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iirs

वार्षिक रिपोर्ट
Annual Report
2023 - 2024

भारतीय सुदूर संवेदन संस्थान
Indian Institute of Remote Sensing
देहरादून / Dehradun

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DIRECTOR'S DESK

The Indian Institute of Remote Sensing (IIRS), a Unit of Indian Space Research Organisation (ISRO), Govt. of India is striving continuously for the capacity building in the field of Remote Sensing (RS), Geographical Information System (GIS) and their applications through training, education and research. IIRS is playing a key role since fiWve decades of its establishment in the country and Asian region in capacity building of various target groups, ranging from fresh graduates, and postgraduate students to policy makers. The Institute also hosts and conduct the training and educational programmes on RS & GIS offered by the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations. As an integral part of capacity building, the Institute undertakes applied research in Remote Sensing & Geoinformation science, technology and applications and also participate in various research programmes of ISRO.

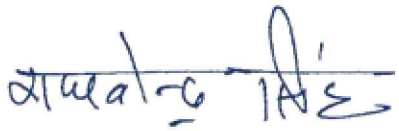
During FY: 2023-24, a total of 631 participants have benefited from regular training, educational programmes (PG Diploma, M.Tech., M.Sc., sponsored, certificate programme, etc.) and special courses as part of capacity building activities. In addition to regular training programmes, the customized special courses were organized for various target groups wherein around 366 participants have benefitted.

IIRS distance learning programmes - both Live and Interactive classroom (Edusat programme), and Online e-learning programme have significantly contributed in the mass capacity building activity of the Institute. Under IIRS outreach programme, several modules of Learning Management Systems (LMS) for various certificate courses in geospatial technology were developed.

IIRS is involved in a number of research projects of ISRO/ DOS such as Earth Observation Application Mission, Disaster Management Support, Climate and Atmospheric Programme (ISRO-GBP) and other Mission Projects. In addition to these ISRO/ DOS projects, IIRS faculty have significantly contributed in the research activity through ongoing TDPs and other in-house research projects. Various research papers were published in peer reviewed international and national journals.

Third IIRS Academia Meet (IAM-2024) on theme 'Space Technology for Disaster Risk Reduction in Himalaya: Challenges and Opportunities' was held on March 19, 2024 at IIRS. There were more than 200 participants from various academic institutions, government departments, industries, Edusat-users from all over India besides faculty and student participants from IIRS.

I am thankful to Shri. S. Somanath, Chairman, ISRO for his continuous support and guidance on various initiatives and endeavours of IIRS.



Dr. Raghavendra Pratap Singh
Director, IIRS

IIRS Profile

Indian Institute of Remote Sensing (IIRS) is a constituent unit of Indian Space Research Organisation (ISRO), Department of Space, Government of India. Since its establishment in April 1966, IIRS has been a premier Institution and key player for capacity building in the field of Remote Sensing and geospatial technology, and its applications through training, education and research.

Considering enhanced capacity building needs, IIRS has been given the status of an independent Unit of ISRO with effect from April 30, 2011. Over the years, the Institute is playing a major role in capacity building activities which can be primarily grouped into the following three domains:

Formerly known as Indian Photo-interpretation Institute (IPI), the Institute is the first of its kind in entire South-East Asia. While nurturing its primary endeavour to build capacity amongst the user community by training mid-career professionals, the Institute has enhanced its capability and evolved many training and education programmes that are tuned to meet the requirements of various target groups, ranging from fresh graduates to policy makers including academia. IIRS is also one of the most sought after Institute for conducting specially designed courses for the officials of Central and State government ministries and stakeholder departments to make more effective utilization of Earth Observation (EO) data and use of Geographic Information System (GIS) tool. As a follow up of the National Meet held on September 07, 2015; IIRS is also given a special responsibility of Capacity Building needs for effective governance using space technology based tools in Ministries and Department under Central & State governments.

To widen its outreach, IIRS has started live and interactive distance learning programme (DLP) in 2007. Further, graduate and postgraduate students from universities spread across the country have also benefitted through EDUSAT-based distance learning programmes being offered by the Institute till date.

Efforts are underway to develop the e-learning content (also in Hindi) for various RS and GIS applications. The Institute campus also houses the headquarters of the Centre for Space Science and Technology Education in

Asia and The Pacific (CSSTEAP), affiliated to the United Nations and first of its kind established in the region in November 1995.

IIRS, as host Institution provides support to conduct all its Remote Sensing and GIS training & education programmes at postgraduate level also. The headquarters of Indian Society of Remote Sensing (ISRS), one of the largest non-governmental scientific society in the country, is also located in the Institute's campus.

The Institute has a strong, multi-disciplinary and geospatial solution-oriented research agenda that focuses on developing improved methods/ techniques for processing, visualization and dissemination of EO data & geo-information for various societal applications and better understanding of Earth's system processes.

Currently, microwave, hyperspectral and high-resolution EO data processing and their applications is the main research focus. Various state-of the-art laboratories, field-based instrumentations and observatories networks help meeting the research goals and objectives.

For further details please visit IIRS website at https://www.iirs.gov.in

Academic and Capacity Building Programmes

The Institute organises about 35-40 courses every year and it has trained 14,608 professionals (till March, 2024), including 1,547 professionals from abroad representing 115 countries mainly from the Asia, Africa and South America. In addition to regular academic programmes, IIRS is one of the most sought after Institute for conducting specially designed courses for the officials of Central & State government ministries and stakeholder departments for the effective utilization of earth observation (EO) data.

Special/ Tailor-made courses were also designed and conducted at IIRS for various user organizations; such as Emerging Trends in Remote Sensing and its Applications (13), Geoinformatics for Field Foresters (57), Hyperspectral Remote Sensing for Mineral and Hydrocarbon Exploration (8), SAR Data Processing for Land Deformation Studies (22), Remote Sensing and GIS Applications in Agricultural Water Management (19), Application of Remote Sensing & GIS in Water Resources Sector (8), Microwave RS & Geological Applications (10), Remote Sensing and GIS Applications in Hydrological Modelling and Data Assimilation (16), RS & GIS in Predictive Soil Mapping (20), Satellite Image Analysis and Photogrammetry (5), Geospatial Inputs for Enabling Master Plan Formulation (20), Remote Sensing and GIS Technology for Disaster Management (24), Geospatial Inputs for Enabling Master Plan Formulation (19), Advance Remote Sensing & GIS and its Application in Water Resources (19), Remote Sensing & GIS in Soil Mapping (20), Application of Remote Sensing & Geographical Information System in Hydropower Projects (20)

Till date CSSTEAP has conducted 67 PG Courses: 26 in RS&GIS, 12 in SATCOM, 12 each SATMET and SAS and 04 in Global Navigation Satellite System. Currently 27th RS&GIS course at Dehradun, 13th SATMET at SAC Ahmedabad and 13th SAS course at SAC PRL are in progress. In addition, the Centre has conducted 92 short courses including webinar and workshops in the past 28 years. These programmes have benefited 3653 participants from a total of 38 countries in the Asia- Pacific region and 74 participants from 26 countries outside Asia Pacific region. Till date 196 participants from 17 countries have been awarded M. Tech. Degree in the 5 disciplines (85 participants in RS & GIS; 55 in SATCOM; 23 in SATMET; 27 participants in SAS and 06 in GNSS). To widen its outreach, IIRS has started live and interactive distance learning programme (DLP) in 2007.

Students passed-out in the year 2023-24

Year	Regular Programme							Special Programme	Total
	PG Diploma*	NNMRS	ITEC	M.Tech.**	M.Sc.**	Decision Makers	Certificate (CRS)		
2023-24	23	57	52	54	09	34	19	383	631

*Completion batch: * PG Diploma (2022-23) * M.Tech (2021-23) ** M.Sc. (2021-23)*

Details of Special courses organised in the year 2023-24

S.No.	Course Title	Course Duration	Course Period		No. of Participants
			From	To	
1	Emerging Trends in Remote Sensing and its Applications	2 Weeks	17-04-2023	28-04-2023	13
2	Geoinformatics for Field Foresters	1 Weeks	24-04-2023	28-04-2023	57
3	Summer school for usefulness of RS & GIS for environmental Studies	1 weeks	19-06-2023	23-06-2023	83
4	Hyperspectral Remote Sensing for Mineral and Hydrocarbon Exploration	1 Weeks	10-07-2023	14-07-2023	8
5	SAR Data Processing for Land Deformation Studies	2 Weeks	31-07-2023	11-08-2023	22
6	Remote Sensing and GIS Applications in Agricultural Water Management	2 Weeks	21-08-2023	01-09-2023	19
7	Application of Remote Sensing & GIS in Water Resources Sector	1 Weeks	28-08-2023	01-09-2023	8
8	Microwave RS & GeologicalApplications	1 Weeks	11-09-2023	15-09-2023	10
9	Remote Sensing and GIS Applications in Hydrological Modelling and Data Assimilation	2 Weeks	03-10-2023	13-10-2023	16
10	RS & GIS in Predictive Soil Mapping	2 Weeks	09-10-2023	20-10-2023	20
11	Satellite Image Analysis and Photogrammetry	4 Weeks	16-10-2023	10-11-2023	5
12	Geospatial Inputs for Enabling Master Plan Formulation	2 Weeks	22-01-2024	02-02-2024	20
13	Remote Sensing and GIS Technology for Disaster Management	1 Weeks	05-02-2024	09-02-2024	24
14	Geospatial Inputs for Enabling Master Plan Formulation	4 Weeks	12-02-2024	08-03-2024	19
15	Advance Remote Sensing & GIS and its Application in Water Resources	2 Weeks	26-02-2024	08-03-2024	19
16	Remote Sensing & GIS in Soil Mapping	1 Weeks	11-03-2024	15-03-2024	20
17	Application of Remote Sensing & Geographical Information System in Hydropower Projects	1 Weeks	18-03-2024	22-03-2024	20
				Total	**383**

