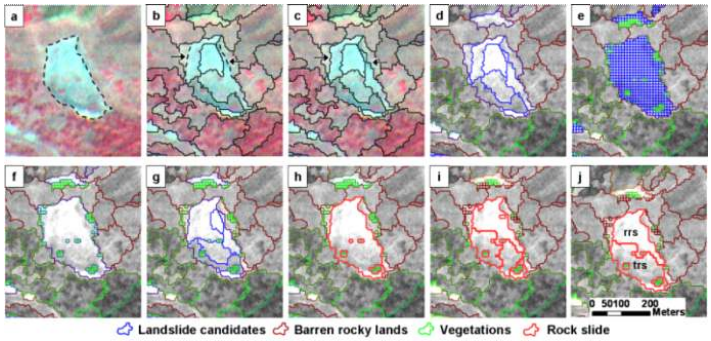


Image and digital topography based segmentation can detect and delineate landslide affected areas efficiently as seen for Okhimath landslide, Uttarakhand (2012)

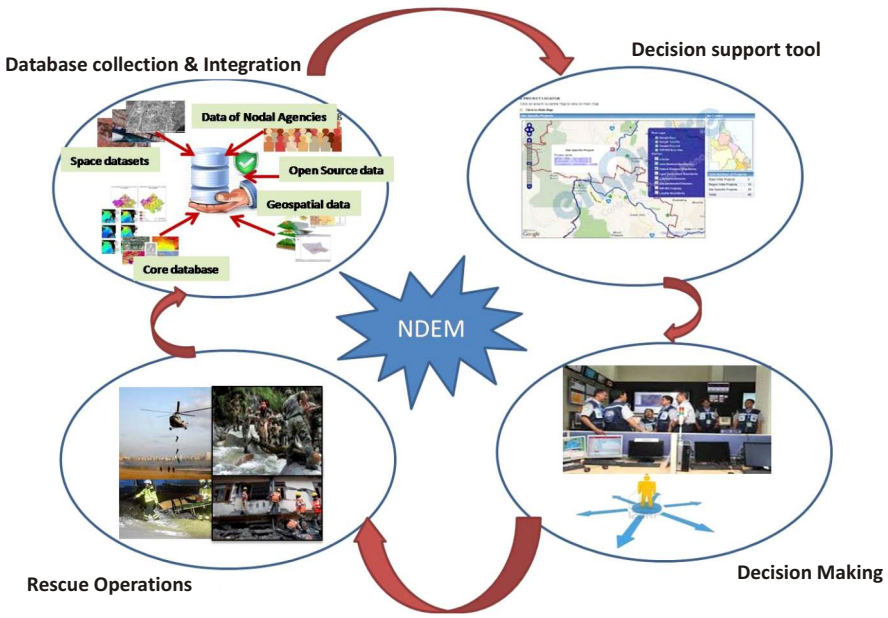
NATIONAL DATABASE FOR EMERGENCY MANAGEMENT

The National Database for Emergency Management (NDEM) is conceived as a GIS-based repository of data to support disaster/ emergency management in the country. The database enables development of decision support system in the form of customised user interfaces with necessary security mechanisms.

Objectives:

- Organisation of multi-scale geo-spatial database for disaster/ emergency management
- Development of Decision support (DSS) tools for addressing disaster/emergency management
- Mirroring/Replica of databases at MHA with suitable access/security mechanism

NDEM Concept



Database Organisation

Database available with ISRO, Central and State Departments are integrated and organised into NDEM. A comprehensive database is worked out to meet the objectives at different scales. At 1:50,000 scale, database covering base layers, thematic layers, infrastructure layers along with raster data sets are integrated. The disaster-specific database covering Flood/ Cyclone, Forest Fires, Tsunami, Drought, Landslides, Earthquakes, etc. are also integrated. The database at 1:10,000 scale is organised for 94 districts out of 350 districts besides NUIS and LSM towns.

MAJOR HIGHLIGHTS

- NDEM version-1 is functional from NDEM at Shadnagar
- NDEM database is organised by bringing the diverse data sets into a common reference framework
- Envisaged database at 1:50,000 scale for 36 States/UTs is served through ISRO-DMS VPN secured network
- Value-added information/ maps (about 388 disaster-specific products covering 36 States/ UTs) derived from satellite data for the disaster events occurred during 1998-2014 were hosted on NDEM server and enabled download of the products through ISRO-DMS VPN secured network
- Decision Support Tools for Spatial, Proximity, Network analysis have been customised and implemented
- Appraised all State Govt. officials about NDEM project, products and services besides training on NDEM server operations by conducting six regional training programmes
- All mobile applications developed under NDEM are made available for download and also appraised all State Govt. Departments regarding its utilisation

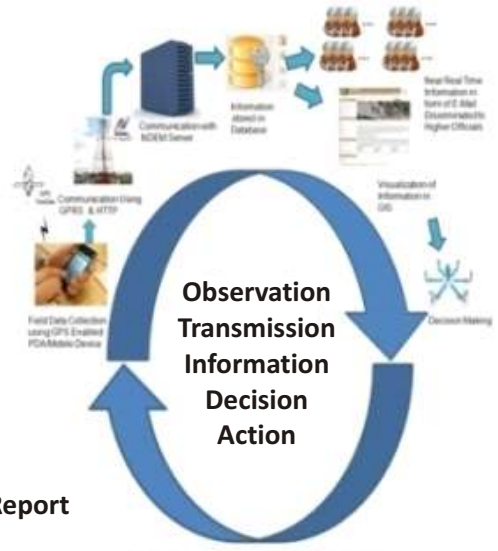
NATIONAL DATABASE FOR EMERGENCY MANAGEMENT

CUSTOMISATION OF DECISION SUPPORT TOOLS

Event reporting: An integrated SMS-based mobile solution is developed, enabling authenticated users to report disaster events using CDMA/GSM technology along with GIS solution for visualisation and analysis of the reported event.

Relief Management application: Mobile application integrated with Web-GIS is developed to collect and upload Geo-referenced real-time information from disaster location along with field photographs to web portal and also receive acknowledgement using GPRS.

Mobile Based Application



- **Distress Call**
- **Emergency Call**
- **First Information Report**
- **Summary Report**

Acknowledgement to PDA Mobile Device

INFORMATION DISSEMINATION THROUGH SECURED SATELLITE-BASED VIRTUAL PRIVATE NETWORK (VPN)

State-wise value-added information and products derived from Satellite datasets on disasters are organised in NDEM Portal and enabled access to respective State Government Departments through ISRO-DMS-VPN secured network. Disaster-specific database layers are organised as historical information along with base, thematic and infrastructure layers. The historical information of flood/ cyclone, tsunami, forest fire, landslide, earthquake, and drought events are integrated in the database.

URL for accessing the portal (on DMS-VPN network): http://10.254.5.13

NDEM INFRASTRUCTURE

Exclusive NDEM facility is established at Shadnagar in a secured environment with necessary computer infrastructure.

National Database for Emergency Management
National Remote Sensing Centre
Indian Space Research Organisation
Department of Space, Government of India
Hyderabad - 500037
Tel: +91-040-23884252 | Fax: +91-040 -23880445 | Email: ndem_admin@nrsc.gov.in

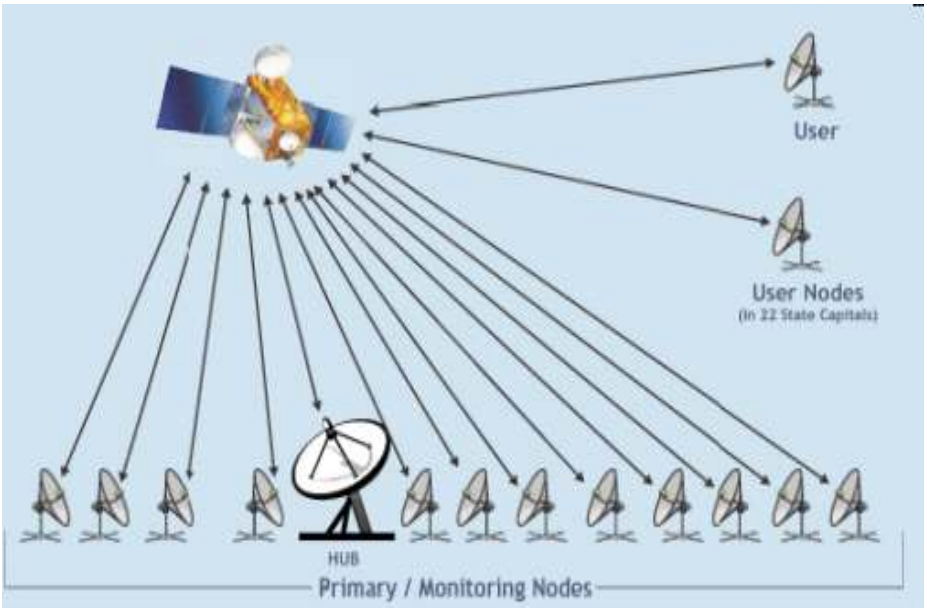
SATCOM APPLICATIONS FOR DISASTER MANAGEMENT SUPPORT

ISRO has set up a Satellite Communication (SATCOM) based broadband Virtual Private Network (VPN) for disaster management support (DMS) in 2008. The network is operational in Extended-C band using GSAT-12 satellite.

The present network has 9 Primary Nodes supporting up to 2.5 Mbps and 33 User Nodes supporting up to 825 Kbps data rates. It is a Point-to-Point n/w supporting Video Conference, IP data communication and telephony (DMS). This network has been effectively utilised during disasters in Uttarakhand and Jammu & Kashmir.

For more effective and efficient utilisation of space resources and for increasing the reach of the network this network is proposed to be upgraded with latest technology. The upgradation is planned with multilayer communication architecture including Optical Fiber backbone. The user nodes shall support integration with diverse terrestrial communication services to improve the communication reach at disaster sites. The upgraded network shall have initial deployment of several user nodes at critical locations with scalable capacity of VSATs and shall operate using central hub.

Configuration of DMS Communication Network



MAJOR HIGHLIGHTS

- Disaster Management Support (DMS) Network is a satellite-based virtual private communication network using VSATs, operational since 2008
- Network is operational in Extended-C band using GSAT-12
- Nation-wide network, presently with 9 Primary nodes and 33 User nodes spread across the country
- Communication hub is operational at New Delhi in the premises of Ministry of Home Affairs (MHA)
- Supports voice, video and data
- Access to Disaster Management data, IP telephony & video conference services
- Plans for the up-gradation of the network with latest ground segment technologies

MAJOR BENEFITS

- Provides effective emergency communication support during disaster/ emergency situations
- Effectively utilised during recent disasters in Uttrakhand and Jammu & Kashmir
- Access from terrestrial networks when needed

SATCOM APPLICATIONS FOR DISASTER MANAGEMENT SUPPORT

Recent DMS Operations: Uttarakhnad Disaster (2013)

- Deployed 5 User nodes at different disaster sites
- Restored basic communication at affected sites
- User node augmented with CDMA cell network for the first time at Pithoragarh
- Portable satellite phones were used effectively by first responders (more than 1000 calls made in the first few days)

Recent DMS Operations: Jammu & Kashmir Disaster (2014)

- Four (4) user nodes deployed under difficult conditions
- Nodes provided internet connectivity and VoIP (Voice over Internet Protocol) telephony over Wi-Fi at disaster sites
- Smart phones used for VoIP calls
- Broadband facility was made operational round the clock; Chief Minister's computer was also enabled through one of the nodes

SPACE APPLICATIONS IN NORTH EASTERN REGION

SPACE APPLICATIONS IN NORTH EASTERN REGION

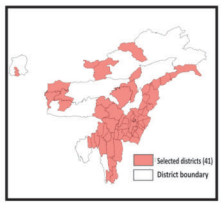
The North Eastern Space Applications Centre (NESAC) set up on September 5, 2000 is a joint initiative of Department of Space (DOS) and the North Eastern Council (NEC). It is registered as a society under the Meghalaya Societies Registration Act, 1983. The scientific programme of the centre is guided by a Governing Council chaired by Secretary, DOS and Policies are framed by a Society chaired by Hon'ble Minister for the Ministry of Development of North Eastern Region (DONER). The Centre has the mandate to provide developmental support to the North Eastern Region (NER) of India using Space Science and Technology.

Mapping & Monitoring of Natural Resources	• Forest Working Plans • Sericulture Development • Annual Land-Use/Land-Cover Mapping • Ground Water Prospects • Watershed Management • Soil Resource Mapping
Providing inputs for Development Planning	• NE District Resource Plan • Space Based Information Kiosk (SBIK) • Sericulture Development • Decentralised Planning • Site Suitability Mapping • Road Alignment
Effective Disaster Risk Reduction Support	• Database Preparation • Flood Early Warning • Landslide Hazard Zonation • Forest Fire Assessment • Thunderstorm & Drought • Hazard, Vulnerability & Risk Analysis
Satellite Communication & Emergency Communication	• Tele-medicine • Tele-education • Village Resource Centre • Emergency Communication • Developmental Communication • Network Maintenance
Space and Atmospheric Science Research	• Aerosol Radiative Forcing • GHG Chemistry • Boundary Layer Dynamics • Climate Change Impact • Numerical Weather Forecast • Surface Observation Network
Academic Interface & Capacity Building	• Training for Government Department • Student Projects • Student Visits • Exhibitions • Workshops / Seminars • Invited Talks

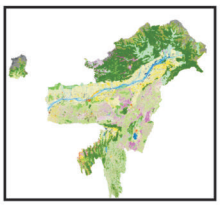
MAJOR HIGHLIGHTS

- To provide natural resource mapping and monitoring support to various State and Central Government departments in NER
- To provide spatial and non-spatial data, information and knowledge support to State Government for development planning
- To provide single window delivery of all possible space technology support for disaster management and risk reduction
- Set up satellite communication network to promote tele-medicine, tele-education and e-governance in NER
- Set up emergency communication network
- Set up a Space and Atmospheric Science research hub to understand processes leading to regional climate change and its impact, improve weather forecast and set up linkages with academic institutions
- Capacity building

SPACE APPLICATIONS IN NORTH EASTERN REGION

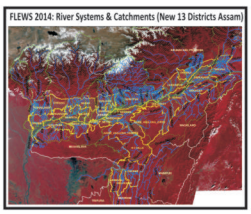


A National Project on Application of Remote Sensing and Geographic Information System (GIS) in Sericulture development (including 41 districts in NER); developed geo-portal called Sericulture Information Linkages and Knowledge System (SILKS).



Providing Remote Sensing and GIS based inputs for forest working plan preparation for Reserve Forest areas and forest working schemes for district council areas in all NE States.

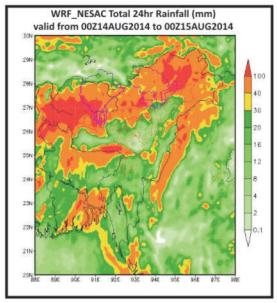
Focus on dissemination of data, information and knowledge by means of web-based and stand-alone systems through North Eastern District Resource Plan (NEDRP), Space Based Information Kiosk (SBIK), SILKS, etc.



Early warning system for flood in Brahmaputra and Barak valleys (Assam) by integrating Hydrological and Meteorological data in a geospatial platform.

North Eastern Regional Node for Disaster Risk Reduction for single window delivery of space-based disaster management services to all States in NER.

Under the EDUSAT network, 7 Hubs and 321 Satellite Interactive Terminals (SIT) covering all States in NER. Telemedicine network has been set up separately for civilian and defence personnel with 39 telemedicine centres.



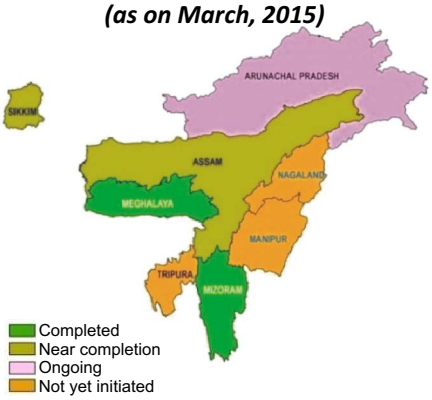
A network of 118 Automatic Weather Stations covering NER; characterisation of major drivers of regional climate change and their impacts; focus on improving Numerical Weather Forecast.

NESAC provides opportunity for B.Tech./M.Sc./M.Tech. students to pursue dissertations. Over 5,000 students from different parts of NE region have visited NESAC facilities during last 14 years.

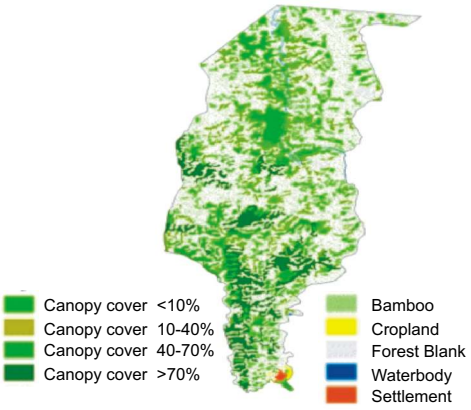
FOREST WORKING PLAN IN NORTH EASTERN REGION

North Eastern Space Applications Centre (NESAC) under the Department of Space has been supporting State Forest Departments in North East Region (NER) in providing Remote Sensing and Geographic Information System based inputs for forest working plan preparation. The broad objectives are: (i) to prepare forest canopy density maps (at 5 levels) on 1:10,000 scale for all Reserve Forests (RF) and also outside RF areas with broad land use categories, (ii) to generate forest type map on 1:50,000 scale along with area statistics and (iii) to estimate compartment-wise timber stock volumes.

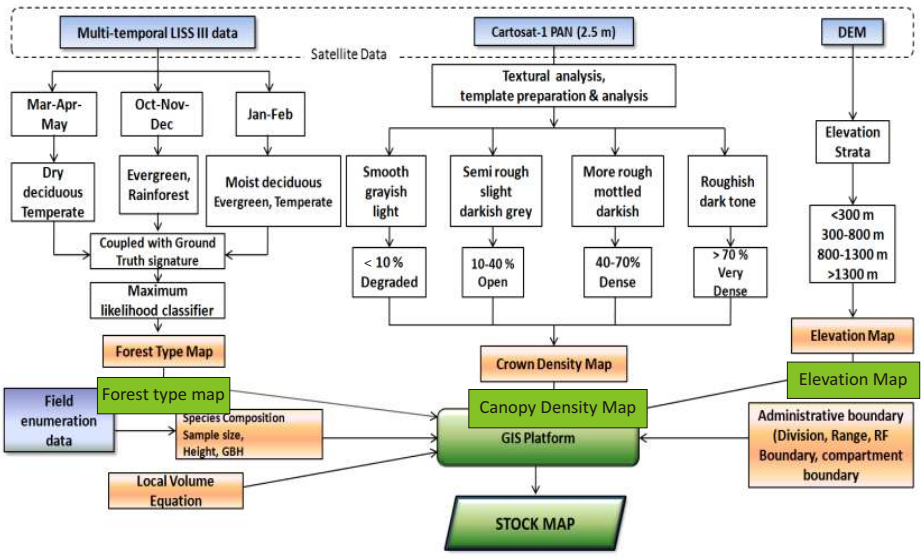
Status of Forest Working Plan in NE states (as on March, 2015)



Forest Canopy Density Map (2011) (Ngengpui RF, Lunglei Division, Mizoram)



Methodology for Forest Stock Map Preparation



Stratification of the forest is done based on the crown density, forest type and elevation. Stratified random sampling technique is used to decide the sampling points. The number of sampling points are based on the variability of forest stock derived from pre-inventory sampling.

MAJOR HIGHLIGHTS

- Forest cover mapping on 1:10,000 scale with 5 levels of crown density
- Forest type map on 1:50,000 scale
- Estimation of compartment-wise timber volume & stem density at different girth classes for all Reserve Forests
- Stock maps of all Reserve Forests
- Habitat mapping of Protected Area Networks
- Biomass and carbon stock assessment
- Biodiversity hotspots and ecologically sensitive zones

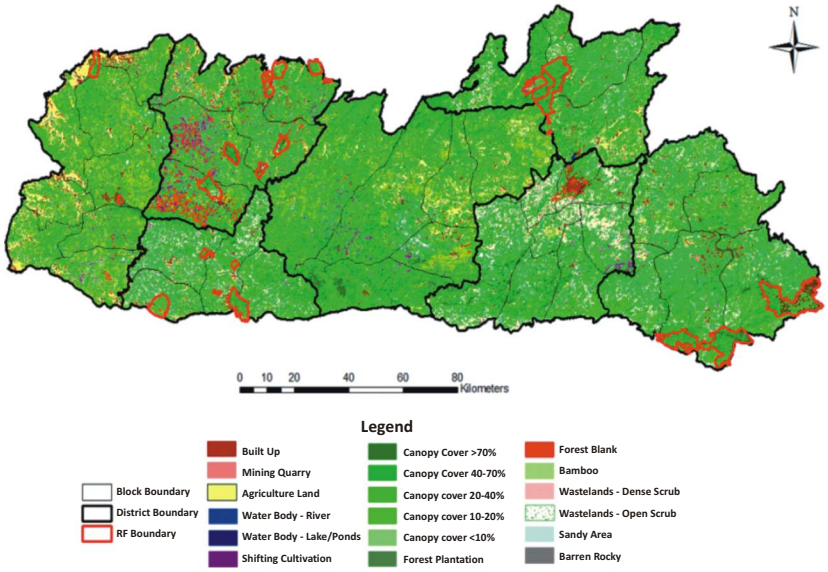
MAJOR BENEFITS

- Forest resource accounting and management planning
- Wildlife habitat conservation and management planning
- Timber volume assessment and carbon accounting
- Web application tool for interactive viewing
- Biologically rich area and hotspot identification and conservation
- Eco-sensitive zonation
- NTFR (Non-Timber Forest Resource) identification and assessment for livelihoods

FOREST WORKING PLAN IN NORTH EASTERN REGION

- Locally developed empirical equations are used to estimate plot-wise timber volume from the field data and derive strata-wise mean volume.
- Compartment-wise stock volume is estimated by extrapolating the mean volume to the area statistics of each stratum per compartment and subsequently for each reserved forest and each division.

Forest Canopy Density and Other Land-Use Map of Meghalaya

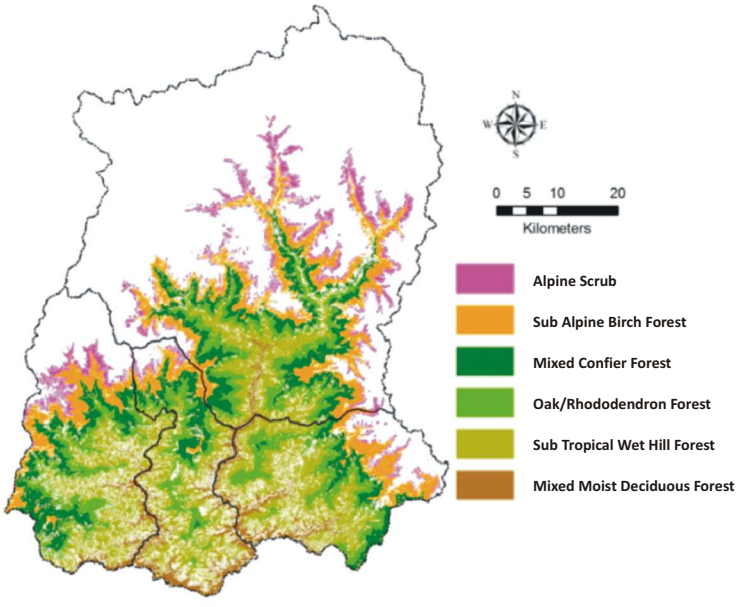


Forest Working Plans prepared for Reserve Forest area of Jaintia Hills Forest Division (FD), Khasi Hills FD and Garo Hills FD of Meghalaya and Lunglei FD, Kolasib FD, North Vanlanphai FD, Chakma ADC Division, and Mamit FD of Mizoram have been approved by the MoEF, Govt. of India.

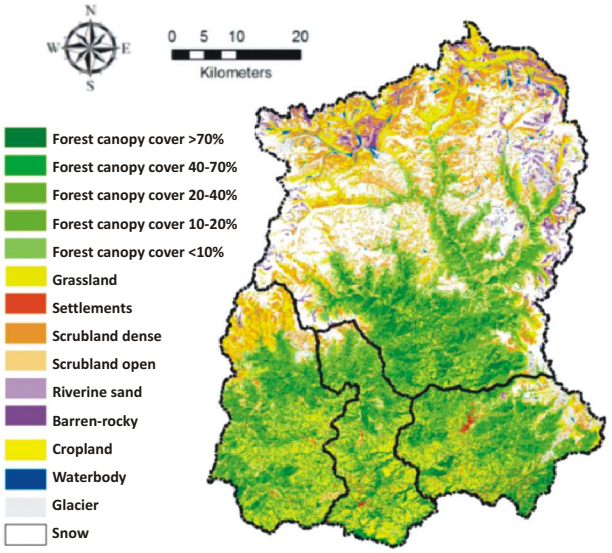
Working schemes for all the divisions (outside RF areas) in Meghalaya have also been prepared and submitted for approval.

Forest density and forest type maps for the state of Sikkim has been completed while the same is in progress for the states of Assam and Arunachal Pradesh.

Forest Type Map of Sikkim



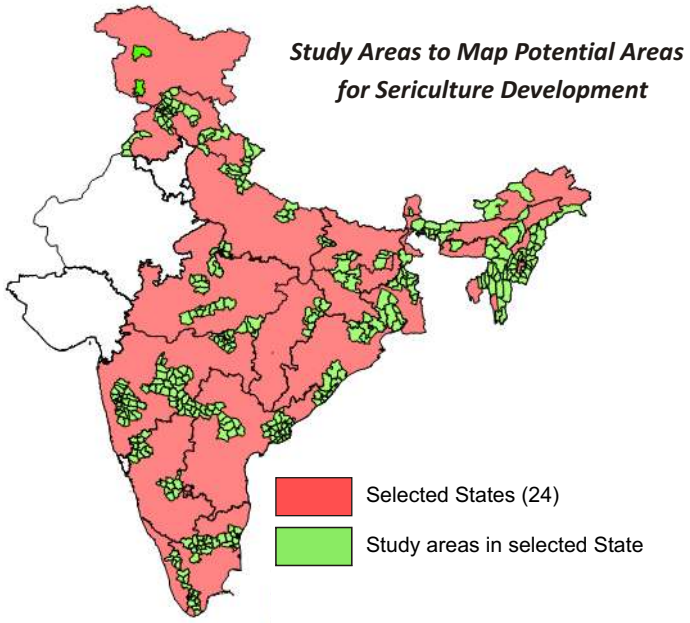
Land-Use and Land-Cover Map of Sikkim



Analysis of field data for the state of Assam and Arunachal Pradesh are being carried out for estimation of the growing stocks.

SERICULTURE DEVELOPMENT

Remote Sensing (RS) and Geographical Information System (GIS) techniques have been effectively used in identifying new areas with potential for expanding plantation under all four types of Sericulture viz., Mulberry, Muga, Eri and Tasar in 108 districts spread over to 24 States, including 41 districts in NER. The project is funded by Central Silk Board (CSB). North Eastern Space Applications Centre (NESAC) under the Department of Space implement the project in collaboration with State Remote Sensing Centres and other Partner Institutions.



Study Areas to Map Potential Areas for Sericulture Development

States	No. of Districts	Potential Area for Mulberry			
		Highly Suitable (ha)	Moderately Suitable (ha)	Marginally Suitable (ha)	Total (ha)
Arunachal Pradesh	7	13	1908	15,321	17,242
Assam	9	1,169	76,893	2,32,377	3,1,0439
Manipur	9	4,164	5,930	44,543	54,637
Meghalaya	2	13,928	32,381	33,425	79,733
Mizoram	6	85,598	73,495	17,567	1,76,660
Nagaland	5	5,160	18,108	41,800	65,068
Sikkim	1	-	827	5,095	5,922
Tripura	2	219	17,388	14,745	32,352
Total	**41**	**1,10,251**	**2,26,930**	**4,04,873**	**7,42,053**

With the need for expanding sericulture in and beyond NE States, potential area mapping was done in 16 States for Mulberry sector, 2 each for Muga and Tasar, and 3 for Eri sector.

MAJOR HIGHLIGHTS

- Potential area mapping for sericulture development spread over 108 Districts in 24 States
- Integration of suitable land-use, soil condition, and climatic parameters
- 13 major non-spatial modules and 4 spatial modules
- ICT-based web portal for data and knowledge dissemination in 12 major local languages (www.silks.csb.gov.in)
- Weekly weather bulletin and sericulture advisories

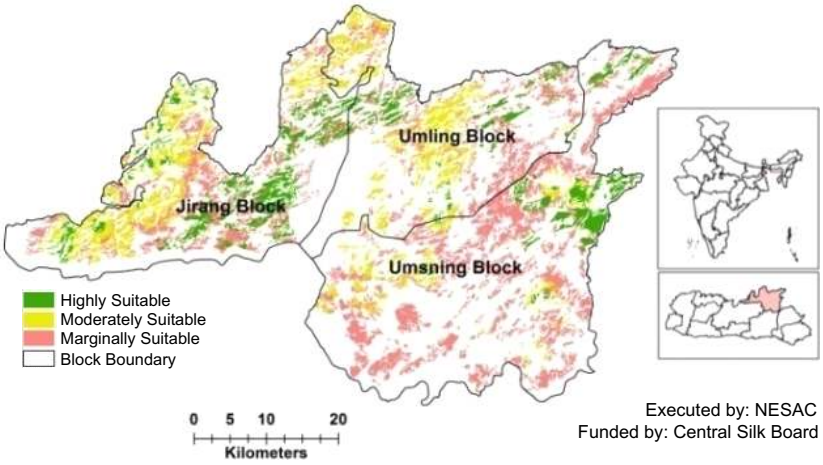
MAJOR BENEFITS

- Potential area map to help expansion of Mulberry, Muga, Tasar and Eri to new areas
- Support to rural livelihood generation
- Data & information in local language to accelerate sericulture development
- Regular weather advisory for better planning and reducing weather related damage

SERICULTURE DEVELOPMENT

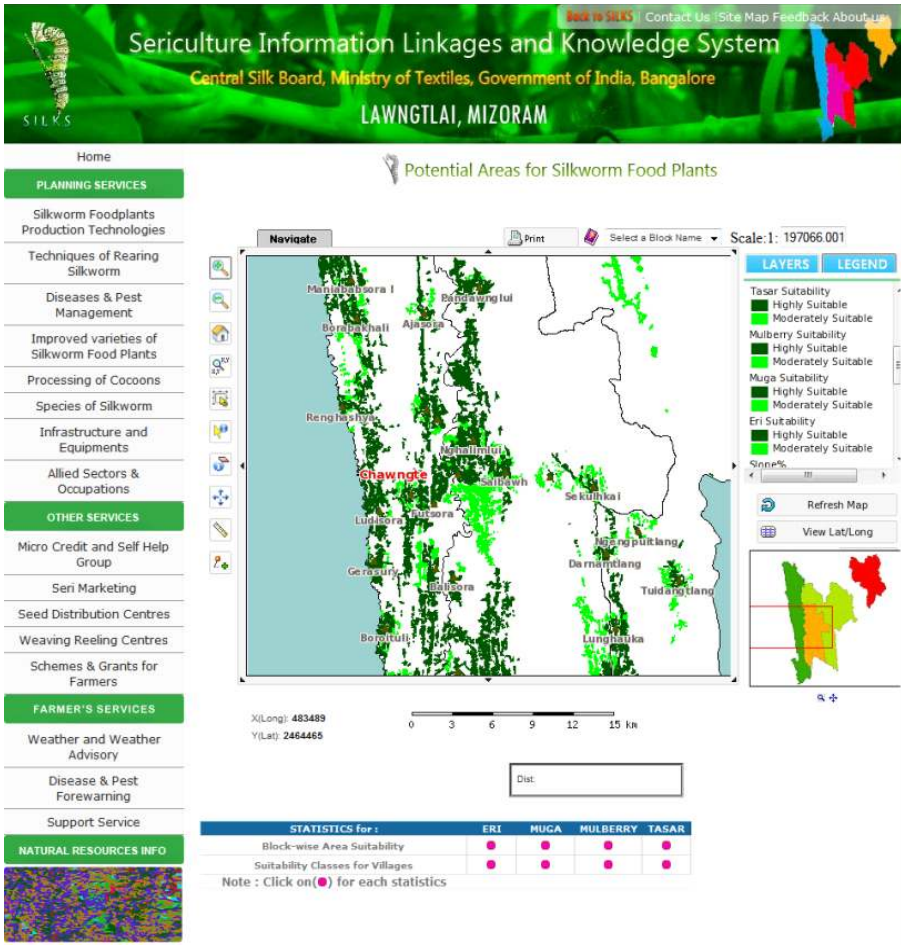
The identification of potential areas for sericulture development involves evaluation of following parameters:

- Suitable land-use (cultivable wastelands, long fallow lands, etc.)
- Soil (soil depth, pH, texture), slope and ground water availability
- Climatic parameters (temperature, rainfall, relative humidity, potential evapo-transpiration (PET) and length of growing period) for the silkworm food plants



Executed by: NESAC
Funded by: Central Silk Board

An ICT-based web portal 'Sericulture Information Linkages and Knowledge System' (SILKS) has been developed for all the selected 108 Districts to disseminate the information for the benefit of all stakeholders, especially the farmers.

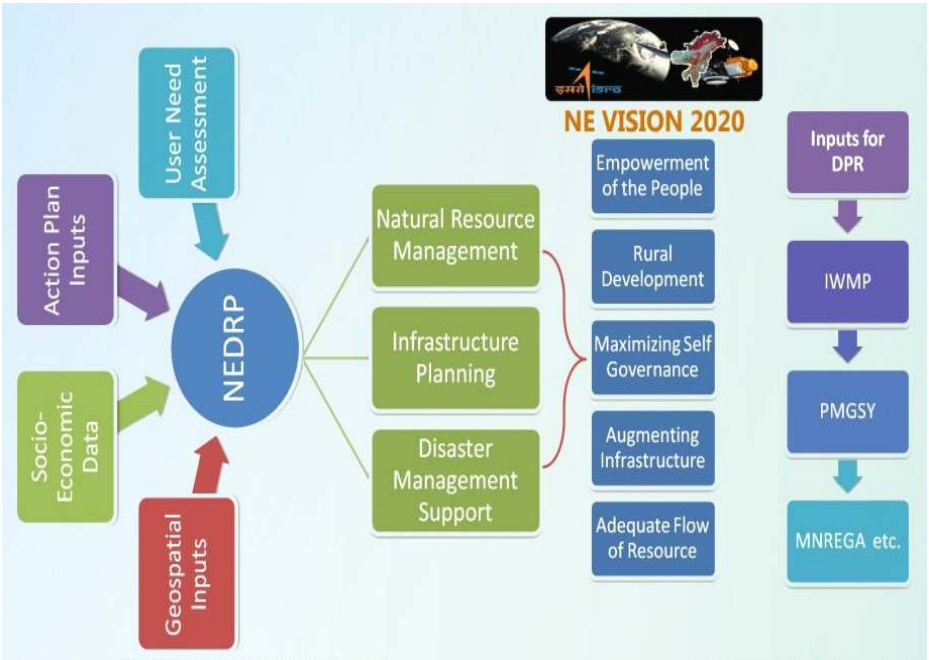


- SILKS web portal hosted in public domain (http://silks.csb.gov.in)
- 13 major non-spatial modules and 4 spatial modules grouped into three categories, viz. Planning Services, Other Services and Natural Resources Management
- The portal is presently available in 12 languages, viz. English, Hindi, Telugu, Kannada, Assamese, Bengali, Manipuri, Mizo, Khasi, Garo, Ao Naga and Sumi Naga
- One module on Farmers Services is available in local languages
- Weather bulletin and sericulture advisories are integrated for SILKS portal as a Joint effort with IMD

DISTRICT RESOURCE PLANNING AND SPACE BASED INFORMATION KIOSK IN NORTH EASTERN REGION

North Eastern Space Applications Centre (NESAC) under the Department of Space, Government of India, has taken up a unique programme on district resource planning in the North Eastern Region (NER) in close collaboration with State Remote Sensing Applications Centres (SRSACs). The programme is called as North Eastern District Resource Plan (NEDRP). It is sponsored by the Ministry of DoNER/ NEC with an objective to strengthen the e-Governance policy.