Education Programmes

M.Tech. Programme in (RS & GIS)

M. Tech. in Remote Sensing & Geographical Information Systems (RS & GIS) is a two-year course and this year 58 participants joined for the M.Tech. 2023-25 batch. Nos. of participants across disciplines are as follows- Agriculture & Soils (05), Forest Resources & Ecosystem Analysis (8) Geoinformatics (7), Geosciences (4), Marine and Atmospheric Science (6) Natural Hazards & Disaster Risk Management (8) Satellite Image Analysis & Photogrammetry (7), Urban & Reginal Studies (5) and Water Resources (8). The Orientation programme for the M.Tech. batch happened on August 02-03, 2023 at IIRS Campus. For M.Tech. (2022-24) batch, Mid-Term presentation (Sem III) was held between 18-22 December, 2023. Under the joint IIRS - Andhra University M.Tech. Programme, 51 M.Tech. students from (2021-23) batch have completed their dissertation.

Project Topics

- Monitoring ET and water productivity of rice-wheat system in Terai region using tie series satellite data
- Spatial Soil quality Assessment using machine learning techniques in a watershed of Himalayan region
- Discrimination of C3 & C4 crops and evaluation of their phenological traits using multisensors Remote Sensing data
- Geospatial modelling of soil erosion integrating InVEST model and FRN Cs137 method
- Estimation of crop area and crop yield in pearl millet using multi-sensor optical and SAR Satellite data
- Systematic biodiversity conservation planning for alpine regions of West Himalaya biographical province using geospatial approaches
- Carbon bookkeeping for large scale tropical deforestation in Eastern Himalayan foothill, North East India
- Assessing the sensitivity of Northwest Himalayan forest gross primary productivity to drought
- Assessing eco-physiological response of Alpine vegetation using climate warming experiments and modelling in the part of Western Himalaya
- Spatiotemporal variations of planetary boundary layer height using GNSS observations for the Indian region
- Spatiotemporal characterization of vegetation in Uttarakhand Himalyas
- Deep learning for weed detection and identification in standing rice crop
- In season crop classification using machine learning
- Land suitability analysis for horticulture crops in Champawat district, Uttarakhand
- Optimized multiclass strategic target detection from high resolution optical imagery
- Ship detection using full polarimetric SAR Data
- Spatiotemporal anomaly detection and visualization of Pine Island Glacier, Antarctica

- Characterization of Ladakh periglacial features as Martian analogues and evidence for climate change
- Evaluation of land subsidence potential in selected cities on Peninsular India
- Land subsidence characterization in Northwest India in relation to groundwater over-extraction, hydrogeological properties, and active tectonics
- Assessment of lithology and morphology bearing potential bio-signatures on Mars and analog environments
- Studying the impact of hydrological loading on tectonic plates movement and strain budget modeling in the Northwestern Himalaya: Insights from GRACE, SAR, and GNSS Data
- Reconstruction of paleo channel network and its significance on geomorphology, tectonics studies
- Customization & improvement of chemistry transport model WRF Chem over the North Indian region
- On the spatiotemporal patterns of PBLH and identification of the best suitable PBLH scheme for numerical simulations of heavy rainfall events over the NWH region
- Characteristics of hydrometeors & identification of the best suitable microphysical scheme for the numerical simulation of extreme rainfall over the North-West Himalayan region
- Assessing the skill of regional weather forecast through the assimilation of CrIS hyperspectral data into numerical weather prediction model
- Study on spatiotemporal variability of oxygen minimum zone in the Indian ocean
- Monitoring & modeling of methane: Investigation of emission hotspots over the Indian subcontinent
- Climatological variation of aerosol optical properties and species composition over South, East and Southeast Asia
- Radiative forcing and its influence on heatwave events in the Indian subcontinent
- Long-term of shoreline change analysis and coral reef geomorphology: A case study from Gulf of Mannar, India
- Hydrological characterization of land subsidence and damaging impacts on urban above-ground infrastructure
- Forest fuel moisture retrieval using dual polari metric synthetic aperture radar data
- Assessment of potential avalanche zones under permafrost region in part of Uttarakhand
- Impact of forest fires on the surface runoff and soil Erosion: A case study of Kosi (Uttarakhand) watershed
- Study of urban growth in Himalayan region with reference to natural hazard
- Optimizing blue-green infrastructure network using complex network algorithm in an urban landscape
- Spatiotemporal dynamics and modeling the sources of criteria air pollutants in Delhi airshed
- Application of machine learning approach to generate urban high-resolution DSM for urban canpony parameters computation
- Exploring water balance dynamics: insights from V-I-S fractions and hydrological modeling
- Leveraging UAV data for shadow pattern assessment in varying urban densities
- Synergistic use of laser scanning & photogrammetry for HBIM

- Study of local convolutional based fuzzy machine learning model for ground nut crop mapping
- Automatic extraction of built-up areas from space-borne SAR data
- Synergistic use hyperspectral and SAR data for identification of mineral properties of lunar surface
- Object based image analysis and convolution neural network for the classification of high-resolution satellite image
- PolSAR-based modelling for scattering characterization of different vegetation ecosystem
- Development of methodology for automatic registration of SAR and optical data
- Investigating contextual and heterogeneity handling in paddy crop monitoring from multi sensor temporal data
- Quantifying river pollutant dynamics using remote sensing datasets and hydrodynamic model
- Remote sensing of seasonal mars water cycle and hydrodynamic analysis of its outflows channels and valley networks
- Quantifying river-flow of paleo-channel by utilizing remote sensing derived river hydraulic parameters
- Long term hydrological assessment of aral sea basin using geospatial technology
- Quantifying the impact of various terrain conditions and dimensionality in hydrodynamic model
- Assessment of groundwater level fluctuation using machine learning and groundwater modelling
- Quantifying the melt/freeze dynamics and associated impact on health of glacier and glacier lake in upper Chenab basin
- Quantification of virtual water content and assessment of water footprint of major crops in river basin
- Parameterization of RUSLE using multi-sensor remote sensing data

M.Sc. Agriculture Analytics (Joint program of DA-IICT-IIRS-AAU)

IIRS conducted II-Semester of Joint M.Sc. Agricultural Analytics program of Dhirubhai Ambani Institute of Information & Communication Technology (DA-IICT), Gandhinagar, Indian Institute of Remote Sensing (IIRS), Dehradun and Anand Agricultural University (AAU), Anand in Private-Government Partnership mode of Education vide recent MoU dated November 29, 2021 and MOA dated December 23, 2022. The first batch of Twenty-nine students joined IIRS in Second Semester in January 2023 and completed in April 2023. The second batch of Twenty-seven students joined IIRS on 1st January 2024 and will complete their second semester in April 2024 (as part of their second semester comprising of 17-week duration).

During semester at IIRS, entire Semester module having 16 credit course with four core subjects such as Geo-data processing & Python Programing, Machine Learning, Spatial Data modeling and assimilation and Big-data Analytics supplemented with specialized module of one-week duration on Agriculture Analytics. Guest lectures by

Eminent experts were also organized to give exposure to all participants on potential of Space observations for Agricultural Analytics. Participants also got opportunity to attend the ISRS Golden Jubilee celebrations and IIRS Academia Meet. Finally, the participants underwent rigorous evaluation in form of internal and end-semester examination. They also did a pilot project work in 20 day's time on advanced topics of applications in agriculture analytics. Feedback by students reveals that this course structure will help them in getting job in emerging digital industries and start-up. More than 90% students are satisfied with academic exposure, the hospitality and stay.

Master of Science in Geoinformation Science and Earth Observation

The Master of Science (M. Sc.) in Geo-information Science and Earth Observation (specialisation/domain: Geoinformatics) is offered within the framework of Joint Education Programme (JEP) of the IIRS and the faculty of Geo-information Science and Earth Observation (ITC) of the University of Twente (UT), The Netherlands. Students follow part of the course at IIRS and another part at the Faculty ITC, The Netherlands. Students undergo research work under joint supervision of IIRS & ITC scientist/faculty. This course is targeted for those who are interested to learn remote sensing and GIS technologies and their applications. Seven M. Sc. students joined for 2023-2025 batch and undergoing required course work for this programme at IIRS-ITC. Eight M. Sc students of (2022-2024) batch are working on dissertation under IIRS-ITC Joint Education Programme (JEP).

Eight M.Sc Students of (2022-2024) batch are working on dissertation under IIRS-ITC Joint Education Programme (JEP). MSc students of this batch worked on the following research topics:

- Comparative analysis of rainfall surface generation using Deterministic, Stochastic and ML methods
- Detailed classification of urban areas using nighttime light products.
- Contrails detection
- Offline and Cross-Platform Location-Based Services for Healthcare: A Progressive Web App (PWA) approach
- Simulation of high spatial resolution hyperspectral data using Sentinel-2 Multispectral data.
- Machine Learning based modeling of SAR data for Soil Moisture Retrieval
- Integrated approach of Multi-Temporal and machine learning for monitoring of land instability
- Web-based web map quality evaluation for web map services using pixel and object-based measures

Training Programmes

The Indian Technical and Economic Cooperation (ITEC) Programme was instituted by a decision of the Indian Cabinet on September 15, 1964 as a bilateral programme of assistance of the Government of India. IIRS has been entrusted by Ministry of External Affairs, Govt. of India to organize training programmes each year under ITEC.

The ITEC Programme of the Ministry of External Affairs is an earnest attempt by India to share the fruits of its socio-economic development and technological achievement with other developing countries. Under ITEC two short-courses are conducted as follows:

GI Science and Modelling (ITEC)

A short course of three weeks duration and sponsored by Ministry of External Affairs, Govt. of India under Indian Technical and Economic Cooperation (ITEC) was organised during September 25, 2023 to October 13, 2023 wherein 19 participants from 13 countries [Burundi (2), Cameroon (2), Eritrea (1), Ethiopia (1), Ghana (1), Malawi (1), Maldives (2), Myanmar (2), Nigeria (1), Sri Lanka (2), Tajikistan (1), Tanzania (2), Uzbekistan (1)] attended the course. Course covered the concepts of earth system, introduction to Remote Sensing & Digital Image Processing, overview of geospatial technology, geographic phenomenon and its representation, spatial reference systems, GIS databases, data model and file formats, hardware and software requirement of GIS, GIS data creation, querying GIS databases, performing spatial analysis, network analysis, concepts of map making/ visualisation. Participants were also introduced to concepts of GIS data quality. Participants also got hands on experience of computer representation of different geographic phenomenon, georeferencing of toposheet, creating GIS data and editing, performed site suitability analysis using vector and raster methods, finding shortest route and service area analysis, interpolating point data, and creating map.

Geospatial Technology Applications in Hydrology and Water Resources (ITEC)

It was the first-ever ITEC special course in the thematic area of hydrology and water resources organised by IIRS during October 16, 2023 - November 03, 2023. The 16 participants from 12 countries [Bangladesh (1), Eritrea (2), Gambia (1), Kenya (1), Malawi (1), Nigeria (1), Paraguay (1), Sri Lanka (2), Syria (2), Tanzania (2), Thailand (1), Tonga (1)]; participated in the course. The participants were exposed to basics of remote sensing and GIS in the first week. In the next week, they were taught the application of geospatial technology as a whole in hydrology and water resources. In the third week, the participants were asked to carry out small pilot project of the problems and data of their own country. During the course,

the participants visited National Institute of Hydrology and Irrigation Research Institute, Roorkee for their Educational tour. Apart from the education tour, they visited Haridwar, Rishikesh, and local places of Dehradun as part of their cultural visit. The lectures were mostly conducted by the IIRS faculty and one guest lecture from ISRO headquarter was organised. The course was highly appreciated by the participants.

Remote Sensing of Geological Hazards (ITEC)

The two-week ITEC course on Remote Sensing of Geological Hazards was organised during November 20, 2023 to December 01, 2023. Seventeen participants from nine countries [Algeria (4), Dominica (1), Ethiopia (1), Malawi (1), Morocco (2), Nigeria (2), Sri Lanka (2), Syria (1) & Tanzania (3)]; working in various fields from different organisations across the globe were selected for the course. The course was designed to share experiences and educate on advanced scientific development with developing partner ITEC countries. The course is designed to include: Overview of remote sensing & GIS applications in geosciences; monitoring of volcanic eruptions and snow cover using geospatial technology; Assessment of land subsidence/mining using microwave/thermal data; Mapping & modelling of landslides using optical data/ UAV with emphasise on early warning system; Integrated application of GNSS/GRACE and geophysics for seismicity/earthquake precursor and crustal deformation study; Practical on structural elements identification, landslide hazard zonation, geophysical instruments (ERT/MASW/GPR), surface deformation and glacier snout monitoring. Also, guest lecturers Dr. Shankar K Nath from IIT Kharagpur and Dr. George Phillip from WIHG were given in the course.

Post Graduate Diploma Programme in (RS & GIS)

Post Graduate Diploma in Remote Sensing and Geographic Information Systems (RS & GIS) is approximately one-year course and this year were selected 27 participants to join the course. The participants across disciplines are as follows: Agriculture & Soils (3), Forest Resources & Ecosystem Analysis (4) Spatial Data Science (3), Geosciences (2), Marine and Atmospheric Science (3) Natural Hazards & Disaster Risk Management (3) Satellite Image Analysis & Photogrammetry (3), Urban & Regional Studies (2) and Water Resources (4). The Orientation programme for the P. G. Diploma batch happened on August 02-03, 2023 at IIRS Campus. Semester I of P.G. Diploma was completed on December 22, 2023.

Post Graduate Diploma in Geoinformation Science and Earth Observation

Post Graduate Diploma (P. G. D) in Geo-information Science and Earth Observation (specialisation: Geoinformatics) is offered within the framework of Joint Education Programmea (JEP) of the IIRS and the Faculty of Geo-information Science and Earth Observation (ITC) of the University of Twente (UT), The Netherlands. Students follow the course at IIRS. Upon successful completion of the course, students receive a diploma certificate from UT-ITC. This course is targeted for those who are interested to learn remote sensing & GIS technologies and their applications. Both the working professionals and fresh graduates (including candidates in the final semester/year) can apply for the course. This year 8 students from PGD (2022-23) successfully completed the course and 6 students joined for P. G. D (2023-24) batch.

NNRMS-ISRO Sponsored Certificate Course in Remote Sensing & GIS Technology and Applications

NNRMS-ISRO sponsored training programme is of eight weeks duration and offered in ten specialisations in technology and applications domain. The main objective of this programme is to train the university/ college teachers in RS & GIS technology and applications, so that they can further teach students in their universities/colleges. In addition to the faculty members from university/ colleges, the course is also open to faculty/Scientists/ Engineers/officials working in government organisations/institutions subject to availability of seats. AICTE has approved this course as Faculty Development Programme (FDP) in collaboration with ATAL academy. This year the course was conducted during May 15, 2023 to July 07, 2023 wherein 57 officials participated from different academic institutions and Govt. organisations across length and breadth of country. The training programme comprises of four modules, each one of two weeks duration. After completing first three modules devoted to the subjects by the various departments, each course participant carried out a pilot project in the fourth module in their respective field of specialization. Participants had opportunity to attend many expert lectures from distinguished scientists during the training period and list included guest lectures by eminent scientists and professors, including Dr. P. K. Pal (Ex-Scientist, ISRO), Prof. Santanu Banerjee (Earth Sciences, IIT, Bombay), Dr. R. D. Deshpande (Sr. Professor, PRL), Dr. Ruchi Badola (Wildlife Institute of India, Dehradun), Dr. J. S. Parihar (Satish Dhawan distinguished professor, outstanding scientist & former Dy. Director, SAC).

Remote Sensing: An Overview for Decision makers

Earth Observation satellites launched over past few decades provide us periodically synoptic and systematic information pertaining to land, ocean and atmosphere and several aspects of environment. This information is a key ingredient in

the programmes of the government at the Centre and State towards ensuring food and water security, monitoring and management of natural resources, monitoring of our environment and eco-system, forecasting weather and disaster management support, planning and monitoring of developmental activities, and information for better governance.

Geographical information Systems (GIS) using satellite images, ancillary data and models play critical role in all spheres of natural resource governance and developmental activities. Amidst all developments in Earth Observation and geospatial technology, resource managers and decision makers often wonder from where to obtain relevant data; how to process and extract relevant information; what are the constraints and time scales; how to train their working level personnel. This year the course was organized during April 10 - 13, 2023 wherein 34 officials from different academic institutions and Govt. organisations comprising of participants from Indian Administrative Services (IAS), India Forest Services (IFS), senior scientists from Research Institutions and academician.