NEDRP provides district resources atlas in the form of web-based Decision Support System (DSS) for decentralised planning. It provides inputs for natural resource management, infrastructure planning and disaster management support.



NEDRP is planned to be operational in 25 selected districts of NER. Currently (as on March, 2015), it is operational in all 11 districts of Meghalaya.

NEDRP is now becoming more relevant for planning and management of developmental programmes of the State and Central Government like Integrated Watershed Management Programme (IWMP), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), etc.

MAJOR HIGHLIGHTS

- Two major programmes - North Eastern District Resource Plan (NEDRP) and Space Based Information Kiosk (SBIK) - launched for the States of NER for easy and quick planning and monitoring of developmental activities
- SBIK primarily caters to the needs of the Secretaries of Line Departments, while NEDRP caters to the requirements of working-level officials in the DC offices and State Line Departments
- Spatial database on natural resources and other ancillary information made available in one platform for visualisation, analysis and output generation

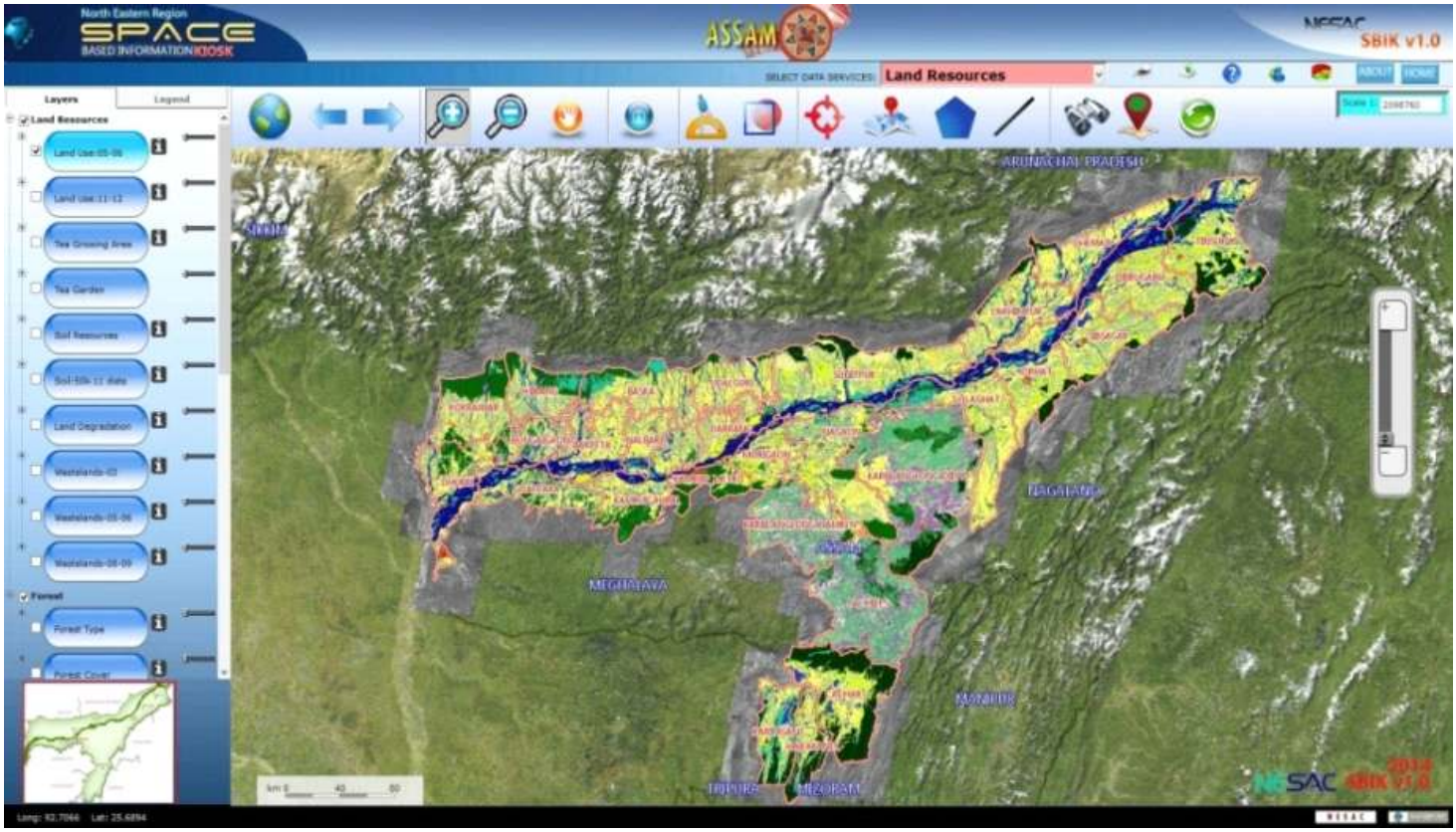
MAJOR BENEFITS

- Ready access to spatial database help in District & State level planning and quick decision making in addition to strengthening the monitoring mechanism of the State and Central Govt. funded programmes
- Quick and improved Detailed Project Report (DPR) preparation leading to easy project approvals

DISTRICT RESOURCE PLANNING AND SPACE BASED INFORMATION KIOSK IN NORTH EASTERN REGION

Space Based Information Kiosk (SBIK) Programme

SBIK is one of the most significant programme taken up for all the States of NER. It is conceptualised to strengthen the planning and monitoring mechanism of the projects funded by Ministry of DoNER and other Central Government funded projects, such as Integrated Watershed Management Programme (IWMP), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), Pradhan Mantri Gram Sadak Yojna (PMGSY), etc.



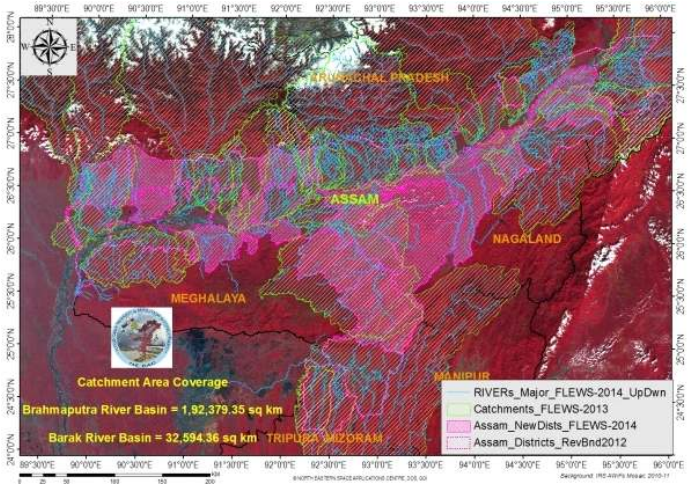
SBIK programme is sponsored by the Ministry of DoNER/NEC and is executed by NESAC in collaboration with SRSACs to support users and Line Departments of respective States of NER for developmental planning.

Each of the SBIK is populated with geospatial layers on natural resources, infrastructure, disaster management, etc. with proper linkages to the socio-economic data. It also contains information related to land and water resource development, forest and environment conservation and infrastructure development.

SBIK has several GIS tools for data visualisation, navigation, analysis and output generation. The statistics of geospatial layers can also be generated based on user-defined area of interest. SBIK portals have been released in different NE states during 2014.

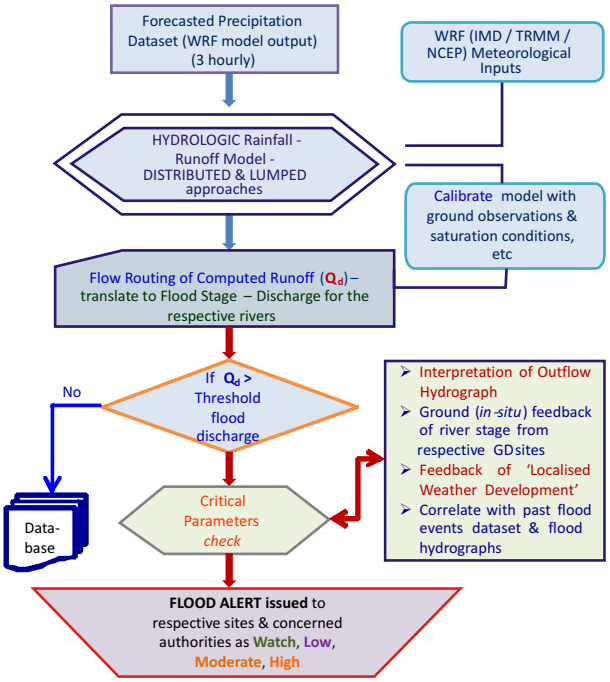
FLOOD EARLY WARNING SYSTEM IN NORTH EASTERN REGION

The State of Assam is covered by two major river valleys, namely Brahmaputra and Barak. While Barak valley covers three southern Assam districts, the rest of the State falls in the Brahmaputra river valley. Around 32 major tributaries laterally join the Brahmaputra in its course. Majority of these tributaries, being snow-fed perennial streams, have heavy discharges during the monsoon season resulting in flood by both the main river channel and the tributaries.



Brahmaputra and Barak river systems and their major tributaries covered under FLEWS

FLEWS Methodology



MAJOR HIGHLIGHTS

- The first of its kind for early warning of flood using a hydro-met coupled model
- Use of improved and in-house generated numerical rainfall forecast
- Real-time weather watch over and around the study area
- Improvement in both extent and success score over the years
- Post-flood embankment monitoring
- Winner of e-North East Award, 2013

MAJOR BENEFITS

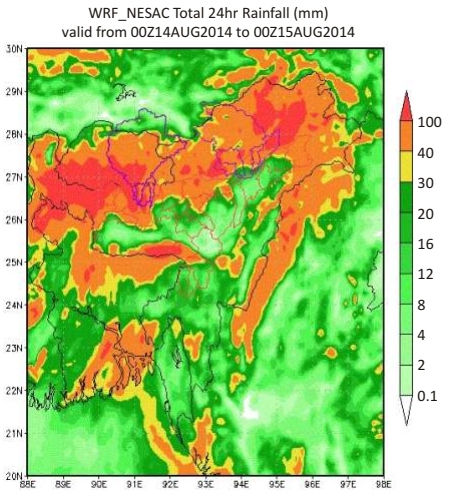
- Flood-prone districts of Assam are getting regular flood watch alerts and advisories during the monsoon period every year
- Monitoring of the embankments facilitates timely repair work before the onset of next flood season
- More emphasis on serious weather monitoring during peak monsoon season

FLOOD EARLY WARNING SYSTEM IN NORTH EASTERN REGION

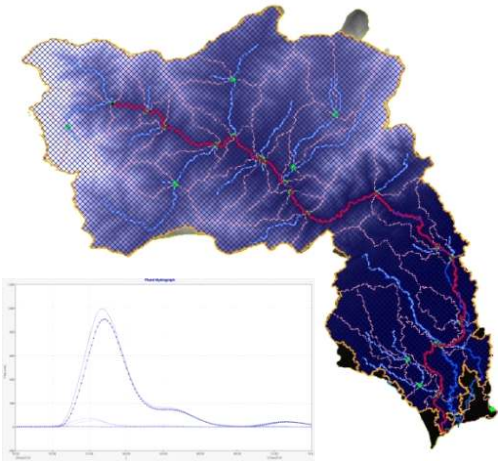
MAJOR COMPONENTS OF FLEWS, ISSUE OF ALERTS, DISSEMINATION MECHANISM & PERFORMANCE

FLEWS core model comprises of two major components, Hydrology and Meteorology. In the meteorology component, numerical weather fore-casting is done at 9 km and 5 km resolutions for rainfall forecast using Weather Research and Forecasting (WRF) model by assimilating several in-situ and satellite based data and products. In addition, an innovatively developed analog synoptic- analog synoptic-scale weather monitoring system to now-cast basin-scale rainfall has also been incorporated. In the hydrology component, along with a distributed hydrologic model known as the Hydrologic Engineering Centre's - Hydrologic Modeling System (HEC-HMS), a lumped hydrological model in the form of rational formula, has been incorporated to estimate catchment-wise river discharge with input from the WRF model.

Meteorology Component



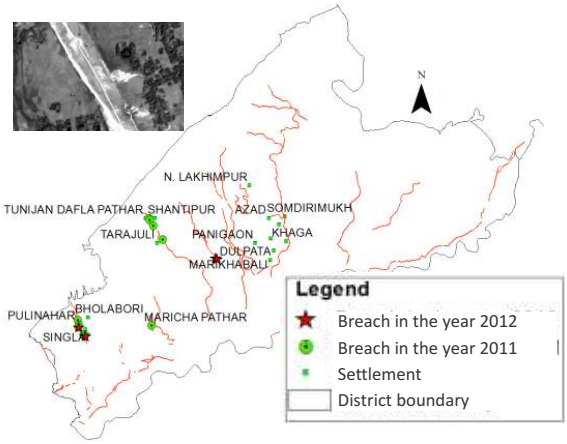
Hydrology Component



Issue of Alert & Dissemination

Flood alerts are generated based on analysis of river discharge, current river level and synoptic-scale weather report. The alerts are classified in four categories, *viz*. Watch, Low, Moderate, and High. The alerts are disseminated to the following end users through SMS and e-mail:

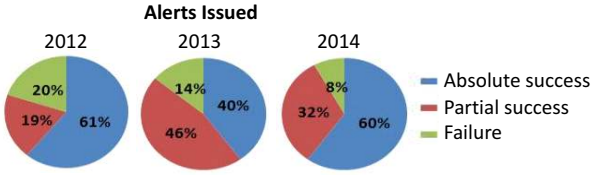
- Deputy Commissioners of the concerned district(s)
- District Project Officers of the concerned district(s)
- State Disaster Management Control Room for further dissemination to RC/ Block/ Taluka level



Post-flood embankment breach monitoring as a subsidiary service. Image on top-left shows the breach in Lakhimpur district during 2012.

Performance

The average success score of this project during 2011-2014 period has been around 70% to 80% (absolute and partial) with alert lead time ranging between 12 to 24 hours, and occasionally going up to 36 hours.



SATCOM APPLICATIONS IN NORTH EASTERN REGION

Tele-education

ISRO's Tele-education programme is established in NE states. This programme is found to be very effective and facilitates in providing education and information in the remote places of this region.

The following tasks were taken up covering 7 Hubs and 321 Satellite Interactive Terminals (SITs) of NER:

- Technical Support and Training Centre
- Hub Operation

Telemedicine

ISRO's Telemedicine programme provides access to high quality healthcare to people at remote locations in NER through tele-consultancy with doctors at Specialty and Super-specialty nodes.

The programme is operational under various networks, namely:

- ISRO-NEC joint Telemedicine project (25 nodes)
- Army Telemedicine project (06 nodes)
- Indian Air Force Telemedicine network (01 node)
- Civilian Telemedicine Network (07 nodes)

Communication Support for Disaster Management

NESAC has the following communication facilities for disaster management support in NER:

- Audio/video/data connectivity through MHA-VPN VSAT network
- Voice connectivity through INSAT type-D terminal
- SMS alert service under Flood Early Warning System (FLEWS) project
- Smartphone-based Mobile application for disaster event reporting

MAJOR HIGHLIGHTS

- Tele-education programme is operational in 7 NER States with 7 Hubs-cum- Teaching nodes and 321 Satellite Interactive Terminals (SITs)
- Tele-medicine programme is operational in 8 NER States with 39 nodes under different networks: ISRO-NEC joint project, Civilian network, Indian Army network, and Air Force network
- MHA-VPN (Virtual Private Network) node for disaster management support with VSAT-based video-conf & data sending facility
- State-of-art content generation studio

MAJOR BENEFITS

- Distance classes for students in remote NER States under the Tele-education programme
- Medical consultancy with super-specialty hospitals
- Communication support for disaster management

SATCOM APPLICATIONS IN NORTH EASTERN REGION

INFRASTRUCTURE FOR SATELLITE COMMUNICATION APPLICATIONS

Indian Regional Navigation Satellite System (IRNSS) Programme

NESAC campus has an IRNSS CDMA Ranging Station (IRCDR) and IRNSS Range and Integrity Monitoring Station (IRIMS), set up under the satellite navigation programme of ISRO. Both these facilities are operational and tracking the three IRNSS satellites as of now.

Content Generation Studio

NESAC has a spacious studio for need-specific content generation. It is equipped with state-of-the-art hardware and software for high fidelity video and audio recording as well as requisite editing and other post processing. Audio/video content has been generated for user agencies like NDRF, State Disaster Management Authorities, Assam Branch of Indian Tea Association (ABITA), etc.

Transportable WLL-VSAT

Voice communication with fixed line nodes via Wireless in Local Loop (WLL) technology can be efficiently done with a transportable Very Small Aperture Terminal (VSAT) based system. Such a vehicle with VSAT and other equipments is placed at NESAC campus.

MSS TYPE-D TERMINAL

At the time of disasters, satellite dependent communication provides one reliable alternative. INSAT Type-D Terminal (Satellite Phone) provides both voice and data communication facility. NESAC has three such sets.

Ka-Band Propagation Experiment

NESAC has a facility for doing propagation characteristics experiment in the Ka-band using the satellite beacon of GSAT-14 satellite.

ISRONET

ISRONET enables access of ISRO's official communication portal as well as for inter-centre video-conferencing and data sending.

ATMOSPHERIC & SPACE SCIENCE RESEARCH IN NORTH EASTERN REGION

North Eastern Space Applications Centre (NESAC) under the Department of Space has set up a regional facility for advanced research in Atmospheric Science area. This will help to understand and quantify the processes leading to regional weather and climate variability, improve weather forecasting in the region, and support disaster risk reduction activities. This will provide weather advisory services and promote space science research in the region.

(a) Nephelometer, (b) 3D Sonic Anemometer, (c) Aethalometer, (d) Disdrometer, (e) Multi-Wavelength Solar Radiometer (MWR), (f) Micro Rain Radar (MRR), (g) Microtops Sunphotometer, (h) Automated weather station, (i) Boundary Layer Lidar (BLL), (j) MRR

Instruments for physical & optical characterisation of aerosols. Facility to study surface, columnar, and vertical profile of aerosols. Instrumented vehicle for conducting field-based land campaign.

Instruments for atmospheric boundary layer physics and dynamics studies. Launching of Pisharoty sonde with Hydrogen filled balloons. Fast response sensors (3D sonic anemometers) on a 32 m multi-layered tower.

Online gas analysers for ozone, methane, carbon-monoxide, oxides of sulfur, and oxides of nitrogen to study their chemistry, transport, and radiative forcing.

Network of 118 Automatic Weather Stations (AWS) spread across NE states of India; One Doppler Weather Radar at Cherrapunjee.

MAJOR HIGHLIGHTS

- Physical and optical charac-terisation of aerosols
- Measurements of regional greenhouse gas (GHG) concentration
- Radiative forcing and long- range transport of aerosols and GHG
- Understanding boundary layer dynamics and its impact
- Research to improve short and medium range weather forecast
- Regional climate change and impact assessment on key sectors
- Improvement and augmen-tation of surface observation network

MAJOR BENEFITS

- Understanding of drivers of climate change over NER
- Quantification of regional climate change potential and study of their impact to develop better mitigation and adaptation strategy
- Improvements in regional weather forecasting helps in flood forecasting
- Thunderstorm nowcasting
- Promotion of space science research

ATMOSPHERIC & SPACE SCIENCE RESEARCH IN NORTH EASTERN REGION

OPERATIONAL PRODUCTS / SERVICES

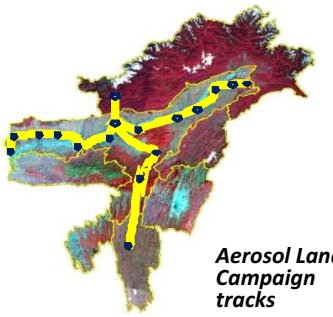
- Data support to national projects under ISRO-Geosphere Biosphere Programme (IGBP)
- High resolution weather forecast for NE region to support flood early warning
- Thunderstorm nowcasting
- Agro-meteorological advisory services
- Operation and Maintenance of surface observation network

RESEARCH AREAS

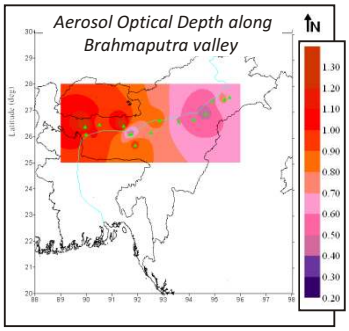
- Assessment of aerosol impact on cloud microphysics and precipitation efficiency
- Inventory and transport modeling for GHG
- Regional climate modeling and impact assessment on key sectors
- Improvement in parameterisation in weather Research & Forecast (WRF) modeling
- Regional atmospheric boundary layer dynamics study and simulation

Aerosol Radiative Forcing and Impact on Regional Climate

Aerosol characterisation and estimation of aerosol radiative forcing over NE India are being carried out using data from Umiam and two land campaigns. The impact of high aerosol concentration observed over Brahmaputra valley on regional weather and climate are being investigated.

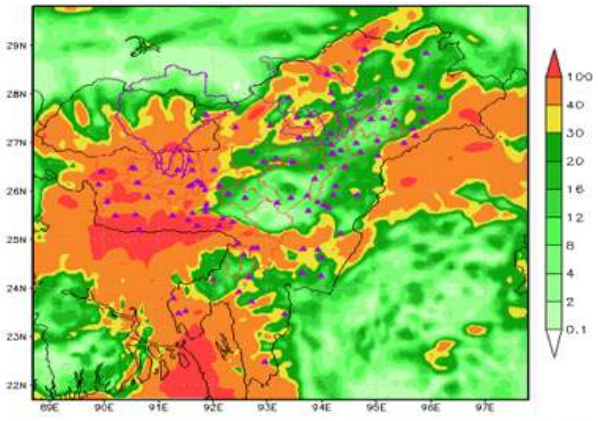


Aerosol Land Campaign tracks



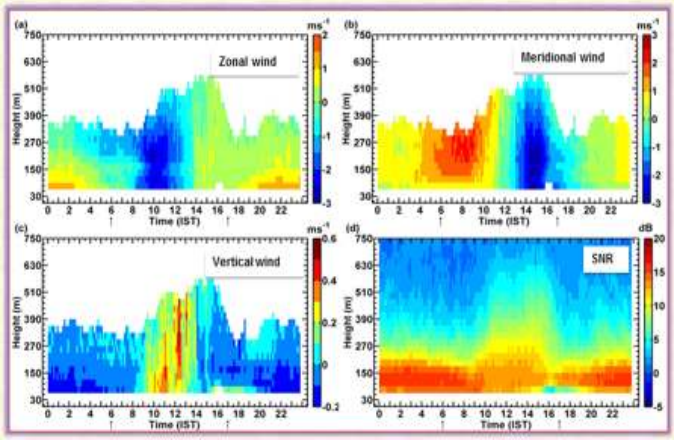
Weather Forecasting Using WRF Model

24 hr rainfall forecast using WRF model



Numerical weather prediction (NWP) over NER by customising the Weather Research and Forecasting (WRF) model and assimilating data from the AWS, satellite derived wind vector, AMSU and INSAT 3D radiance.

Atmospheric Boundary Layer (ABL) Dynamics Studies



Zonal, Meridianal, and Vertical wind as measured by SODAR (Sound Detection And Ranging)

Fixed station & campaign data are used to understand the ABL dynamics and its impact on cloud generation along the hill slopes in Brahmaputra valley.

COMMUNICATION AND NAVIGATION APPLICATIONS

COMMUNICATION & NAVIGATION APPLICATIONS

Satellite communication technology offers the unique capability of simultaneously reaching out to a large number of people living even in the remote areas of the country. The Indian National Satellite (INSAT) system, established in 1983, has revolutionised the country's communication sector. The system provides services for telecommunications, TV broadcasting, rural area connectivity, weather forecasting, disaster warning and search & rescue operations.

In view of growing demand for location-based services in the country, ISRO has recently embarked upon developing its own satellite navigation systems, i.e. Indian Regional Navigation Satellite System (IRNSS) and GPS Aided and GEO Augmented Navigation (GAGAN). IRNSS is being developed to provide position information services to users in the country and the region extending up to 1500 km from its boundary. GAGAN is a Satellite Based Augmentation System (SBAS), implemented jointly with Airport Authority of India, to provide navigation services with accuracy and integrity required for civil aviation applications.

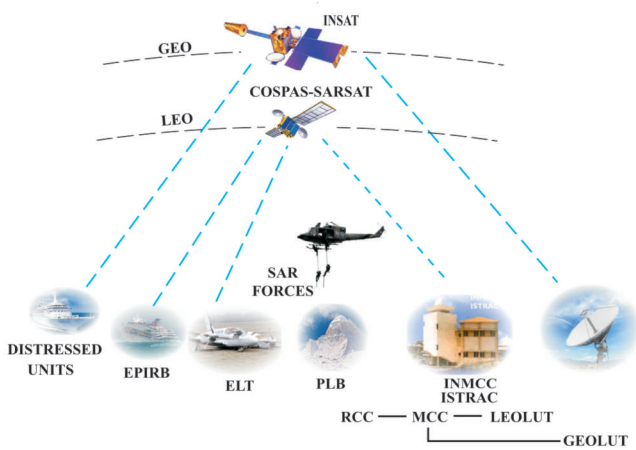
MAJOR HIGHLIGHTS

- Telecommunications
- Television broadcasting
- Internet
- VSAT connectivity for remote locations
- Satellite news gathering and dissemination
- Radio networking
- Mobile satellite services
- Satellite aided search and rescue
- Tele-medicine
- Tele-education
- Village Resource Centres
- Independent regional navigation satellite system

MAJOR BENEFITS

- Ubiquitous coverage
- Serving far-off areas
- Anywhere connectivity

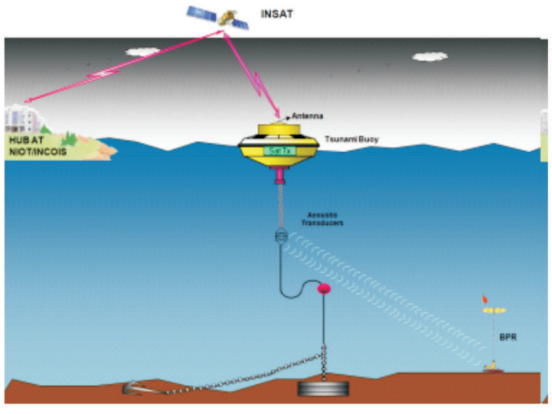
Satellite Aided Search and Rescue System



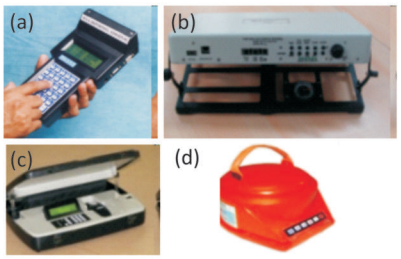
COSPAS: Space System for the Search of Vessels in Distress
SARSAT: Search and Rescue Satellite Aided Tracking
ELT: Emergency Locator Transmitter
PLB: Personal Locator Beacon
INMCC: Indian Mission Control Centre
EPIRB: Emergency Position Indicating Radio Beacon
RCC: Rescue Coordination Centre
MCC: Mission Control Centre
SAR FORCES: Search and Rescue Forces
LEO: Low Earth Orbit
GEO: Geostationary Orbit
LEOLUT: LEO Local User Terminal
GEOLUT: GEO Local User Terminal

Satellite Communication Link with Maitri Station at Antarctica

Tsunami Early Warning Communication System



Equipments for Emergency Communication



(a) SMS & vehicle tracking system
(b) Portable multimedia terminal
(c) Type-D terminal (satellite phone)
(d) Distress alert transmitter for fishermen

Automatic Weather Station

COMMUNICATION & NAVIGATION APPLICATIONS

OPERATIONAL PRODUCTS / SERVICES

- Telecommunications, TV & radio broadcasting, rural area connectivity
- Weather forecasting, disaster warning and search & rescue operations
- Navigation, location-based services, time synchronisation
- Commerce and industry applications
- Agriculture, environment study, fisheries, civil engineering, etc.
- Scientific and strategic applications

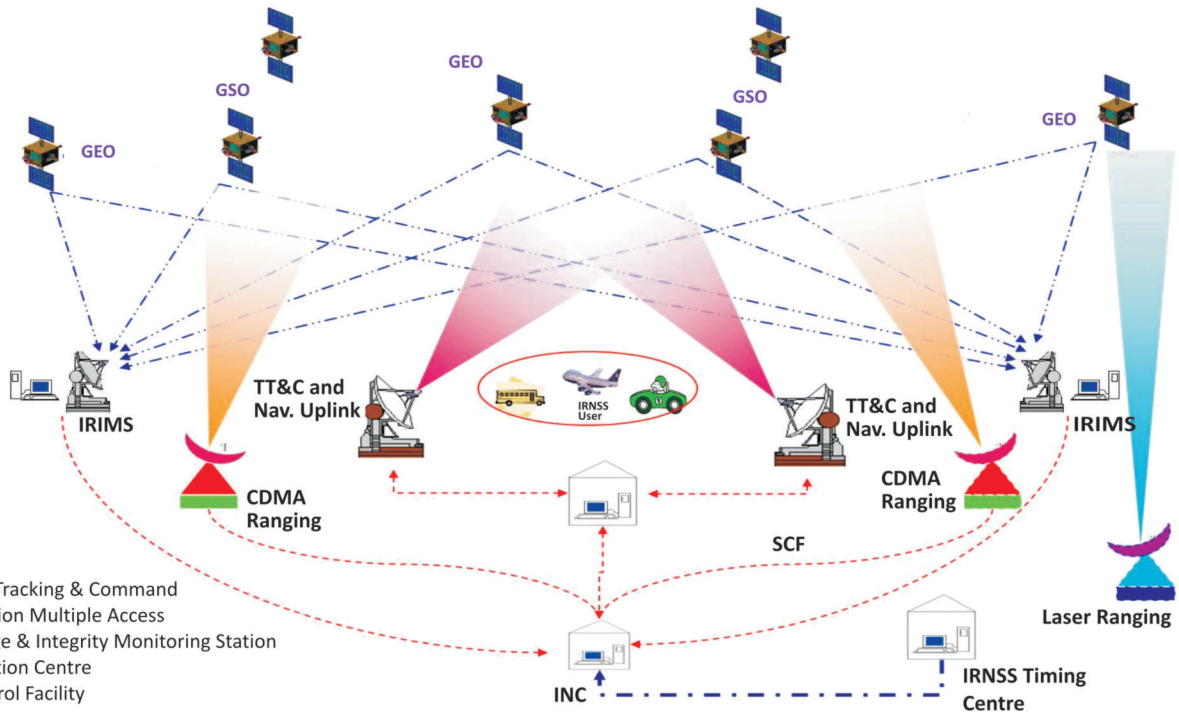
***GNSS:** Global Navigation Satellite System
****INS:** Inertial Navigation System

RESEARCH AREAS

- Hand-held terminal development for Mobile Satellite Services (MSS)
- High throughput satellite for broadband connectivity
- Advanced technologies adopting high frequency bands (like Q & V), optical communication through satellite
- GNSS* signal monitoring, GNSS-based remote sensing, GNSS/INS**/Pseudolite integration, software defined GNSS receiver, multi-GNSS, Application-Specific Integrated Circuit (ASIC) development, low-cost multi-GNSS simulator, ionospheric delay processing
- Spoofing detection and mitigation
- Indoor navigation and strategic applications

Indian Regional Navigation Satellite System (IRNSS)

..... an independent regional navigation satellite system with 4 satellites in geosynchronous (GSO) and 3 satellites in geostationary (GEO) orbits



TT&C: Telemetry, Tracking & Command
CDMA: Code Division Multiple Access
IRIMS: IRNSS Range & Integrity Monitoring Station
INC: IRNSS Navigation Centre
SCF: Satellite Control Facility

IRNSS Applications: Terrestrial, Aerial and Marine Navigation; Disaster Management; Vehicle tracking and fleet management; Integration with mobile phones; Precise Timing; Mapping and Geodetic data capture; Terrestrial navigation aid for hikers and travellers; Visual and voice navigation for drivers

COMMUNICATION SATELLITES

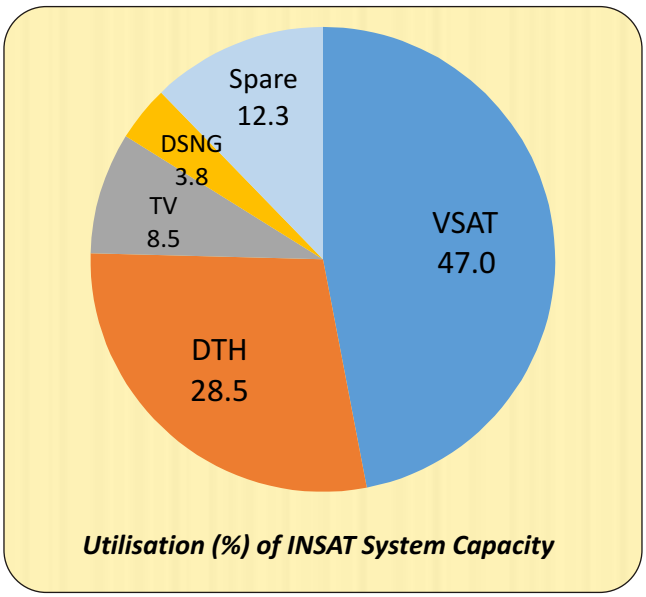
INSAT System

Indian National Satellite (INSAT) system, established in 1983, is the largest domestic communication satellite system in the Asia-Pacific Region. Presently, INSAT system has constellation of several operational satellites including commercial satellites like INSAT-3A, INSAT-3C, INSAT-4A, INSAT-4B, INSAT-4CR, GSAT-8, GSAT-10, GSAT-12, GSAT-14 and GSAT-16.

The satellites carry communication payloads in different frequency bands like C, Extended C, Ku, S, UHF bands. Meteorological imaging systems, Data Relay Transponder (DRT), Satellite Aided Search & Rescue (SAS&R) payload and GPS Aided Geo Augmented Navigation (GAGAN) payloads are some of the special purpose payloads that are also carried by these communication satellites.