The course aimed to provide an exposure to recent trends in geospatial technologies and its applications in governance and development with specific emphasis on natural resource management, environmental monitoring and disaster management, to senior level officers of various line departments, scientists and academicians. This course focussed on strengthening the technical skills and knowledge of senior functionaries in governance, academia, industry and entrepreneurs on geospatial technology and its applications. Lectures on Overview of Remote Sensing, GIS, Applications of Space based Technology for Enhancing Governances and Development, Remote Sensing applications in natural resource management, geological applications, Geospatial Applications in Forestry and Ecology, Geospatial Applications & Disaster management, Geospatial Applications in Urban Studies, Geospatial Applications in Agriculture and Soil, Geospatial Applications in Water Resources, Geospatial Applications in Costal and Marine, Studies, Overview on ISRO Geo-portals and data repositories, Recent Trends in Remote Sensing Applications, Remote Sensing Data products and GNSS & GPS were delivered.

Special & Customised Training Programmes

Emerging Trends in Remote Sensing and its Applications

This special short course of two week duration during April 17-28, 2024 with thirteen participants was designed for professionals/research scholars/students from different government and private organizations engaged in remote sensing technology and its application in various fields. This special short course was designed to make the participants aware about advance remote sensing technologies and their data processing and applications. The training included theoretical lectures on topics related to hyperspectral remote sensing & its processing techniques, SAR, INSAR, POLSAR remote sensing and data processing, LiDAR remote sensing and data processing, UAV remote sensing and data processing, Machine/Deep learning for remote sensing data and its applications. For the benefit of course particiapnts special lectures on GPR Data processing, Application of Hyperspectral remote sensing for Planetary Sciences, Geo-portals of ISRO (VEDAS, Bhuvan, Bhoonidhi and MOSDAC) and Demonstration on Google Earth Engine was also organised. Demonstration of practical exercises on hyperspectral, SAR, LIDAR, UAV data processing were included as part of the curriculum. Demonstration on Terrestrial Laser Scanner was conducted and a field exercise for spectral data collection using ground spectro-radiometer was also conducted.

Geoinformatics for Field Foresters

This one-week training course for RFO trainees was organized during April 24-28, 2023 with fifty-seven RFO trainees from eight different states across country. The target of the course was to sensitize the course participants to the basic concepts of RS, GIS, and GNSS technology and how it can be used for the effective management of forests and its resources. Exposure to different satellite data and their sources, creation, and handling of different geospatial data using different software was demonstrated to enable the RFO trainees to harness the potential of geospatial technology in their field. The course comprises lectures, practical hands-on, and field visits. Twelve (12) lectures on diverse topics including basic of RS, GIS, and GNSSS; Aerial remote sensing in forest survey; Mapping of vegetation type, community, and dominant species; Sampling design consideration for plant diversity, phytomass, and NTFPs inventory; Forest height, growing stock, biomass and carbon sequestration; Soil and water conservation planning in forested watersheds; Forest fire vulnerability, monitoring and impact assessment; Wildlife habitat suitability, corridor connectivity, and ranging patterns; Geoportals and database in support of forestry sector schemes were delivered during the training program. Guest faculty were invited to deliver lectures on special topics during the one-week training. Practical demonstrations were also a core component of the training program, a total of 14 practical sessions were conducted during the course, including Basic GIS operations of vector and raster layers; Digital stratification of forest type and density; Topographical analysis of forested watersheds; Forest burnt area and severity estimation; Ecological niche modeling of RET species; Multicriteria geospatial modeling for wildlife habitat suitability and forest survey using DGPS.

YUVIKA 2023

Two weeks, Yuva Vigyani Karyakram (Yuvika) course for school children to impart basic knowledge on Space Technology, Space Science and Space Applications was organisd during May 15-26, 2023. The course aims to encourage younger students to pursue career in space science and technology. A total of 350 participants studying in class IX and X were selected for the program by ISRO out of which of 47 students from three states (Himachal Pradesh, Uttarakhand and Punjab) and two union territories (Jammu& Kashmir and Ladakh) joined program at IIRS. The course is simultaneously conducted at seven ISRO centres throughout the country. A two week exhaustive schedule consisting of lectures, practical sessions was conducted. The course content included topics related to space science, Indian Space program, ISRO planetary missions and Applications of space technology and Drone technology. Special sessions by eminent scientists such as Dr. R.P.Singh, Director IIRS, Dr. Kalachand Sain, Director, Wadia Instiitute of Himalayan Geology, Dr. Y.V.N.Krishnamurthy, Registrar, Indian Institute of Space Science and Technology, Dr. Dipankar Banerjee, Director, Aryabhatt Research Institute of Observational Sciences. The practical sessions included preparation and launch of water rocket, model rocket, CANSAT and Wireless Rover. Demonsrations on satellite tracking, Geoportals and Remote Sensing Instruments were also conducted. Special interactive session was conducted live from India's Antarctic research station. Apart from academic activities, extracurricular activities such as Yoga, Meditation, Outdoor/ Indoor sports, Bird watching and cultural activities were also included in the curriculum. To sensitise the participants about environment and science visits to Rajaji National Park, Forest Research Institute and Vigyan Dham were also conducted. To inculcate a feeling of national pride, participants were taken on a visit to Indian Military Academy.

Summer School on Usefulness of Remote Sensing & GIS for Environmental Studies

Since last 11 years, IIRS is conducting this special course for school students from 10th to 12th standard. The aim of the course is to create an awareness about remote sensing technology & its use for the study of earth and its environment among the school students. This year, the course was organized from June 19 - 23, 2023. Eighty three students from 45 different schools of Dehradun and other parts of the country participated in the course. Broad subjects covered in the course are: Overview of Indian Space Programme, benefits of Space Science to Mankind, ISRO Launch vehicles and satellites, Physics behind the Rockets and satellites, basics of remote sensing, basics of GIS, Tsunami and its impact on coastal zones, RS & GIS applications in ecology, geological studies, hydrology, agriculture, soils, forestry, atmosphere and urban studies. The talks on Careers in Space and Satellite remote sensing of planetary surfaces were also organized. Practical demonstrations were also arranged to familiarize the students with satellite images for land & atmospheric studies and various satellite data portals. There were also demonstrations on Model Rocket Launch and Wireless Rover. A visit to Space Exhibition was also the part of the programme. Videos on Indian space programme were also shown to the students.

Hyperspectral Remote Sensing for Mineral and Hydrocarbon Exploration

One-week short course was organised during July 10-14, 2023 with eight participants. The course was targeted at researchers/ working officials and students of the Earth sciences discipline. The lectures covered the basics of hyperspectral remote sensing, hyperspectral sensors, hyperspectral data quality and its end-to-end processing, spectral characterisation of minerals, and rocks and its mapping. The compositional analysis of Lunar and Martian rocks was also discussed. The persons pioneered in the field of hyperspectral remote Sensing field namely, Dr. Arindam Guha, Scientist, RRSC, Kolkata, and Dr. Aashish Misra ONGC, Silchar, Assam shared their expertise with the students and delivered the lectures on Hyperspectral Remote Sensing for Minerals Exploration and the Role of Hyperspectral Remote Sensing for Hydrocarbon Exploration, respectively. The students also used an ASD field Spectroradiometer during their practicals to understand the reflectance spectra of minerals and rocks. Overall, the participants rated the course as excellent to very good and requested to increase the duration of the course.

SAR Data Processing for Land Deformation Studies

A special course was organised during July 31, 2023 to August 11, 2023 for the researchers/ scientists/ Ph.D scholars / working level professionals in the field of SAR remote sensing wherein 22 participants joined the course from 20 institutions across the country, namely NCEGR-GSI, Faridabad, CSIR-CBRI Roorkee; WIHG, Dehradun, Anna University, Ariyalur, WCL (CIL), Nagpur; CWRDM, Kerala; CSIR-NGRI, Hyderabad, VIT, Vellore, RPS, Degree College Mahendergarh; CSIR-NIO, Goa; AMU, Aligarh; IIT Guwahati; PRMSM, Bankura University; University of Allahabad; Central University of Haryana; IIST, Thiruvananthapuram; Central University of Punjab; SHUATS, Prayagraj; and Bangabasi College, Kolkata. The overall objective of this two weeks training programme was to generate critical understanding among participants on SAR data processing for various land deformation studies. The participants were familiarised with SAR concepts, SAR interferometry (InSAR), various advanced InSAR techniques, SAR data processing in open source software environment (ISCE, SNAP, Mintpy and StaMPS), land deformation time-series, graphical data analysis.