Indian communication satellites are indigenously designed and developed by ISRO. World class facilities are established for assembly, integration and testing of satellites for space-worthiness. A large number of Indian industries are contributing in the satellite building process.

At present, the total capacity offered by INSAT system for commercial use including the hired capacity on foreign satellites is about 320 transponders [36 MHz equivalent].



Utilisation (%) of INSAT System Capacity

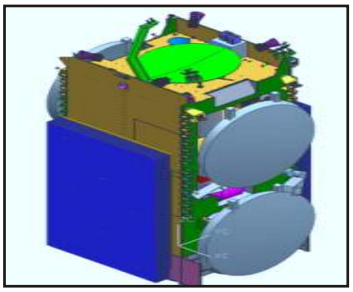
MAJOR HIGHLIGHTS

- Payloads in different frequency bands like C, Extended C, Ku, S, UHF bands
- Satellites are built using ISRO's standard I-1K , I-2K, I-3K and I-4K (K = about 1000 kg) bus
- The total capacity including the hired capacity on foreign satellites is about 320 transponders [36 Mhz]
- Deployment of 10 more communication satellites during the 12th Five-Year Plan (FYP) period to augment the capacity
- Adoption of latest technologies like steerable beams, high throughput using multiple beams, higher frequency bands, high capacity unified modular spacecraft-bus, etc. in future
- Capability to realise communication satellites indigenously enabling the self-reliance in meeting Country's communications needs
- Realised and delivered spacecraft to other countries under commercial contracts
- Used for not only conventional satellite communication applications but also for various societal applications

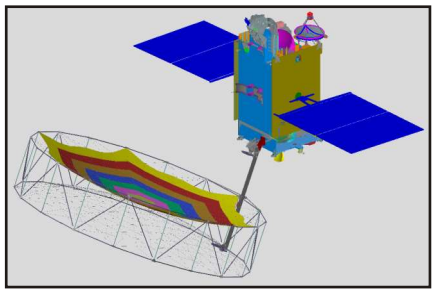
COMMUNICATION SATELLITES

MAJOR PLANNED SATELLITES

GSAT-11



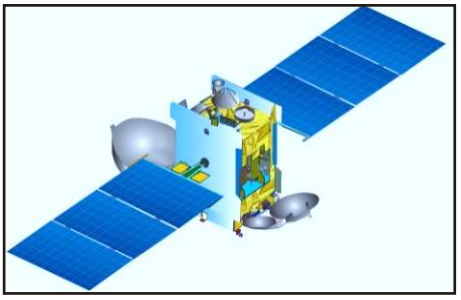
- Multibeam satellite with about 10 Gbps throughput
- 32 User beams in Ku-band, 4 colour-frequency reuse
- Hub communication in Ka-band
- Use of latest technologies like multiple spot beams, onboard Radio Frequency tracking, high capacity modular bus supporting 4000-6000 kg mass, etc.



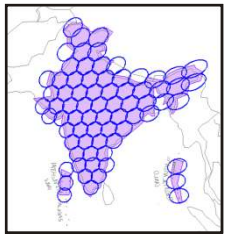
GSAT-6

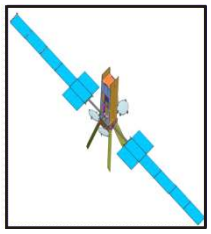
- Multibeam S-band satellite
- Use of multiple spot beams for reuse of frequency
- Six meter unfurlable antenna for enabling communication using small, portable and mobile terminals

GSAT-17



- 36 C & Ext C Transponders to augment the transponder capacity
- Data Relay Transponder (DRT), Satellite Aided Search & Rescue (SAS&R) and Mobile Satellite Services (MSS) payloads for continuity of services
- ISRO's standard I-3K bus

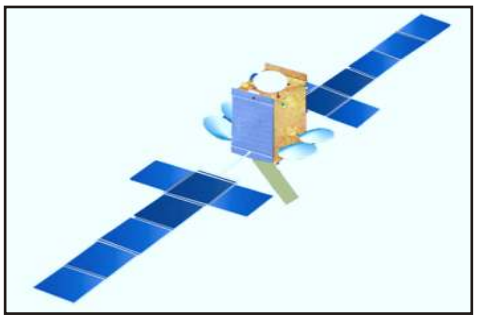




GSAT-Ka

- Multibeam High throughput satellite in Ka-band
- Possible use of latest technologies like steerable beams, electrical propulsion, deployable thermal radiators, etc.

GSAT-19E



- Payload for the first developmental flight of GSLV MK-III
- Experimental satellite to act as test bed for several new technologies like unified modular bus, deployable thermal radiators, electrical propulsion, indigenous Li-Ion batteries and C-band Travelling Wave Tube Amplifiers (TWTA), optical payload, etc.

SATELLITE COMMUNICATION – GROUND INFRASTRUCTURE

Satellite Communication (SATCOM) technology is being used for a large number of societal applications in the country. ISRO has established a strong ground infrastructure to provide operation support for communication services under MSS, BSS, FSS (Mobile/ Broadcast/ Fixed Satellite Services) satellite systems, conducting experiments, and developing communication techniques. Tele-education, Tele-medicine, and Disaster Management in the country are some of the major societal applications, which are supported through SATCOM infrastructure.

Space Applications Centre (SAC), Ahmedabad, is the nodal centre for developing, establishing and maintaining the SATCOM ground infrastructure. Presently, Earth Stations (ground transmit/ receive systems) are supported in all frequency bands, starting from L band to Ka band. ISRO also establishes ground systems for receiving meteorological data from Indian Satellite systems, such as Kalpana (METSAT), INSAT-3A (VHRR/CCD), and INSAT-3D (Imager & Sounder) data.

Earth Station Facility Area at SAC, Ahmedabad

MAJOR HIGHLIGHTS

- 9.3 m multi-band DVB-S Video and Data Broadcast
- 6.3 m IRNSS (Indian Regional Navigation Satellite System) Navigation Signal Monitoring with Data Archival & Recording System (SIGMON+DARS)
- 2.4 m Ka-band Beacon Reception System
- Ahmedabad Earth Station facility - 14 m/ 6.1 m Ext. C-band, 3.8 m Ku-band DVB-RCS hub & 6.3m MSS hub for SATCOM experiments & operation support for societal applications (Gramsat, Edusat, MSS)
- 2.4 m Ext. C & Ku-band Video Flyaway Broadcast Terminal (DSNG)
- 1.8 m/ 1.2 m Transportable VSATs (Very Small Aperture Antenna)

MAJOR BENEFITS

- Extends communication support for a large number of societal applications in the country, such as Tele-education, Tele-medicine, Disaster Management, etc.

SATELLITE COMMUNICATION – GROUND INFRASTRUCTURE

Meteorological & Oceanographic satellite data reception, archival and post-processing facility for weather forecast and other applications through MOSDAC

9.3m EUMETCAST Data Reception

4.5 m & 2.4 m MET Data Reception

MOSDAC Data Processing Facility

Navigational Signal Monitoring & Data Archival for Indian Regional Navigation Satellite System (IRNSS)

6.3m L & S Band Signal

Archival Facility

Dual Frequency, Dual Polarization 2.4 m Ka band Beacon Signal Reception facility

Used for Conducting Ka Band Propagation Experiment using GSAT-14

Master Control Facility (MCF)

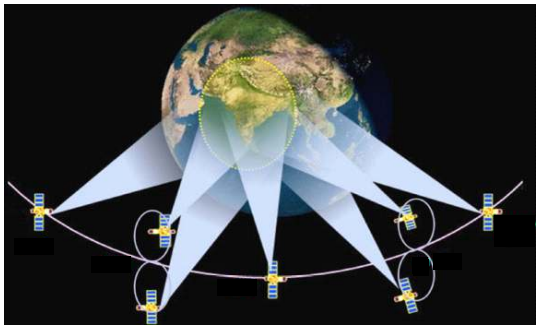
MCF at Hassan (Karnataka) and Bhopal (Madhya Pradesh) monitors and controls all the geo-stationary satellites of ISRO. MCF interacts with the user agencies for effective utilisation of the satellite payloads and to minimise the service disturbances during special operations.

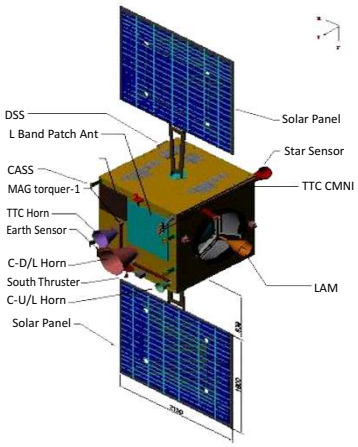
INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM

Indian Regional Navigation Satellite System (IRNSS) is an independent regional navigation satellite system developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area.

IRNSS will provide a position accuracy of better than 20 m. So far, ISRO has already launched 4 satellites. The constellation of 7 satellite is expected to be operational by 2015-16.

IRNSS Concept





IRNSS Receiver

IRNSS Antenna

IRNSS GUI

MAJOR HIGHLIGHTS

- An indigenous, independent regional navigation satellite system for providing location and time information
- Service Area – Indian landmass & surrounding 1500 km
- Location accuracy better than 20m
- Navigation Services: Standard Positioning Service (open to all users), Restricted service (to authorised users only)
- IRNSS space segment: 4 GSO (Geo-synchronous) + 3 GEO (Geo-stationary) satellites
- Navigation Payload: L5 & S Ranging Payload: C x C, Atomic Clocks: RAFS

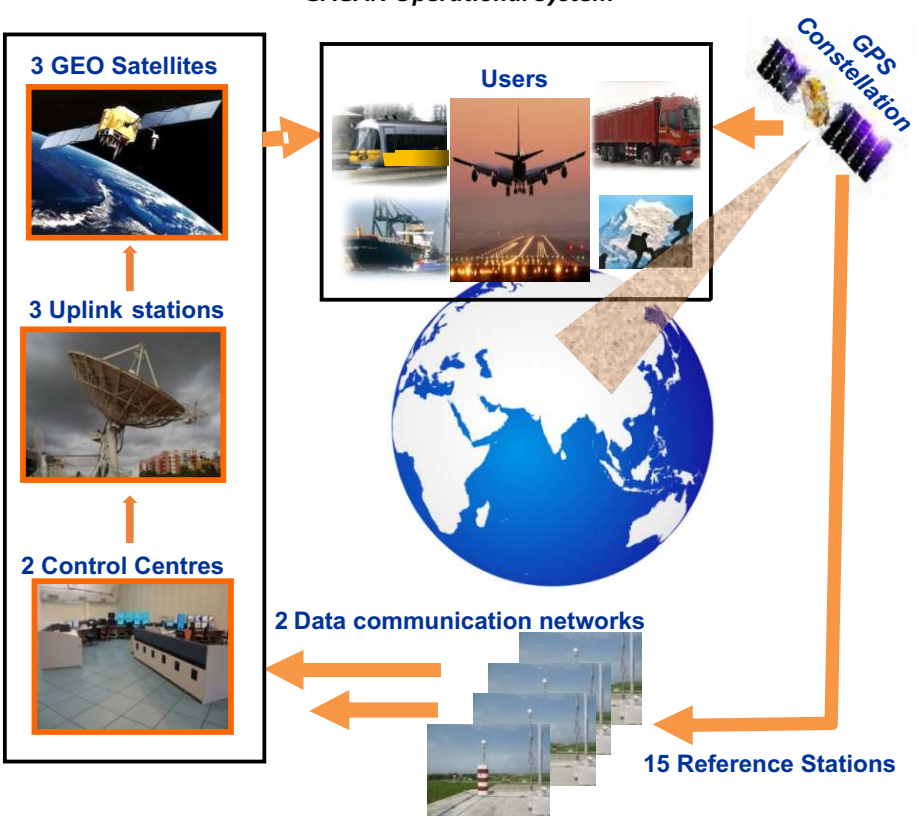
MAJOR BENEFITS

- Terrestrial, aerial & marine Navigation
- Location based services, fleet management
- Geographic data collection & surveying
- Disaster management, etc.

GPS AIDED GEO AUGMENTED NAVIGATION (GAGAN)

GPS Aided Geo Augmented Navigation (GAGAN) is a Satellite Based Augmentation System (SBAS) implemented jointly with Airport Authority of India (AAI). The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace. The system will be interoperable with other international SBAS systems and provide seamless navigation across regional boundaries. The first GAGAN navigation payload was flown on GSAT-8 which was launched on May 21, 2011 and the second on GSAT-10 launched on Sep 29, 2012.

GAGAN Operational System



Jointly developed by ISRO and AAI

MAJOR HIGHLIGHTS

- A joint initiative with Airport Authority of India
- Developed to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications
- Interoperable with other Satellite Based Augmentation System (SBAS) to provide seamless air navigation across the World
- GAGAN Payload in GSAT-8, GSAT-10, GSAT-15
- SBAS Signals in L1, L5 band

MAJOR APPLICATIONS

- Vastly improved GPS accuracy with GAGAN
- Navigation and safety enhancement in civil aviation, railways, ships, spacecraft, etc.
- Geographic data collection
- Location based services, etc.

SATCOM APPLICATIONS

Space Applications Centre (SAC), ISRO is the nodal centre for development and field demonstration of different SATCOM (satellite communication) applications and associated technologies.

INSAT-3A and INSAT-3D satellites have Data Relay Transponders (DRT) which support reporting services at low bit rate in UHF (ultra high frequency) band. INSAT-3C has a MSS (mobile satellite services) transponder which also supports low bit rate communication in S-band.

Various applications like Distress Alert Transmitter, Tsunami Early Warning System, Automatic Weather Stations and transmitters for Cal-Val projects to support different applications have already been proven in the field and are providing operational service. The first satellite communication link between Antarctica and India has also been established.

Distress Alert Transmitter (DAT)

- UHF Transmitter for Emergency Alert Messaging & Position reporting
- Built-in GPS receiver
- 2.4m Operational Hub at Maritime Rescue Coordination Centre (MRCC), Chennai
- Operational since 2005
- Technology available with Indian industries

MAJOR HIGHLIGHTS

- INSAT-3A & INSAT-3D satellites with Data Relay Transponders (DRT) to support low bit rate data reporting services
- Developed different terminals like Distress Alert Transmitter (DAT) & Automatic Weather Stations (AWS) and are available through Indian industries
- More than 5,000 terminals of DAT and 1200 AWS stations are operational in the field
- Special applications like data collection for Tsunami Early Warning is supported
- Suitable for all weather and all terrain data collection applications
- The terminals are available through Indian industries

MAJOR BENEFITS

- Low-cost terminal to support search & rescue operations for fishermen
- Providing meteorological sensor data collection for weather prediction
- In-situ data collection and reporting for calibration and validation of sensors

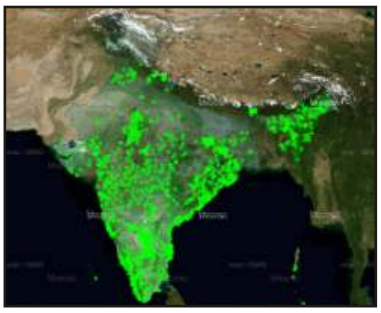
SATCOM APPLICATIONS

Automatic Weather Station (AWS) Highlights

Automatic Weather Station (AWS)

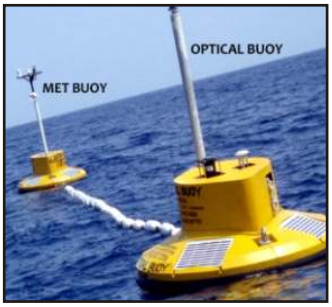
- 5W UHF Transmitter (402.65-402.85 MHz)
- Built-in GPS receiver
- Time Division Multiple Access (CDMA) transmission on hourly basis for automatic weather data collection
- HUB in Ext-C band at SAC, Ahmedabad
- More than 1200 AWS stations set up across India
- Supports more than eight meteorological sensors
- 23 Agro-met stations (AMS) are operational
- Technology available through Indian Industries

AWS Installations Across India



Calibration-Validation (Cal-Val) Highlights

Cal-Val Installation



- S-band Transmitter for collection of in-situ sensor data for Cal-Val of OCEANSAT-2 sensor
- TDMA communication of sensor data of Radiometer & Sun-Photometer
- S-band terminal with marine enclosure
- Receive Hub in Ext-C band at Delhi Earth Station
- Installed and Operational for OCEANSAT-2

Cal-Val Transmitter

Antarctica Communication Link

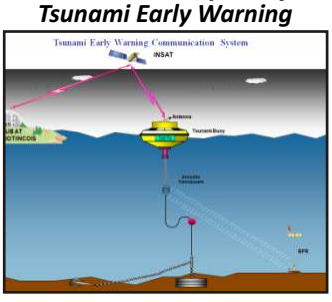
First Antarctica Communication Link

- Bi-directional communication between Maitri, Antarctica and National Centre for Antarctic and Ocean Research (NCAOR), Goa
- 3m C-band Earth station at Maitri (71° S, 11° E) to support communication at 2048 Kbps
- 7.2m C-band station at NCAOR (15.3° N,73.5° E)
- Extreme low elevation angle of 5° to support services of data transfer, video-conferencing and internet access

Maitri, Antarctica

Tsunami Early Warning System Highlights

Communication System for Tsunami Early Warning



- UHF transmitter and S-band transmitter for Tsunami Early Warning
- TDMA transmission support for Acoustic Tide Gauge & BPR (bottom pressure recorder)
- S-band terminal with receive line for command response
- Receive Hub in Ext-C band at INCOIS, Hyderabad
- Technology available through Indian Industries

TECHNOLOGY DIFFUSION AND SPACE EDUCATION

TECHNOLOGY DIFFUSION & SPACE EDUCATION

Technology diffusion and space education are integral part of the Indian space programme. A number of initiatives are taken to ensure meaningful utilisation of space technology for addressing the problems of humankind; to provide opportunities for space research to the younger generation; and to generate awareness amongst public.

Capacity building

- Undergraduate and post-graduate programmes
- Customised courses for Central and State Departments/ Ministries
- National Natural Resources Management System (NNRMS) supported training courses for academia and stakeholder departments
- Satellite-based distance learning and e-learning programmes
- International training programmes supported by UN, SAARC and MoEA

Dissemination of space-based products & services

bhuvan Gateway to Geospatial World

A geoportal showcasing Indian imaging capabilities and portraying thematic information for societal applications (http://bhuvan.nrsc.gov.in/)

India-WRIS WebGIS Water Resources Information System of India

A portal for comprehensive data & information on India's water resources (http://www.india-wris.nrsc.gov.in/)

MOSDAC

A portal for weather forecasting, cyclone prediction and continuous weather & ocean data availability (http://www.mosdac.gov.in/)

Biodiversity Information System Indian Space Research Organisation Department of Space, Government of India

A portal for providing spatial data on biodiversity (http://bis.iirs.gov.in/)

MAJOR HIGHLIGHTS

- Capacity building through education, training and research programmes for different target groups from India and abroad
- Geo-Web portals for creation, visualisation, analysis and dissemination of space-based products & services
- Tele-education, Tele-medicine and Village Resource Centre programmes to reach out remote and rural areas for improving quality in education & health-care services and providing information on natural resources & weather
- RESPOND programme (Research Sponsored by ISRO) to promote research in space sciences at academic and non-academic research institutions
- Technology Transfer and Industry Cooperation (TTIC) programme
- ISRO education portal (http://shiksha.isro.gov.in/) for school and college students and public interface through social media

TECHNOLOGY DIFFUSION & SPACE EDUCATION

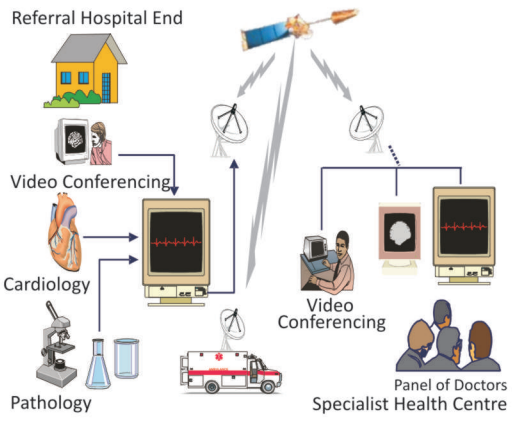
OPERATIONAL PROGRAMMES

- Capacity building programmes are implemented through Indian Institute of Remote Sensing (IIRS); Indian Institute of Space Science and Technology (IIST); National Remote Sensing Centre (NRSC); Space Applications Centre (SAC); Physical Research Laboratory (PRL)
- About 15,500 participants have been trained (till April, 2015) from India and abroad in regular programmes
- Satellite-based distance learning programme has benefited about 19,000 participants from 223 universities/institutes/colleges (till April, 2015)
- Web portals providing a variety of data, value-added products and services, including 2D/3D visualisation, to the public and government departments/ ministries are operational 24x7

SERVICES & CURRENT STATUS

- Towards providing Tele-healthcare services, 382 nodes including 16 mobile units are operational across the country benefitting around 1.5 lakh people every year
- For Tele-education services, 83 networks are operational covering 26 States and 3 Union Territories with about 4700 interactive and 55,000 receive-only classrooms
- 456 Village Resources Centre (VRC) nodes established in 22 States/Union Territories
- Over 290 technologies have been successfully transferred and made operational in industries
- Space Technology Cells have been set-up in IITs and IISc for promoting research in the areas of space technology and applications

Tele-Medicine Network



Village Resource Centre Network

WEB PORTALS FOR DISSEMINATION OF SPACE-BASED PRODUCTS & SERVICES

bhuvan
Gateway to Geospatial World

- ISRO's Earth Observation Visualisation Portal
- Comprehensive and versatile web-based visualisation system (2D/3D) showcasing Indian imaging capabilities in multi-sensor, multi-platform and multi-temporal domain
- Allows users to Browse and Download satellite data and products
- Rich Thematic datasets and services (Land, Ocean, Weather, Disaster etc.) to select, browse and query thematic datasets and consume as interoperable OGC (Open Geospatial Consortium) compliant web servi ces
- Allows users to digitise/interpret the features from the 2D/3D virtual globe and download it
- Collaboration tool for community participation

http://bhuvan.nrsc.gov.in/)

MOSDAC

- MOSDAC – Meteorological and Oceanographic Satellite Data Archival Centre – archives the meteorological and oceanographic data products from ISRO science missions and *in-situ* observation network
- Data/ products/ information is disseminated to the scientific community in near real time.

(http://www.mosdac.gov.in/)

- Joint initiative of Central Water Commission, Ministry of Water Resources and ISRO, Govt. of India
- Single window solution for comprehensive, authoritative and consistent data and information of India's water resources along with allied natural resources in a standardised GIS framework
- Currently, the portal contains 95 spatial layers along with large attribute data of the water resources assets

(http://www.india-wris.nrsc.gov.in/)

MAJOR HIGHLIGHTS

Bhuvan Portal

- Gateway to Indian Earth Observation (EO) data products and services
- Visualisation of multi-resolution Earth Observation (EO) images in 2D or 3D environment
- Free data download under Open Data Archive
- Rich Thematic information and services
- Crowdsourcing (community participation) enabled

MOSDAC Portal

- A portal for weather forecasting, cyclone prediction and continuous weather and ocean data availability

India-WRIS Portal

- A Web-enabled single window system for comprehensive data and information on India's water resources

WEB PORTALS FOR DISSEMINATION OF SPACE-BASED PRODUCTS & SERVICES

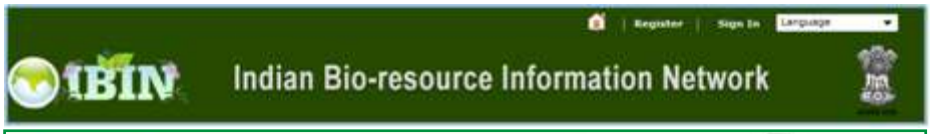
- National Natural Resources Management System (NNRMS) is a unique system established under the aegis of erstwhile Planning Commission with Department of Space as the nodal agency
- Multi-scale spatial datasets on natural resources have been generated using remotely sensed imagery under the aegis of NNRMS programme
- OGC-compliant WMS (Web Map Services) provide accessibility of the maps at users desktop which allows users to overlay these layers with other available datasets

(http://www.nnrms.gov.in/)

ISRO - Disaster Management Support Programme
Decision Support Centre

- ISRO evolved Disaster Management Support (DMS) programme to provide information on natural disasters viz., Flood, Cyclone, Agricultural Drought, Forest Fire, Earthquake and Landslide
- DMS - Decision Support Centre (DSC) website is designed and developed to enhance the outreach of disaster related space enabled products and services in a timely and reliable manner

(http://www.dsc.nrsc.gov.in)



- An initiative of Dept. of Space and Dept. of Biotechnology, Govt. of India.
- Indian Bio-resource Information Network (IBIN), a de-centralised bio-resource database based on distributed architecture, provides spatial biodiversity and species datasets of the country from different collaborating institutions
- Biodiversity Information System (BIS), a centralised biodiversity database, provides spatial datasets on vegetation cover, fragmentation, disturbance and biological richness of the country

(www.ibin.gov.in) *(http://bis.iirs.gov.in/)*

MAJOR HIGHLIGHTS

NNRMS Portal

- Provides access to spatial datasets on natural resources generated using satellite imagery under NNRMS programme
- Provides metadata services, thematic layer visualisation, and OGC-compliant WMS services

ISRO-Disaster Management Support – Decision Support Centre Portal

- Provides single window disaster management support services on major natural hazards/ disasters

Indian Biodiversity Portals

- Indian Bio-resource Information Network (IBIN) and Biodiversity Information System (BIS) portals provide spatial biodiversity and species datasets and related information in a GIS framework

BHUVAN GEOPORTAL

bhuvan
Gateway to Geospatial World

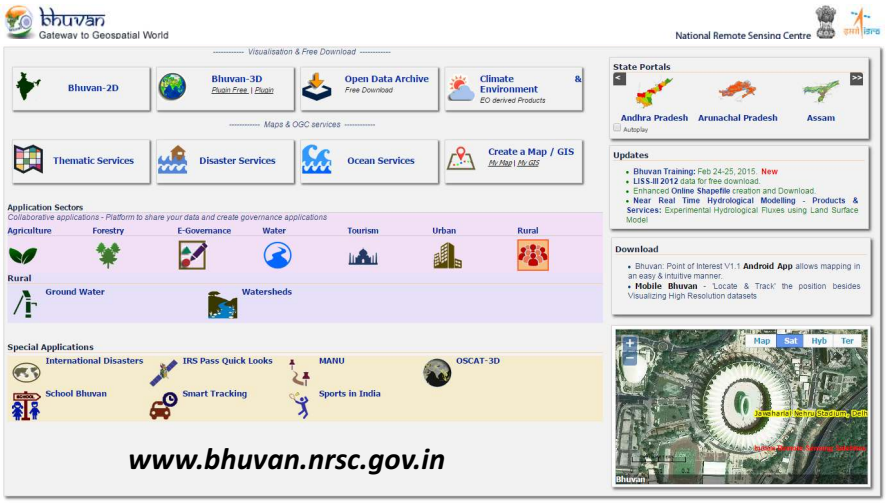
Bhuvan geoportal (www.bhuvan.nrsc.gov.in) is India's geospatial gateway. It provides broad canvas of geospatial services covering visualisation, free data download, thematic map display and analysis, timely information on disaster, crowdsourcing and project-specific GIS applications and it is also multi-lingual.

Visualisation & Free Download

- Seamless visualisation of 2.5m ortho-rectified satellite data for the entire country
- Satellite data with 1 m spatial resolution for more than 180 cities
- 2D and 3D data visualisation
- Administrative and Hydrological boundaries
- 3D Citymodels & 2.5D depiction
- Satellite data for free download

Crowdsourcing Applications

- Complete mapping tool to embed asset and participatory GIS data
- Android Apps provide mapping in an easy and intuitive manner using smart phones
- Customised Android Apps developed for more than 20 Projects
- Enhanced Shapefile creation tool



Maps and OGC Services

- Multi-Thematic data
- Dissemination of OGC compliant Web Mapping Services (WMS)
- Create your maps from text/csv using GIS Viewer
- Support for Disaster Services in a near real-time manner

State Portals

- Supporting State Governments for Geo-Governance
- Provisioning information on Administrative, Agriculture, Soil, Specific Disasters, Geology & Mines, Land-use/Land cover, Urban, etc.

MAJOR HIGHLIGHTS

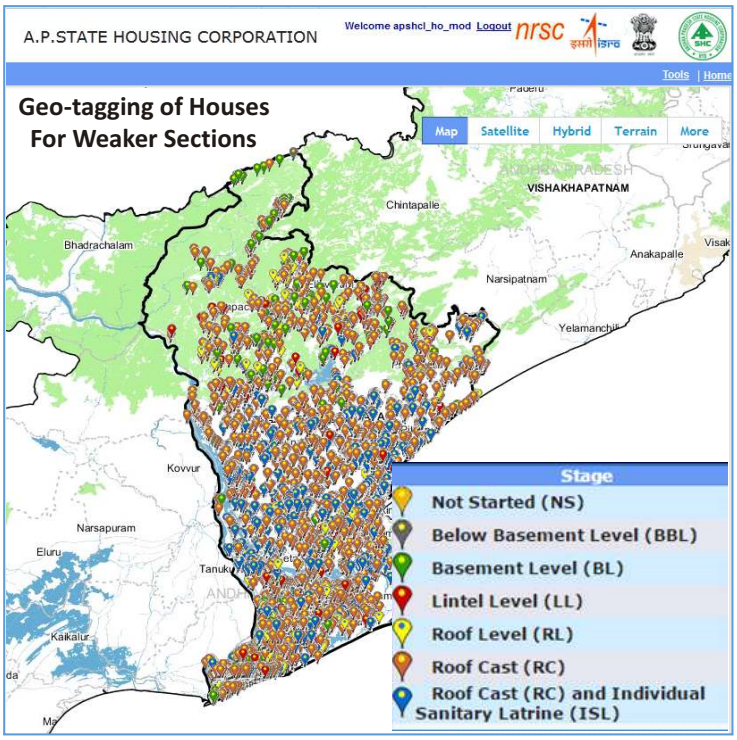
- Bhuvan geoportal showcases India's imaging capabilities and portrays thematic information for societal applications
- Hosting ~17 TB of data consisting of multi-resolution & multi- temporal satellite and thematic datasets
- Thematic Map engine to create GIS maps
- State Portals for 30 States available
- Over 1 Lakh field photographs collected through Mobile Apps under various projects & programmes
- Near real-time support during Hudhud, Phailin, Uttarakhand disasters
- Over 3 lakh users have downloaded different datasets from Open Data Archive

MAJOR BENEFITS

- Bhuvan provides a web-based platform to create, visualise, share, analyse Geospatial data products and services for societal applications
- Platform for geospatial governance

BHUVAN GEOPORTAL

Bhuvan for Societal Applications

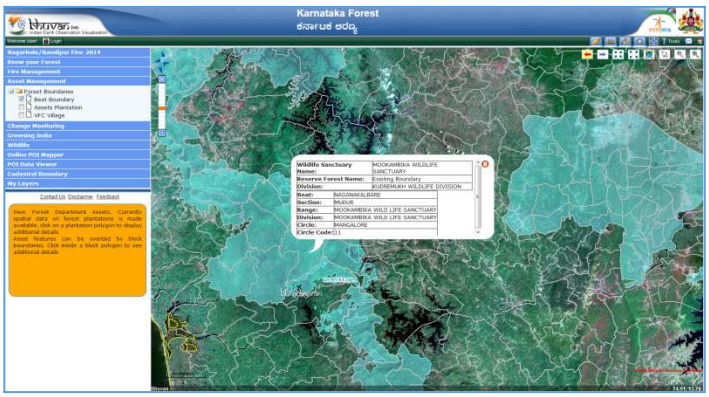


Information on damage due to Kedarnath disaster and Points of Interest (PoI) were collected through crowdsourcing for around 20,000 points under the Map the Neighbourhood in Uttarakhand (MANU) programme (Partner Institutions: DST, HNB Garhwal University, Kumaun University, Wadia Institute of Himalayan Geology)

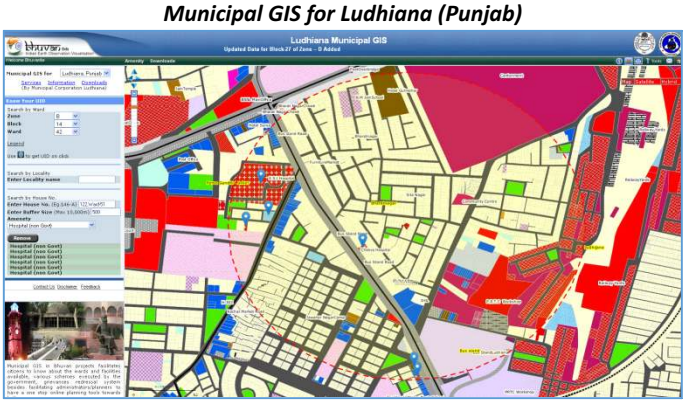
.....Bhuvan is now supporting International Disasters under International Charter

Tourism GIS for Amritsar (Punjab)

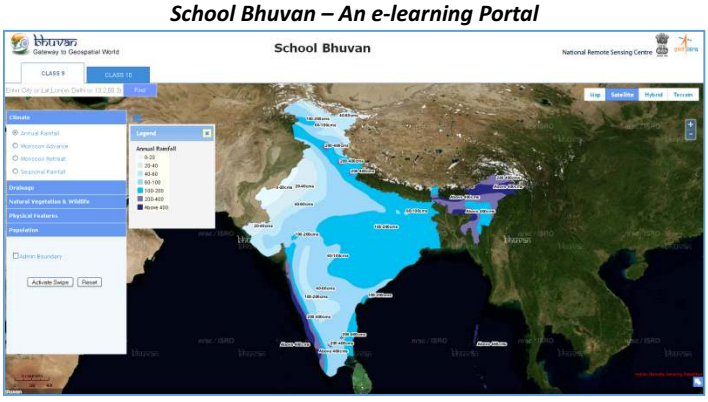
Forest Resource Management for Karnataka Forest Department



Municipal GIS for Ludhiana (Punjab)

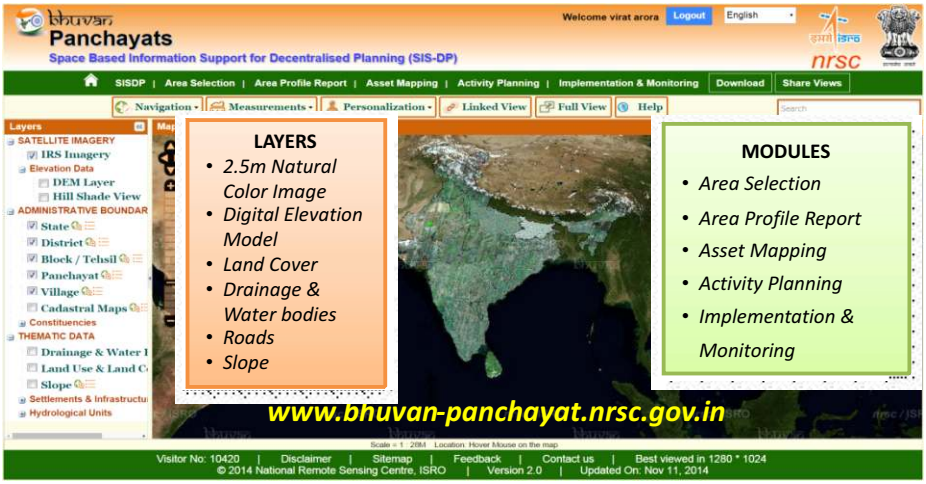


School Bhuvan – An e-learning Portal



BHUVAN PANCHAYATS – A WEB PORTAL FOR DECENTRALISED PLANING

- *Bhuvan Panchayats is a web-based portal to facilitate "Decentralised Planning" at grassroots level*
- *Designed to provide the information in spatial and non-spatial format for assisting the development activities of the local bodies in rural and urban areas*
- *Provides information on various themes with high-resolution satellite images in the background*
- *Gives the detailed information regarding household amenities data and Census Population data at district and village level, respectively*