RS & GIS Applications in Agricultural Water Management

A two-week special course was conducted during August 21, 2023 to September 1, 2023 wherein 19 participants were selected. Concept and principles of geospatial technology, fundamentals of Agricultural Water Management, Fundamentals of ET and Instrumentations, Crop Inventory & Mapping, RS Modelling based ET Estimation, Irrigation Water Requirement, Crop Water Stress Assessment and Crop Yield Modeling were covered through theory as well as practical classes besides the special/ guest lectures on spatial decision support system and irrigation advisory services, UAV for agricultural water management and geoportals & bio-geophysical products for water management. A field campaign was coordinated to give hands-on training about instrumentation for crop observations and operational handling of instruments. During the field visit, the field based observatory of eddy covariance tower set-up was illustrated and showed the potential use of this sophisticated instrumentation. With this, a memorable interaction with Padma Shri awardee farmer Dr. Sethpal Singh Ji and course participants was also much praised by everyone.

Applications of Remote Sensing and Geographical Information System in Water Resources

A course on Applications of Remote Sensing and Geographical Information System in Water Resources sector as part of 33rd Induction Training Programme for Group-A Probationary Officers of CWES, CWC, Government of India was organised during August 28, 2023 to September 01, 2023 at IIRS in association with National Water Academy wherein 08 participants attended the course. During the course, the participants were exposed to basics of remote sensing, Platform and Sensors; Spectral Signature of Different Land Surface Features, Visual Image Interpretation, Digital Image Processing, etc. A day was entirely dedicated to the GIS Technology, where the overview of geospatial technology, GIS Data models, concepts of map projections were covered. Last three days, the participants were trained in the applications of RS and GIS in water resources starting from quantification of hydrological elements, concepts of watershed, digital elevation model and its applications in water resources; water body and water quality mapping; water level retrieval and reservoir sedimentation; flood inundation mapping, damage assessment, hydrological modelling for flood peak estimation and hydrodynamic modelling were taught. Apart from these lectures, the hands-on practical were conducted on the selected topics. The participants visited Tehri dam as part of their field work.

Microwave Remote Sensing for Geological Applications

A one-week special course was organised during September 11–15, 2023 wherein 10 people participated in the course. A systemic approach was used in which first the basics were covered and then advanced InSAR, PolSAR, DInSAR techniques were discussed using an application intensive perspective. Registration, co-registration, Geocoding and its applications were also taught. Microwave Remote Sensing applications in Water Resources and Hydrology, Mining, Glacial Dynamics, Process Modelling, Improved Terrain Mapping, Planetary Science etc. were elaborately discussed. Ground Penetrating Radar principles, data processing and applications were also covered. All the lecture topics were extremely informative and captivating for the participants. A guest lecture by Mr. Deepak Putrevu from SAC was also arranged for the participants on the hot topic of the upcoming NISAR mission. Hands on sessions are essential to the spirit of any body of knowledge and as such these were carefully thought out and incorporated into the course. SAR data processing and visualisation for geological feature extraction, both basic and advanced DInSAR processing (SBAS, PSInSAR) for displacement map generation were demonstrated to the participants. Hands on practical for SAR data processing using EOS-04 data and glacier facies mapping using microwave SAR backscatter were also conducted. A lecture and practical by Mr. Parikshit Parashar from SAC, Ahmedabad was also arranged on Chandrayaan-1 MiniSAR and Chandrayaan-2 DFSAR data analysis.

RS & GIS Applications in Hydrological Modelling and Data Assimilation

A two-week special course was organized from October 03-13, 2023 wherein 16 participants including researchers, officials and academicians from different research organizations, universities, and government officials were shortlisted out of 145 applications. During the course, the participants were exposed to basics of remote sensing, Platform and Sensors; Data Sources, Formats & Handling; Spectral Signature of different Land and Water Surface Features, Visual Image Interpretation, Digital Image Processing, etc. A day was entirely dedicated to the GIS Technology, where the overview of geospatial technology, GIS Data models, concepts of map projections were covered. Further, participants were made aware of the innovations & progress in Remote Sensing for Hydrological and Hydrodynamic Modelling; Data Assimilation Techniques and their Applications in Water Resources; Assimilation of Remote Sensing Derived Variables and Parameters in Hydrological Model, etc. The lectures delivered were supported by videos & demos. A field campaign was coordinated to give hands-on training about instrumentation for water level and water quality observations and operational handling of instruments. During the field visit, the field based soil & water conservation observatory was illustrated and showed the potential use of several ground based instrumentation. Overall, the participants rated the course as excellent to very good and requested to increase the duration of the course.

Remote Sensing & GIS in Predictive Soil Mapping

A special course of two weeks duration was organised during October 09 - 20, 2023 wherein twenty government sponsored candidates representing various research organisations as well as universities across the country attended the course. The course content was designed to give them wide exposure of applications of Remote Sensing and GIS technologies for soil survey and digital soil mapping and comprising of lectures, hands-on practical exercises, and field visit for data collection. The major topics covered during lectures were: Introduction to RS, Data Analysis and GIS; Soil-landscape Analysis, Overview of Predictive Soil Mapping, Environmental Covariates, Spectral Indices for soil studies, Application of machine learning/ geostatistical techniques for soil mapping, role of spectroscopy for DSM as well as global soil web resources and databases available for soil mapping. Senior scientists from ICAR-IASRI, New Delhi and IIT, Kharagpur delivered invited guest lectures on the topics such as Statistical Measures for Sampling and Accuracy and Proximal Soil Sensors for Digital Soil Mapping, respectively for the benefit of the participants. Hands-on exercises were carried out on different above mentioned topics and a one-day field visit was carried out in Bidholi and surrounding area for identification of soils in the field and study of the soil-landscape relationship using RS data.

Satellite Image Analysis and Photogrammetry

The special short course of one-month duration was organised during October 16, 2023 to November 10, 2023. The training was designed for the frontline personnel from Tamil Nadu Biodiversity Conservation and Greening Project (TBGP), Forest Department, Chennai; wherein five participants including one forest range officer and four foresters attended the course. This special short course was designed to make the participants aware about remote sensing technologies and their data processing and applications. For the benefit of course participants, special lectures on Hyperspectral Remote Sensing, Introduction to LiDAR Remote Sensing with TLS & Data processing, PolSAR Data processing for forestry applications, Temporal data processing for forest species mapping, Basic Geodata processing in Python and Geodata access through geoportal was also organised. Demonstration of practical exercises on satellite data processing, hyperspectral, PolSAR, LIDAR, Raster/Vector data handling in Python and Hands on Geoportal were included as part of the curriculum. Demonstration on Terrestrial Laser Scanner was conducted and a field exercise for spectral data collection using ground spectro-radiometer was also conducted. At the end of all the lectures and practical, a small case study was also carried out by the participants in groups on utilisation of remote sensing data for forestry applications and change detection analysis.

Geospatial Inputs for Enabling Master Plan Formulation

This two week training programme was conducted from during January 22, 2024 to February 02, 2024 and was attended by twenty middle level officials of town planning and valuation department, Government of Maharashtra, Maharashtra. Lectures were delivered to the course participants on basics of remote sensing and GIS, survey techniques, navigation systems, digital image processing, mobile apps for field data collection, close range photogrammetry etc. The course participants were also taught about drone survey planning, data acquisition and data processing, geospatial and drone data policies in India and DGCA guidelines.

Lectures were also delivered on the application of these geospatial techniques in various aspects of urban planning namely site suitability analysis, urban green spaces, etc. Guest lecture from officials of Ministry of Housing and Urban Affairs (MoHUA) was organized on topic "Government initiatives for urban development" and a field visit to IIT Roorkee was also conducted. The lectures were augmented with corresponding practical's and demonstrations. The feedback from course participants indicated that the participants were satisfied with the course structure, quality of course material and the training would be useful in their present nature of job.

Short Course on Remote Sensing and Image Analysis (C-RS)

A Short Course on Remote Sensing and Image Analysis (CRS) was organized from January 15, 2024, to March 8, 2024. 19 Participants had participated in this short course. It had 1 Indian Government sponsored trainee and 18 self-financed Indians.

The primary objective of this course was to enhance the capacity of middle-level professionals in the field of remote sensing with special emphasis on the processing of remotely sensed data using digital image processing techniques.

This course of 8 weeks duration was designed in such a way that it offered a blend of the latest technology and conventional techniques. It covers the basic and advanced concepts of Remote Sensing and Digital Image Processing. These topics were covered in theory classes followed by practical demonstrations & field visits. On the view of new space open data policy, the participants have also been given exposure on Bhoonidhi webportal for downloading the free data from Indian remote sensing optical and SAR sensors. There was also a 2 week project in this course and total 12 projects were done by the course participants in groups and individually on different topics.

Remote Sensing and GIS Technology for Disaster Management

One-week special training programme was sponsored by National Statistical System Training Academy (NSSTA), Ministry of Statistics and Programme Implementation, Govt. of India. The course was commenced on February 5, 2024 and successfully completed on February 9, 2024. In this course in-service officers of Subordinate Statistical Services were nominated by NSSTA wherein 24 officers (12 Senior Statistical Officers and 12 Junior Statistical Officers) from 6 states joined the course. Out of 24 participants, 16 were from New Delhi, 3 from Odisha (Bhubaneshwar, Sambalpur, Cuttack), 2 from West Bengal, 1 from Uttar Pradesh (Lucknow), 1 from Jharkhand (Dhanbad), and 1 from Assam (Guwahati). The overall objective of this one-week training programme was to generate awareness among the in-service officers of subordinate statistical service on remote sensing and GIS technology and its applications in the field of disaster management.

The entire course was focused on the concepts of remote sensing and GIS technology, disaster management and applications of space technology in the field of disaster monitoring and management. The course was designed with theory lectures, practical demonstrations, field trips and demonstration of web-portals. Varied topics were covered during the course followed by the half-day field trip to Mussoorie. All participants found course to be meeting the objectives, relevant, well-structured, nicely organized and very useful to their current nature of job.

Geospatial Inputs for Enabling Master Plan Formulation (AMRUT Tier-3) program

This AMRUT Course (Tier-3 program) for TCPO Officials was organized during February 12, 2024 to March 08, 2024 which was attended by nineteen officials from Town Planning & Valuation Department Maharashtra State, Pune. The course comprised of lectures covering essential topics related to AMRUT program, Government Initiatives, Survey techniques, Navigation Systems, Coordinate systems, Basic principles of Remote sensing, image interpretation, Digital Image Processing and Mobile mapping for field data collection, GIS and GIS based analysis, GIS data portability across various platforms like Auto CAD to GIS, Base Map preparation as per AMRUT guidelines, Suitability Analysis, 3D urban applications and LiDAR data, Urban Sprawl and Growth Modelling, Utility mapping and GPR, Basic concepts of UAV and its application in urban studies. There was one expert lecture in online mode on Government Initiatives for Urban Development by Shri. Monis Khan, Town & Country Planner, TCPO, Delhi.

One-day field to IIT Roorkee was organized, featuring a lecture and demonstration by Prof. Kamal Jain on drone surveying, flight planning, data acquisition, and processing. This excursion proved valuable for town planners seeking deeper understanding of drone survey techniques and data processing methods. The batch was divided into four groups to complete a mini-project which the participants completed successfully.

The course had hands on sessions on exposure to ISRO Bhuvan portal, Mobile Apps and server configuration, demonstration of Total Station and DGPS, Georeferencing, image enhancement, geodatabase preparation and base layers generation, building footprint extraction and land use map preparation, utility mapping, CAD to GIS conversion and map composition, UAV data processing, and green space proximity analysis.

Advance Remote Sensing & GIS and its Application in Water Resources

Based upon the request from Rajasthan State Water Informatics Centre, Water Resources Department, Government of Rajasthan to conduct special training course for their 20 officials under National Hydrology Project during 2023-24, the course was conducted during February 26, 2024 – March 08, 2024 wherein nineteen participants attended the course at IIRS Dehradun. The course syllabus was designed mutually considering the problems of the Rajasthan State. During the initials 02 days of the course, the participants were exposed to the basics of remote sensing and GIS through lectures and hands-on exercises. Later, the participants were taught retrieval of rainfall, mapping of water spread area, soil moisture, evapotranspiration using remote sensing data along with role of digital elevation model in water resources. Further, the advance applications of the geospatial technology in water resources management such as river flow modelling, soil erosion, sediment yield modelling using hydrological models. The course participants exposed to reservoir sedimentation, land degradation, site suitability for water harvesting assessment. Dedicated lectures on urban hydrology were also conducted for the benefit of the participants. Specialized topics namely drought monitoring and assessment; and ground water targeting were also covered. Each day practical exercise on the relevant topics were conducted. The field demonstration of various hydrological instruments was also organized at Asan watershed. A one-day field excursion to Mussoorie was also arranged. The participants provided very high feedback to the course.

Remote Sensing & GIS in Soil Mapping

A Special Course entitled "Remote Sensing & GIS in Soil Mapping" of 01-week duration was conducted during March 11-15, 2024 with twenty participants on request from Soil and land Use Survey of India (SLUSI) comprising of Assistant Field Officers sponsored from different centres of SLUSI across the country attended the course.

The course content was designed to give them wide exposure of application of Remote Sensing and GIS technologies for soil survey and soil mapping and comprised of 07 lectures, 05 hands-on practical exercises and 01 field visit for data collection. The major topics covered during lectures were: Fundamentals of RS, GIS and GIS software; Land use Land cover (LULC) mapping, Soil Resource inventory using RS data, Digital Terrain analysis, RS based Soil Quality Assessment and Land Use Planning as well as concept and approaches of Digital soil mapping.

Hands-on exercises were carried out on different above mentioned topics and a one-day field visit was carried out to Mussoorie and surrounding area for identification of soils in the field and study of the soil- landscape relationship using RS data.

At the end of the course, all participants found the course highly relevant to the current job and very useful in executing their job more efficiently in future. They have also requested for continuing the course in coming years.

Application of Remote Sensing & Geographical Information System in Hydropower Projects

Based upon request received from the North Eastern Electric Power Corporation Limited (NEEPCO), Shillong, Meghalaya, and Satluj Jal Vidyut Nigam (SJVN), Shimla, Himachal Pradesh, to conduct a specialized training course for 20 of their officials (10 from each organization) during 2023-24. The aforesaid course was during March 18-22, 2024 with twenty participants. The course syllabus was collaboratively designed to address the specific challenges faced by NEEPCO and SJVN. The initial 1.5 days focused on introducing participants to the basics of remote sensing and GIS through lectures and hands-on exercises. Subsequent sessions covered topographic surveying using high-resolution satellite data, mapping and monitoring of water bodies and glacial lakes, and additional practical exercises. Advanced applications of Digital Elevation Models (DEM) in water resources, the basics and modeling aspects of Glacial Lake Outburst Floods (GLOFs), and site suitability assessments for hydropower projects were also discussed. The participants were further introduced to reservoir sedimentation and given demonstrations on flood modeling and damage assessment. Dedicated lectures on the fundamentals of Land Use Land Cover (LULC) classification and catchment delineation were provided. Practical exercises relevant to each topic were conducted daily, and a field demonstration of various hydrological instruments was organized. The participants gave highly positive feedback on the course and recommended follow-up course.

Outreach Activities

With the rising trend and increasing popularity of online learning, especially after the emergence of a global pandemic, distance learning – along with new information technology, has been adopted extensively by educational and training institutes. Over the past few years, the Government of India through its policy of Digital India, has been promoting such endeavors to popularize digital leaning environment. Distance Learning Program (DLP) offered by Indian Institute of Remote Sensing (IIRS), Indian Space Research Organisation (ISRO), is an innovative initiative for training students and professionals from academia and user departments in the field of Geospatial Technology & Earth Observation. IIRS DLP started in the year 2007 with 312 participants from twelve universities in India. Till date, IIRS has successfully conducted 140 outreach programmes through live and interactive classroom mode (also known as EDUSAT programme) benefiting more than 8.0 lakh participants from 3565 network Institutions distributed across the country. During April 2023 and March 2024 around 2.64 Lakh participants got benefitted by various programs conducted under IIRS Distance Learning Program. The present outreach programme is being conducted through following two major modes:

- Live and Interactive classroom Programmes
- E-learning or Massive Open Online Courses (MOOC).

1. Live and Interactive classroom Programmes

IIRS uses internet based digital platform for conducting live and interactive online courses to primarily complement the educational programmes of the Indian Universities/Intuitions. During April 23 - March 24, IIRS has conducted total 31 online courses/full day workshops/webinar series benefiting 156262 participants from 1423 networked Institutions. IIRS has conducted 13 advanced topic courses, 10 basic courses, 6 full day workshops, 2 special customized courses. A total of 1.56 Lakh participants participated in IIRS online courses in from 1423 unique institutes across the country. The courses offered covered a wide range of topics like Basics of Remote Sensing and GIS, SAR Data Processing & its Application with Special Emphasis on RISAT-1A/EOS-4, Overview of Free and Open Source Software for Geospatial Technology (FOSS4G), Application of Geomatics in Urban Disasters, Applications of Machine learning in Urban Studies, Space Technology & Applications, Geospatial Technology for Climate Smart Agriculture, Overview of Space Science and Technology (START Programme), Geospatial Technology for Archaeological studies, Satellite meteorology applications in weather and climate studies, Integration of ground-based in-situ observations/ measurements with EO data for enhanced Geological Applications: Advantages and Challenges, Monitoring Forest Disturbances using Geo-spatial Technology, Remote sensing based data analytics in Agriculture, Automated Feature Extraction from High Resolution Images, Geo-data sharing and Cyber Security, Eddy Covariance Technique for Ecosystem Studies, Geodata Processing using Python, Exploring Earth's Moon through Chandrayaan, Geospatial Analysis using Google Earth Engine, Advances in Remote Sensing Techniques for Geological Applications, Aditya L1: India's first space-based observatory, Soil Health : Measurement & Modelling, A special course on Overview of Space Technology was also conducted in Hindi language for the benefit of Hindi speaking participants. All the courses of IIRS DLP are made available through in-house developed Electronic Collaborative Learning and Knowledge Sharing System (E-CLASS) platform. The status of total benefiting participants is given in Table 1.