Salient Features:

- Visualisation by all citizens
- Enabling environment for Panchayati Raj Institutions (PRIs)
- Asset mapping (inventory of assets, their classification as per database standards-codes and symbols)
- Activity planning under Centre and State sponsored schemes
- Implementation and monitoring (Scheme, Department and Sector-wise at three tiers of Decentralised Planning and Governance)
- Area profile generation
- Geo-tagging point of interest (Crowdsourcing)
- Outreach to citizens and data dissemination

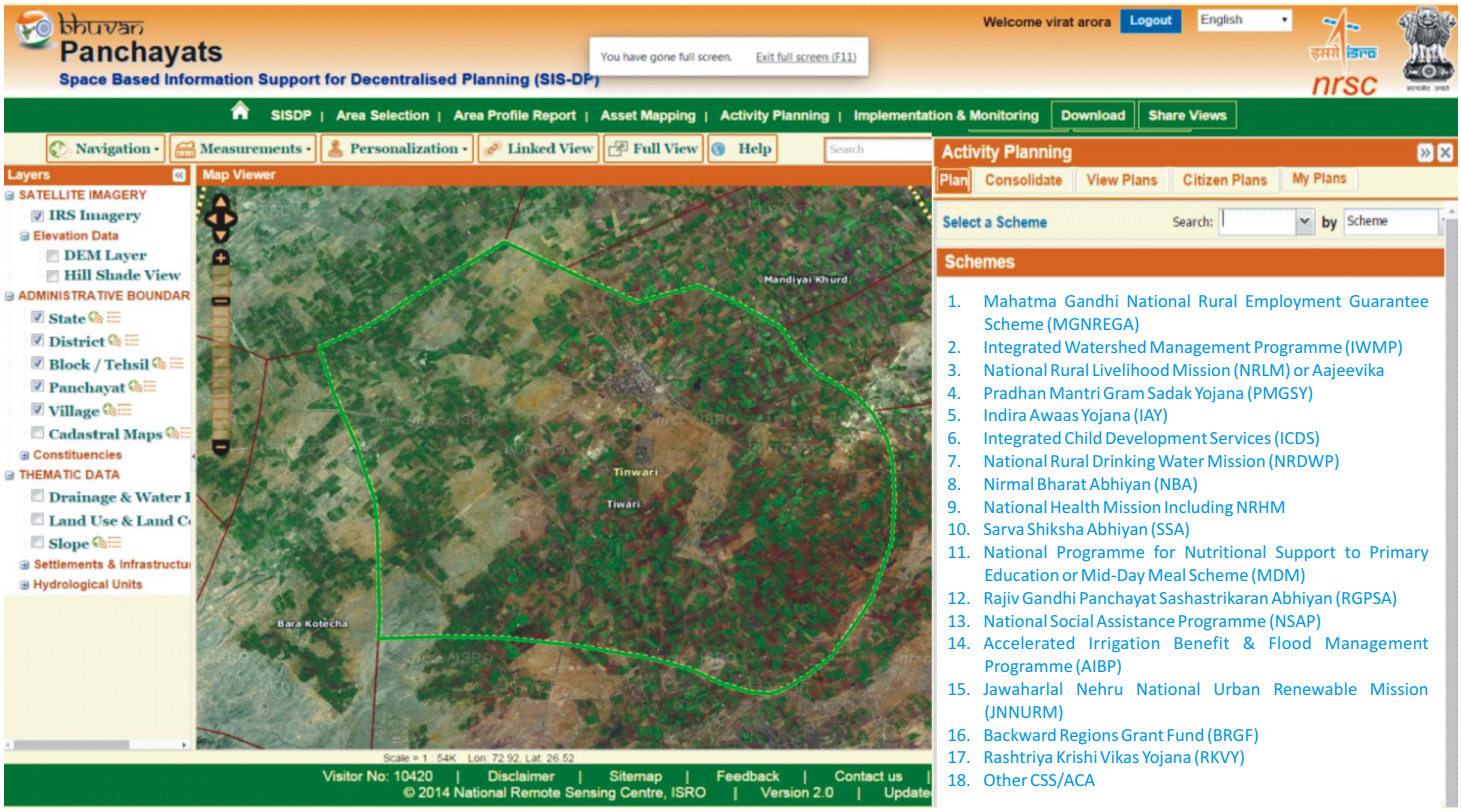
MAJOR HIGHLIGHTS

- High-resolution satellite imagery (2.5m, natural color composite) available for entire country along with various thematic maps
- Planning activities through crowdsourcing (public participation)
- A web-enabled spatial database for visualization and monitoring of assets at Panchayat level
- Integration of Centrally-Sponsored Schemes for planning the activities at grassroots level
- Login for concerned officials at all tier of decentralised planning for better implementation and monitoring

MAJOR BENEFITS

- Access to respective Panchayats through registration of citizen
- Time-effective planning through involvement of general public
- Automated report generation for the area of interest (including the maps and meteorological data)

BHUVAN PANCHAYATS – A WEB PORTAL FOR DECENTRALISED PLANING



Activity Planning

Under Bhuvan Panchayats portal, 29 activities and 85 sub-activities entrusted to PRIs at three levels, viz. Village, Block and District along with CAG code, are categorized into 5 sectors :

- Land & Water Development Activities: 2 activities, 9 sub-activities
- Productive Activities: 8 activities, 30 sub-activities
- Civic Amenities & Infrastructural Development Activities: 11 activities, 21 sub-activities
- Social Welfare Activities: 6 activities, 20 sub-activities
- Governance Activities: 2 activities, 5 sub-activities

Assets Mapping

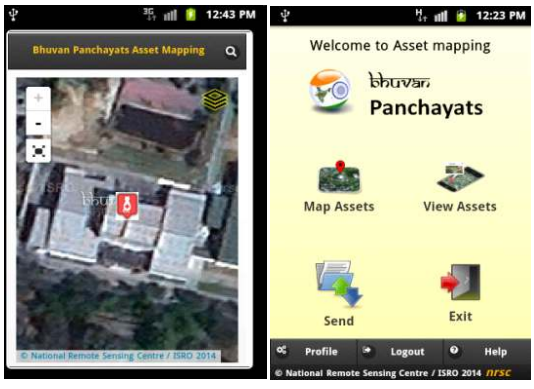
This module lists a total of 67 assets with 213 attributes which are broadly classified into 25 sub-categories and 5 major categories as enumerated below:

- 41 Civic Amenities/Infrastructure Assets
- 7 Governance Assets
- 9 Productive Assets
- 2 Human Resources and Livestock Assets
- 8 Natural Resources Assets

Area Profile Report

This module generates reports automatically containing maps of user's area of interest, tables and charts representing statistical information for climate data. It provides a resource inventory on natural resources, assets, disaster prone areas, etc. These reports can be downloaded and printed through Print area module.

Asset Mapping through Mobile Application



INDIA – WATER RESOURCES INFORMATION SYSTEM (INDIA-WRIS)

A 'Single Window' solution for comprehensive, authoritative and consistent data & information of India's water resources in a standardised national GIS framework for planning, development and management of water resources in the country.

GUI of India-WRIS V 4.0

http://www.india-wris.nrsc.gov.in

12 Main Information Systems

1. Base Data Info Systems
1. Administrative
2. Region
3. Infrastructure
4. Terrain

2. Surface Water Info Systems
5. Water Resource Division
6. Basin
7. Watershed
8. River
9. Surface Water Body
10. Water Resources Projects
11. Command Area
12. Minor Irrigation
13. Canal

3. Ground Water Info Systems
14. Aquifer/Lithology
15. Ground Water Level
16. Ground Water Potential (RGNDWM)

4. Hydro-Met Info Systems
17. Meteorological
18. Climate
19. Hydro-Observation
20. Flood Forecasting

5. Water Quality Info Systems
21. Surface Water Quality
22. Ground Water Quality

6. Snow Cover / Glacier Info Systems
23. Snow Cover / Glacier

7. Inland Navigation Waterways Info Systems
24. Inland Navigation Waterways

8. Inter-Basin Transfer Links Info Systems
25. Inter - Basin Transfer Links

9. Hydro-Met Extremes
26. Flood
27. Drought
28. Extreme Events

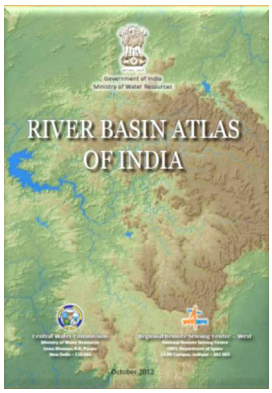
10. Land Resources Info Systems
29. Land Use / Land cover
30. Land Degradation
31. Wasteland
32. Soil

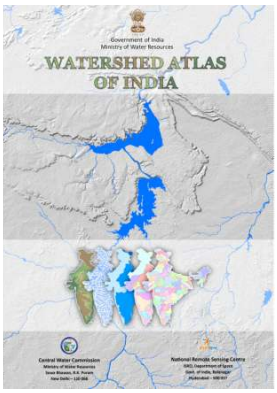
11. Water Tourism Info Systems
33. Water Tourism

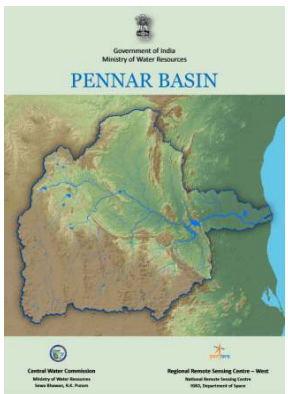
12. Socio-Economic Info Systems
34. Rural
35. Urban

- **6 modules** :
  - WRIS Info Discovery
  - WRIS Explorer
  - WRIS Connect
  - Share Success Story
  - WR Planning & Management
  - Input Data Builder
- **12 Main information systems**
- **35 Sub-information systems**
- **95 Spatial layers with over 700 attributes, 5-100 years data**

India-WRIS Publications







MAJOR HIGHLIGHTS

- Satellite data derived outputs and value-added products generation (map products, statistics, reports etc.) to meet the requirements of CWC & other stakeholders in the country involved in water resources planning and management
- Delineation of hierarchical hydrological units of India (Basin, Sub-Basin & Watershed) on 1:50,000 scale using satellite data (LISS-IV + Cartosat-1 imagery)
- The River network for entire country has been digitised on 1:50,000 scale
- Stream ordering has been done first sub-basin wise, and then it has been integrated at basin-level as well as at country-level
- Mapping of Waterbodies for entire country. Total number of waterbodies 7,98,909 (4,52,449 having area >0.5ha and 3,46,460 having area <0.5ha)

MAJOR BENEFITS

- State-of-art web portal design for sharing information with Govt. Departments, and also dissemination of non-classified information in public domain
- Several State-level workshops organised at various places across the country to appraise the stakeholders about the outcome of the project for integrated water resources management

INDIA – WATER RESOURCES INFORMATION SYSTEM (INDIA-WRIS)

WATER RESOURCES ASSETS OF THE COUNTRY

WATERSHED ATLAS

• No. of Water Resource Regions	6
• No. of Basins	27
• No. of Sub-basins	101
• No. of Watersheds	4,707
• Total Length of River (Line)	42,86,044.55 km
• Total Length of River (Polygon)	6,27,726 km

Milestones of India-WRIS

- ❖ Website: Released December 10, 2009
- ❖ Version 1.0: Released on December 7, 2010
- ❖ Version 2.0: Released on March 22, 2012
- ❖ River Basin Atlas of India: Released on November 1, 2012
- ❖ Version 3.0: Released on December 4, 2012
- ❖ Version 4.0: Released on March 28, 2014
- ❖ Watershed Atlas of India: Released on April 15, 2014

2D-3D Linked View

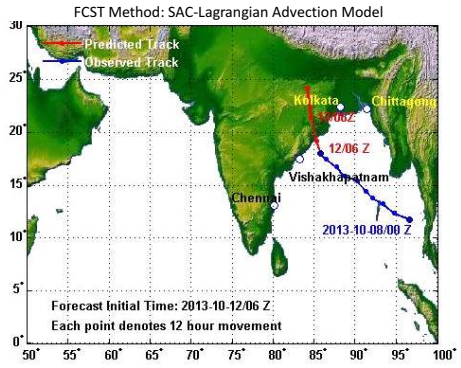
WATER RESOURCES PROJECTS

Spatial Layer Details	Number/ Area	No. of Attributes
• No. of Major & Medium Irrigation Projects	1,747	55
• No. of Lift irrigation Schemes	352	15
• No. of ERM Projects	131	50
• No. of Hydroelectric projects	222	17
• No. of Powerhouses	293	39
• No. of Dams	4,575	34
• No. of Barrages/Weir/ Anicuts	540	51
• No. of Reservoirs	4,517	38
• Total Length of Canal	3,24,600 km	3
• No. of Hydro-Structures	1,14,709	6
• Waterlogged Areas in Major & Medium Command	17,192.79 km^2	5
• Salt-Affected Areas in Major & Medium Command	10,345.41 km^2	5
• No. of Surface Water bodies	7,98,909	5
• Area under Surface Water bodies	48,379.89 km^2	-
• No. of Inter-Basin Transfer Links	30	8
• No. of Inland Navigation Waterways	6 (4,487 km)	15

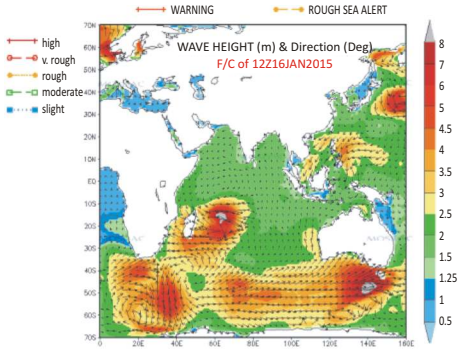
MOSDAC – A PORTAL FOR METEOROLOGY, OCEANOGRAPHY DATA AND SERVICES

MOSDAC – Meteorological and Oceanographic Satellite Data Archival Centre – portal archives the meteorological & oceanographic data products from ISRO science missions and in-situ observation network. The portal provides a variety of products and services on a wide spectrum of applications comprised of weather forecasting, cyclone prediction and other vital ocean and atmospheric parameters needed by national/ international forecasting agencies, research organisations, educational institutions, individual researchers and students for advanced research. In this novel mission, the contributions of the Indian satellite data from Kalpana, INSAT, Megha-Tropiques, Saral and Oceansat play a vital role.

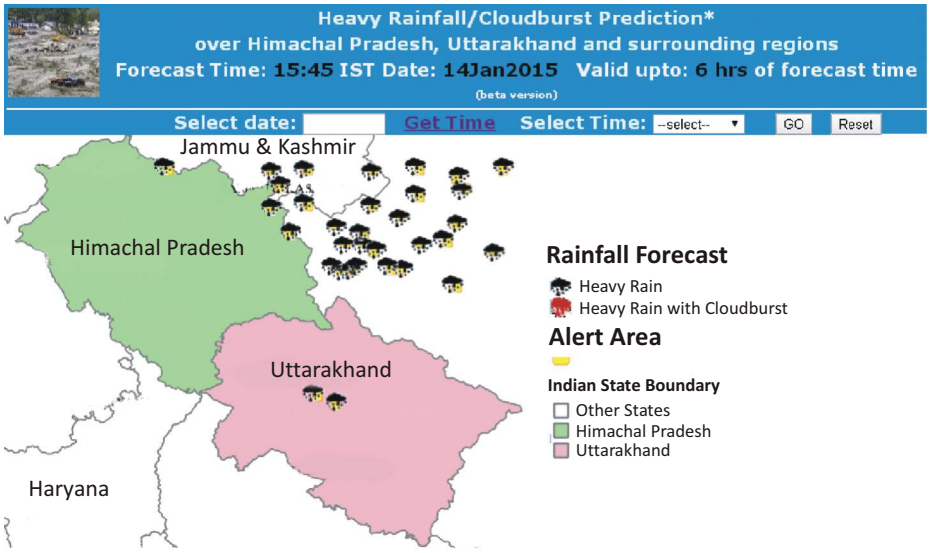
Real-time Track Prediction of Cyclone Phailin



Sea State Forecast in terms of Wave Height



Half Hourly Forecast of Heavy Rain/Cloud Burst Events



MAJOR HIGHLIGHTS

- A Storehouse for Space-based Weather and Ocean Data
- Near Real-time Meteorological and Oceanographic data dissemination over high speed network
- Free data to global scientific and academic community
- Web and email alerts for cyclogenesis
- Heavy rain and cloudburst related nowcasting over Uttarakhand and Himachal Pradesh
- Freely available tools and utilities for data analysis

MAJOR BENEFITS

- Advanced alerts related to cyclone and heavy rain events to administrators and users
- Free scientific data to students and researchers

MOSDAC – A PORTAL FOR METEOROLOGY, OCEANOGRAPHY DATA AND SERVICES

OPERATIONAL MISSIONS & PRODUCTS

KALPANA-1 / INSAT-3A / INSAT-3D

Half-hourly data of land, ocean and atmosphere, covering India and its neighborhood for weather and ocean state forecasting