Table 1: Courses conducted in 2023-24

Sl. No.	Courses	Institutions	Participants
1	SAR Data Processing & its Application with Special Emphasis on RISAT-1A/EOS-4	473	2275
2	Overview of Free and Open Source Software for Geospatial Technology (FOSS4G)	656	4258
3	Application of Geomatics in Urban Disasters	446	2492
4	Applications of Machine learning in Urban Studies	1063	8852
6	Space Technology & Applications	1	809
7	Geospatial Technology for Climate Smart Agriculture	851	6822
9	Overview of Space Science and Technology (START Programme)	257	32847
10	Geospatial Technology for Archaeological studies	429	1691
11	Satellite meteorology applications in weather and climate studies	580	2731
12	Integration of ground-based in-situ observations/ measurements with EO data for enhanced Geological Applications: Advantages and Challenges	793	4221
13	Basics of Remote Sensing, Geographical Information System and Global Navigation Satellite System	871	9301
14	Remote Sensing and Digital Image Analysis	492	3428
15	Overview of Space Technology (course in hindi)	689	4909
17	Overview of Global Navigation Satellite System	543	3924
18	Monitoring Forest Disturbances using Geo-spatial Technology	273	1603
19	Overview of Geographical Information System	368	2249
20	Remote sensing based data analytics in Agriculture	617	4800
21	Overview of Geocomputation and Geo-web services	485	2717
22	RS & GIS Applications in Natural Resource Management	882	8559
23	Automated Feature Extraction from High Resolution Images	506	3115
24	Geo-data sharing and Cyber Security	888	8804
25	Eddy Covariance Technique for Ecosystem Studies	558	3729
26	Geodata Processing using Python	1189	10177
27	Exploring Earth's Moon through Chandrayaan	609	4792
28	Geospatial Analysis using Google Earth Engine	852	7045
29	Advances in Remote Sensing Techniques for Geological Applications	538	4385
30	Aditya L1: India's first space-based observatory	494	3394
31	Soil Health : Measurement & Modelling	251	2333

2. E-learning or Massive Open Online Courses (MOOC).

It is essential to create eLearning content that arouses the curiosity of learners and keeps them engaged for the entire duration of the course. At the same time, the content needs to be relatable to your target audience and ensure long-term knowledge recollection.

To enhance the outreach of geo-spatial science and technology, IIRS has also developed e-learning contents and Learning Management Systems (LMS) for different certificate courses in Remote Sensing and Geo-spatial Technology and its applications. E-learning is an active learning platform which provides learner centric online courses to the online learners. It provides a platform where the individual gets a customized package related to key thematic areas, through a computer-guided process. The learning is made available through interactive 2D and 3D animations, audio, video for practical demonstrations, software operations with free and open data sources. The e-learning contents are created as an interactive multimedia application and integrated with customized LMS using open source Moodle platform. The most attractive part of these online courses are "learning anytime from anywhere". The learners can join these course any time and can complete the course with self-pace.

Currently, more than 29,000 participants have registered for these courses out of which 4178 participants have opted for certificate. The courses contents of RS&GIS technology are also available in Hindi language. To expand the scope of E-Learning from technology to application of technology in thematic disciplines, e-Learning content for eight thematic disciplines demonstrating applications of geospatial technology were prepared. The developed thematic contents are organized in form of e-Learning courses and made available to the learners through IIRS e-learning portal. A total of 11 courses on advanced topics are ready and will be soon available to users.

IIRS eLearning course "Comprehensive course on Remote Sensing and GIS" was approved by All India Council for Technical Education (AICTE) as a 04 credit course and made available on SWAYAM portal of MHRD. The course was conducted twice during 2023-24, one in each academic semester In the year 2023-24, around 17,000 participants were registered for the course through SWAYAM portal. The examination was conducted by National Testing Agency and around 350 participants successfully completed the first course and received certificate from AICTE. Results for second course are still awaited.

To cater to the needs of International participants, IIRS is conducting International Distance learning programme under "ISRO-IIRS Space Application Training (ISAT)" programme The International Outreach Programme is targeted to impart the training to Student community-Undergraduate, Post graduate and PhD scholars; Scientist and Researchers; and Governmental users from SAARC and Asia Pacific countries. Total 84742 participants from 115 countries have registered for the course. IIRS has developed online learning platforms and LMS for ISAT programme and made available to the learners through URL-https://isat.iirs.gov.in . The home page for ISAT LMS are shown in Figure 1.

Table 1: Courses conducted in 2023-24

	Remote Sensing for Natural Resource Studies- For school students.	Advances in Geospatial Techniques for Monitoring and Modelling Hydro-meteorological Disasters	MOOC on "Earth Observation for Climate Action"
Course Start Date	June 12, 2023	July 17, 2023	September 15, 2023
Course End Date	June 23, 2023	July 28, 2023	October 14, 2023
Total Registration	1945	426	2476
Total Certificate issued	274	63	467
No. of Countries	15	11	64

In the year 2023, IIRS conducted ISRO Space science and Technology Awareness Training (START) for the Post-Graduate and Final Year Undergraduate Students in collaboration with science Programme Office, ISRO HQ. the program was conducted during July 20, 2023 – August 20, 2023. A total of 35099 participants registered for the program out of which 32842 were approved and around 7000 participants successfully completed the course and were awarded certificates. 22 number of sessions were conducted by eminent speakers from ISRO and academia. The course included sessions on basic and advanced topics such as India's Space Exploration Endeavour, Space observations of Geosphere - Biosphere – atmosphere interactions and climate, Introduction to Cosmic Rays, Earth's Ionosphere, Magnetosphere etc.

IIRS has designed and developed an Online Learning and Knowledge Sharing System "Antriksh Jigyasa" under ISRO STEM program. The portal is an active learning virtual platform which offers self-paced online courses to the learners on space science, technology, and its applications. It consist of six major verticals viz. Shiksha Gagan, Space Varta, Sky-Picks, Antariksh Navachar, Space Quiz and Space Park. In the said duration, the portal was enhanced further for incorporating the automation of various courses and workshop within the portal. It was fully utilized during the ISRO-START, YUVIKA, SSA programs conducted by ISRO HQ. A module was integrated into it for conducting quizzes on special occasions like launch of Chandrayaan and Aditya L1. In the year 2023, five Space Vartas by eminent scientists of space domain have been conducted through this portal namely on Applications of Space Technology in Oceanography, Basics of Satellite and Oceansat-3 Realization & Challenges, Journey to the Unknown: Scientific Quest for Chandrayaan-3 at the Moon, Challenges in Lunar Landing, Science and its role in building civilization as well as its role in growing economies. The home page for Shiksha Gagan are shown in Figure 2.

CSSTEAP Activities

Dr. R. P. Singh, Director, IIRS took additional charge of Director, CSSTEAP w.e.f. October 09, 2023 (vide OO No. SC/CH/A.22/125/2023 dated October 6, 2023).

Governing Board Meeting

The 28th meeting of the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) Governing Board (GB) held at ISRO Headquarters, Bengaluru, India on December 12, 2023.

Brief list of courses organised during 01.04.2023 – 31.03.2024

ONLINE SHORT COURSES	Start Date	Concluding Date	Participants (with Country)
Online Short Training course on "Planetary Science "	15.05.2023	19.05.2023	46 (07)
Online Short Training course on "Solar Physics "	22.05.2023	26.05.2023	73 (11)
Online Short Training Course on "Use of Space Technology for Weather and Climate Studies"	22.05.2023	02.06.2023	34 (11)
Online short course on "Open-Source GIS Technology and Geoweb Services"	04.09.2023	15.09.2023	32(5)
Online Short Training Course on "GNSS: Advanced Technologies and Applications"	28.11.2023	08.12.2023	29(9)
Online short course on "SAR Data Processing and its Applications"	04.12.2023	08.12.2023	20(06)
Online short course on "Space Laws and Policy"	04.12.2023	08.12.2023	56(10)
Online Short Training course on "Fuzzy Machine Learning and Deep Learning for Remote Sensing Data Classification "	11.12.2023	15.12.2023	23(07)
Online Short Training course on "Overview of Web GIS "	18.12.2023	29.12.2023	
OFF LINE SHORT COURSES	Start Date	Concluding Date	Participants (with Country)
Short Training course on "Geospatial Application in Disaster Risk Reduction for Environmental Disaster (Forest Fire, Heat Wave and Atmospheric Pollution)"	17.07.2023	28.07.2023	25 (13)
Short Training course on "Remote Sensing Data Acquisition"	21.08.2023	01.09.2023	14 (07)
Short Training course on "Remote Sensing Data Processing"	09.10.2023	20.10.2023	16 (07)
Short Training course on "Small Satellite Mission"	04.12.2023	15.12.2023	20 (10)
ONGOING PG COURSES	Start Date	Concluding Date	Participants (with Country)
27th PG course in Remote Sensing & Geographic Information System at IIRS	01.09.2023	31.05.2024	18 (10)
13th Post Graduation Course in Satellite Meteorology at SAC, Ahmedabad	01.09.2023	31.05.2024	08 (04)
13th Post Graduate Course in Space in Atmospheric Science at PRL, Ahmedabad	01.09.2023	31.05.2024	11 (04)
06 Meritorious participant from PG courses completed his M.Tech degree			