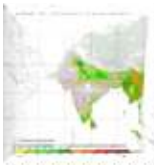
MEGHA-TROPIQUES

Measurements for under-standing of tropical mesoscale convective systems and hydrological cycle

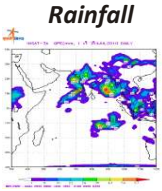
SARAL

Observations for the study of sea level, climate and ocean circulation

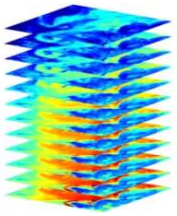
Normalised Difference Vegetation Index



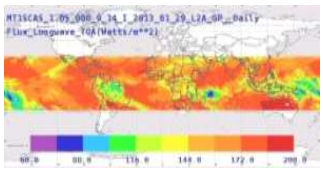
Rainfall



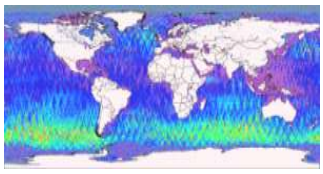
Humidity Profile



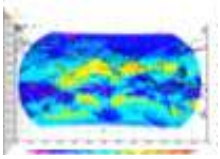
SCARAB – Longwave Flux



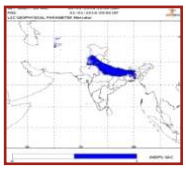
Significant Wave Height



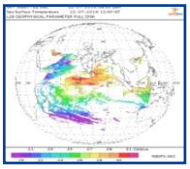
Outgoing Long-wave Radiation



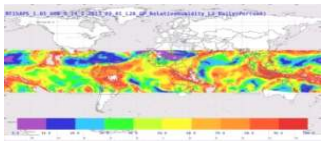
Fog



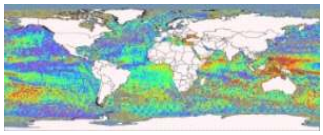
Sea Surface Temperature



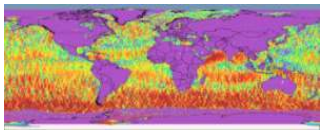
SAPHIR– Atmospheric Humidity Profile



Sea Surface Height Anomaly

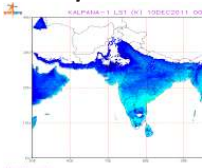


Wind Speed

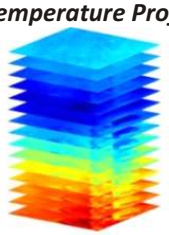


Water Vapor Winds

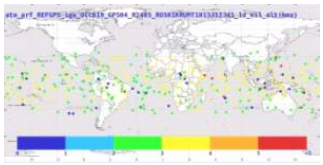
Land Surface Temperature



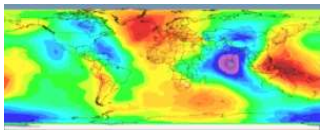
Temperature Profile



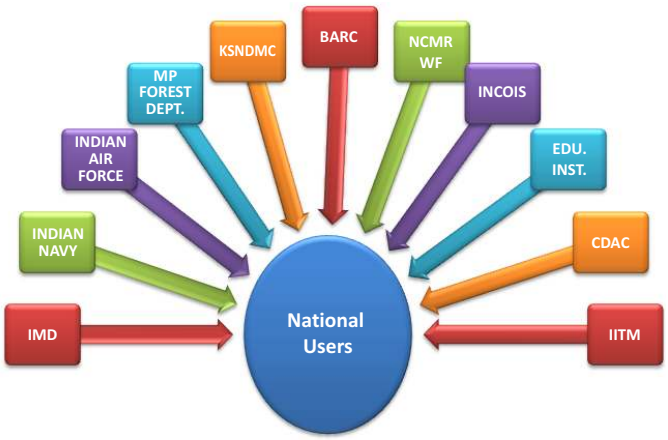
ROSA – Locations of Occultation



Mean Sea Surface

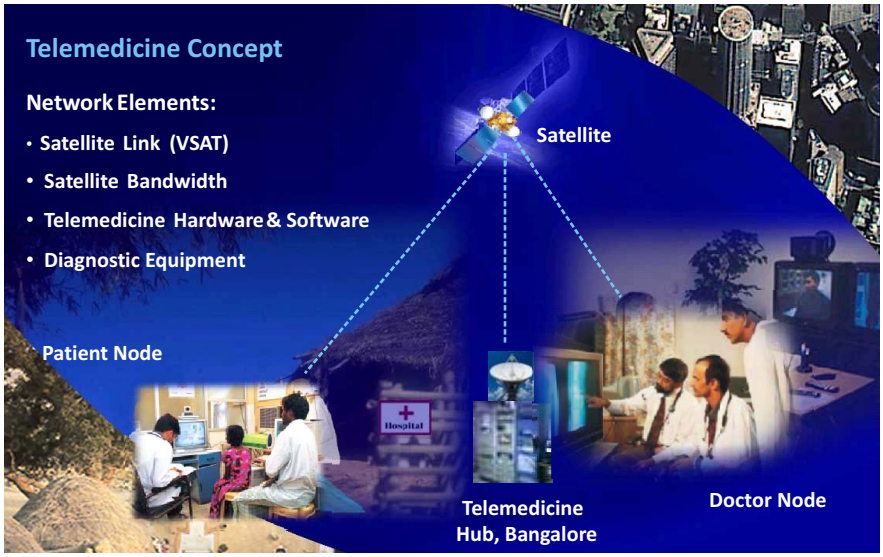


USER OUTREACH (http://www.mosdac.gov.in)



TELE-MEDICINE

ISRO's Telemedicine programme, started in 2001, utilises satellite links to provide medical consultaion and treatment by specialist doctors to patients located in remote & rural areas.



MAJOR BENEFITS

- Improved connectivity in remote and rural areas for healthcare services with access to Super-Speciality hospitals
- Significant cost savings for patients
- Timely advice to save lives
- Continuing Medical Education (CME) for Doctors and healthcare providers
- Support to disaster relief

384 nodes set-up across the country with 64 specialty hospitals connected to 302 remote/rural/district hospitals & medical colleges including 18 Mobile Telemedicine units

- Telemedicine nodes in 5 Lakshadweep Islands
- Proven useful as the patients are not required to be flown to Mainland
- First consultation and opinions can be taken using telemedicine

Patient Node at Kavaratti, Lakshadweep

Network Monitoring

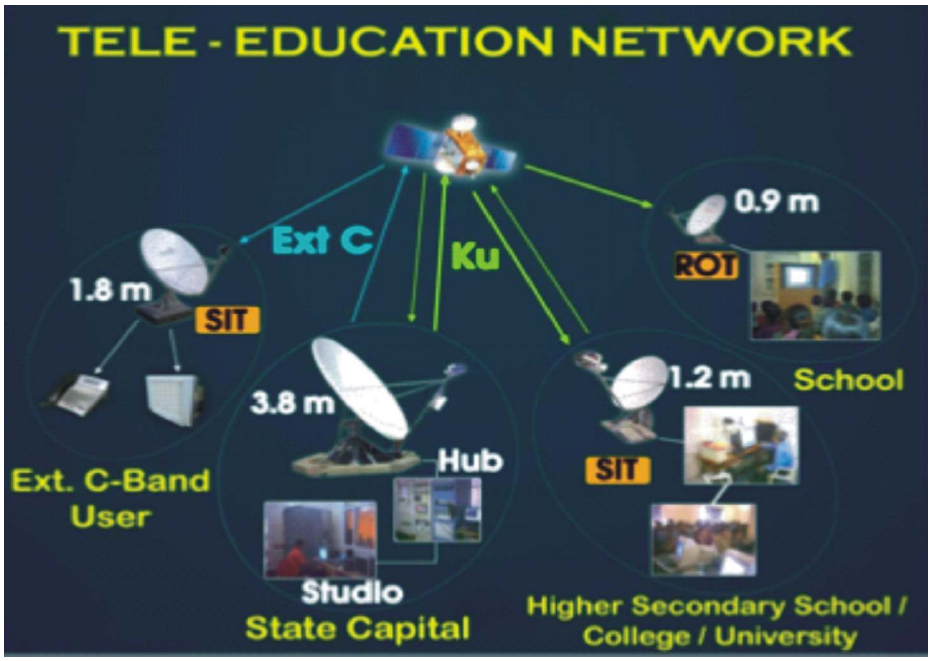
Telemedicine Networks Monitoring facility established at Development and Educational Communication Unit (DECU)/ ISRO, Ahmedabad for providing technical support to remote nodes

Mobile Telemedicine Vans

(Health services at doorstep)

TELE-EDUCATION

ISRO's Tele-education programme provides satellite-based distance education services for bridging rural-urban divide and improve quality in education sector across the country.



ROT: Receive only Terminal; SIT: Satellite Interactive Terminal

MAJOR BENEFITS

- Supplementing curriculum-based teaching
- Effective teachers' training
- Access to quality resource persons and education
- Taking education to nook and corners of the country
- About 15 million students get benefitted every year

- Coverage in 26 States and 5 Union Territories
- 83 Networks connecting 60,000+ schools and colleges 5,000+ Interactive and 55,000+ Receive-Only Classrooms

ROT Classroom

Interactive Classroom

Tele-education Glimpses

Network Monitoring

Tele-education Networks Monitoring facility established at DECU/ISRO, Ahmedabad to monitor quality of transmission and utilisation of network

VILLAGE RESOURCE CENTRES

The Village Resource Centres (VRCs) programme launched by ISRO/ DOS disseminates a portfolio of services emanating from space systems directly to the rural communities. The programme is executed in association with NGOs/ Trusts and State/ Central agencies.

MAJOR BENEFITS

- Rural empowerment
- SMART Governance
- Computerised Gram Panchayats
- Distance education
- Remote healthcare services
- Employment opportunities
- Access to products and services available to city dwellers

- 461 VRCs were set-up in 22 States/Union Territories
- Services include Tele-education, Tele-healthcare, Land & Water Resources Management, Interactive advisory services, Tele-Fishery, e-Governance Services, Weather Services and other services based on local needs

- Over 6,500 programmes have been conducted till addressing the issues in Agriculture/ Horticulture, Fisheries, Livestock, Water resources development, Tele-healthcare; Awareness programmes; Women empowerment; Supplementary education; Computer literacy; Micro-credit; Micro-finance; Skill development/ vocational training for livelihood support, etc.

Glimpses of Village Resource Centre

CAPACITY BUILDING

Capacity building is an important component of ISRO's activities enabling the users for effective use of space science & technology in the fields of Earth observation, satellite communication, satellite meteorology, satellite navigation, space & atmospheric sciences, etc. Indian Institute of Remote Sensing (IIRS), Dehradun; Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram; National Remote Sensing Centre (NRSC), Hyderabad; Space Applications Centre (SAC), Ahmedabad; and Physical Research Laboratory (PRL), Ahmedabad conduct regular training, education and research programmes. ISRO has also established tele-education networks taking education to every nook and corner of the country.

Indian Institute of Remote Sensing (IIRS)

IIRS is a premier institute for capacity building in Remote Sensing & Geoinformatics technology and their applications. It conducts a range of training & education programmes of different duration that suit to the requirements of stakeholders, decision makers, academia and fresh graduates. Recently, it has also started distance learning programmes in live and e-learning mode. IIRS is also the nodal centre to support United Nations affiliated 'Centre for Space Science & Technology Education in Asia and the Pacific' (CSSTEAP) for conducting Remote Sensing & GIS related training & education programmes.

iirs

Indian Institute of Space Science and Technology (IIST)

IIST is a world class educational & research institute contributing significantly to space science, technology and applications. It is the Asia's first space institute and first in the world to offer complete range of undergraduate, postgraduate and doctoral programmes.

MAJOR HIGHLIGHTS

- Capacity building through education, training and research programmes for different target groups from India and abroad
- IIRS, IIST, NRSC, SAC & PRL conduct undergraduate, post graduate and tailor made courses in various fields of space science & technology and their applications
- Established & operationalised Tele-education networks providing educational services in 26 States & 3 Union Territories connecting over 56,000 schools & colleges
- Strong linkage with academic institutions for promoting quality research in areas relevant to the Indian space programme
- IIRS, SAC & PRL support international training & educational programmes of CSSTEAP, affiliated to UN

MAJOR BENEFITS

- A large number of participants (over 31,500) have been trained from India and abroad through classroom and distance learning programmes
- About 15 million students get benefited through ISRO's Tele-education (EDUSAT) programme every year

CAPACITY BUILDING

National Remote Sensing Centre (NRSC)

NRSC offers regular and specialised courses to participants from Government, Private, NGO and Academic Institutions enabling effective utilisation of geospatial data for various applications.

Space Application Centre (SAC)

SAC imparts training programmes related to Satellite Communication, Satellite Meteorology & Global Climate, and Satellite Navigation under CSSTEAP (affiliated to UN). SAC also organises programmes as per institutional/ departmental requirement.

Physical Research Laboratory (PRL)

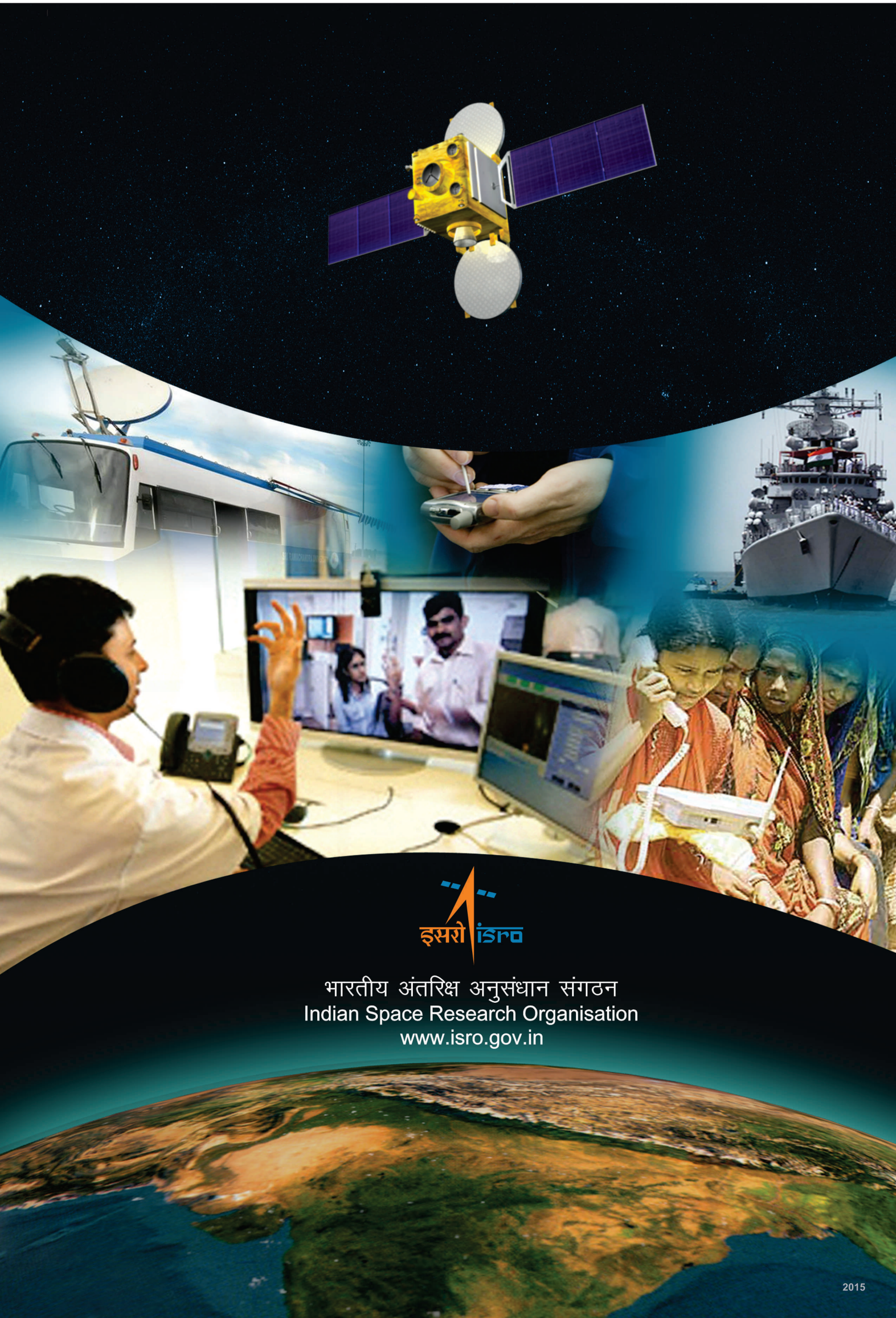
PRL is involved in basic research in experimental and theoretical physics, astronomy & astrophysics, Earth, planetary and atmospheric sciences. PRL runs training programmes on Space & Atmospheric Sciences under CSSTEAP (affiliated to UN). It also conducts extensive academic programmes for doctoral & post doctoral research, and programmes for university teachers

Tele-education/ Satellite & Internet-based Distance Learning

Satellite & internet-based distance learning involves creating awareness and enabling value addition in the existing primary/ secondary/ higher education systems. Under the ISRO's Tele-education programme, a total of 83 networks have been established connecting over 56,000 schools & colleges in 26 States and 3 Union Territories. Distance learning programmes (live and e-learning mode) in Remote Sensing & GIS have been initiated at IIRS benefiting a large number of stakeholders, scientists, researchers, university teachers and students every year.

Sponsored Research (RESPOND)

This programme promotes quality research in areas of relevance to the Indian space programme. Financial support is provided to academia and non-academic R & D institutions and laboratories for conducting research and development activities. ISRO has also set up Space Technology Cells at premier institutions like IITs and IISc.



इसरो isro

भारतीय अंतरिक्ष अनुसंधान संगठन
Indian Space Research Organisation
www.isro.gov.in

2015