For further details please refer CSSTEAP website: https://www.cssteap.org

Research Activities

Earth Observation and Applications Mission
1. Retrieval of Geo-physical parameters using GNSS/IRNSS signals
ISRO- Geosphere Biosphere Programme
2. Carbon Dynamics Assessment in Tropical Forests of Northeast India using Multi-sensor Data
3. Aerosol Radiative Forcing Over India (ARFI)
4. Soil & Vegetation Carbon Flux (SVF)
5. Spatio-temporal variations of gases air pollutants over the Indian subcontinent with a special emphasis on foothills of North Western Himalayas
6. Understanding the impact of climate and its Variability on Hydrological Fluxes vls-a-vis Water Availability for sustainable Development
Disaster Management Support Programme
7. IIRS-Advance Studies (AS)
8. IIRS-Advance Building (CB)
In- House R&Ds
9. Continuation of Long Term Surface Energy Balance Studies for North-West Himalayan Agro- eco system using Large Aperture Scintillometry
10. PolSAR-based modeling for scattering characterization of different components of forest vegetation
11. Land Deformation Detection from Space: A Persistent Scatterer Interferometry and SBAS Approaches
12. Assessment of the Seasonal Water Level Variations Based on Hydrological Sensitivity Analysis of Time-Series SAR Backscattering Coefficients in conjunction with DEM and Gauge Data
13. Automated detection of rock glaciers in Western Himalaya, India
14. Advanced Technique Development for River Discharge Estimation using Multi-Sensor Approach
15. Machine Learning based extraction of Urban Canopy parameters using Cartosat Datasets
16. Proximal Remote Sensing for Digital Soil mapping of Nutrients and Heavy Metals
17. Multi-satellite observations based assessment of river and lake bathymetry for hydrodynamic studies
18. Provenance and process of formation of highland anorthosite and mare basalt of the Moon from the study of selected lunar analogues in India by spaceborne and in situ spectral analysis
19. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II)
I. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – I: Geodynamics of Himalaya and Earthquake Precursor Studies

II.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – II: Strengthening Vegetation Phenology-Productivity and Climate Linkages in North-West Himalaya
III.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – III: Climate and Ecosystem Response Studies through Long Term Ecological Research Stations (LTERS)
IV.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – IV: Soil Erosion Estimation based on Radio Tracer Technique and Soil Quality Assessment in Mountainous Landscape of North-West Himalaya
V.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – V: Monitoring and Modeling of Hydrological Processes in Glaciated and Non-Glaciated Water sheds of North-West Himalaya
VI.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – VI: Modeling Temporal & Spatial Growth of North-West Himalayan Cities
VII.	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – VII: Observational and Simulation Study of Extreme Rainfall Over the North-West Himalayan Region
20.	Assessment of the impact of Hyperspectral Infrared Sounding Observation Assimilation on Regional NWP Model Forecasts
Other Project	
21.	Geo Ladakh: SDI for UT Ladakh
22.	NMHS: Himalayan Alpine Biodiversity Characterization and Information System-Network
23.	USDMA funded Satellite Based Mountain Hazard Assessment and Monitoring (MHAM) in Uttarkhand
24.	Geo-Ganga: Space Based Mapping & Monitoring of Ganga River

Carbon Dynamics Assessment in Tropical Forests of Northeast India using Multi-sensor Data (IGBP-CAP)

Tropical forests play a crucial role in maintaining global climate balance by storing significant carbon stocks. However, the rate of tropical deforestation remains alarmingly high, contributing to carbon emissions and threatening ecosystems. Northeast India, with unique ecological characteristics, have experienced significant deforestation due to agricultural expansion, shifting cultivation, urbanization, and illegal logging. The rapid deforestation threatens critical carbon sequestration and biodiversity, underscoring the urgent need for conservation. Hence, to address this issue, this project aims to assess forest carbon dynamics under two disturbance scenarios: large-scale deforestation and shifting cultivation. Understanding the impact of large-scale deforestation on carbon emissions in the Eastern Himalayan region is crucial.

The study's findings highlight a significant decline in forest cover and aboveground biomass in the eastern Himalayan foothills from 1990 to 2024, largely driven by extensive

deforestation. From 1990 to 2024, a loss of 581.92 km² of forest cover was observed in the study area. This loss has severe environmental implications. A significant reduction in aboveground biomass has been observed due to deforestation.

The decline in forest cover and aboveground biomass directly correlates with increased carbon emissions. Forests act as carbon sinks, absorbing atmospheric carbon dioxide. When forests are lost, they no longer serve this role, effectively becoming carbon sources due to the release of stored carbon. This transition from a carbon sink to a carbon source significantly contributes to climate change. To quantify the impact on carbon emissions, CCDC algorithm was used to check for disturbances and analyzed the carbon uptake and emission data for various periods. The data showed that between 1990 and 2024, the study area experienced a net loss of 12.20 Tg. This indicates a significant imbalance, with carbon emissions far exceeding carbon uptake.

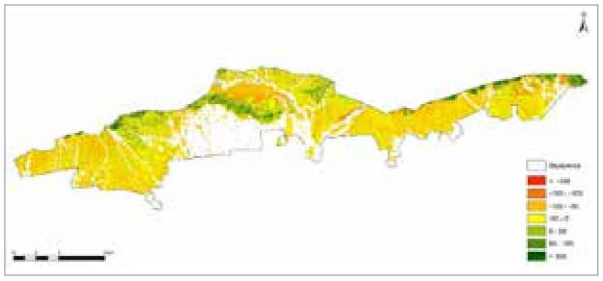


Fig.: Gain and loss of carbon stocks from 1990 to 2024

The study provides essential insights into the extent of deforestation and its impact on carbon emissions, aiding in the development of effective climate change mitigation strategies. By quantifying the carbon emissions associated with land-use changes, the study provides evidence-based support for policies aimed at preserving forests as vital carbon sinks and reducing anthropogenic carbon emissions.

Soil-Vegetation-Atmosphere-Carbon Flux [Inter-disciplinary Project (IGBP-CAP)

i. Agricultural component

The project is part of Soil-Vegetation-Atmosphere Carbon Flux (SVAF) under ISRO-Geosphere-Biosphere programme and aims to use state of the art eddy co-variance (EC) flux-towers and remote sensing technique to measure and monitor carbon and water vapor exchange between vegetation systems and atmosphere. The flux towers observations are integrated with satellite observations for generating carbon exchange components and evapotranspiration estimates over large areas. The project is being extended for next 5-years till 2026 with an aim of Understanding Dynamics of Carbon and Water Vapor Fluxes over North-west Himalayan ecosystems. was envisage with objectives (i) Continuity of measurements from eddy covariance based flux-tower and other meteorological sensors for measuring energy, CO2 and water vapor exchanges over diverse cropland and natural forest ecosystems (ii) To analyze seasonal and inter-annual variability of carbon and water fluxes of diverse North-western Himalayan ecosystems (iii) Multi-model (LUE based, process-based model and empirical) evaluation for gross primary production estimates of NWH region. Currently project operated in North western Himalayan foot hills with four eddy covariance sites namely Moist Deciduous Sal Forests (Barkot, UK), Mixed Dry Deciduous Plantation (Haldwani, UK), Sugarcane cropland (Saharanpur, UP) and Rice-wheat cropland (Palampur, HP).

The key achievement of the project comprises generation of long-term inter-annual and seasonal carbon balance over natural forests and cropland ecosystems at site and regional scale using flux-tower observations and

modeling approaches. Light use efficiency model was used to estimate the gross primary productivity over sugarcane-wheat, rice-wheat cropping system in Saharanpur region. The study presents an innovative approach to estimating crop productivity by integrating multisensor satellite data, in-situ measurements, and eddy covariance (EC) flux data into a light use efficiency (LUE) model. Sugarcane-wheat system exhibits higher productivity than the rice-wheat system, attributed to the higher photosynthetic efficiency of the C4 crop (sugarcane) compared to C3 crops (rice and wheat). LUE model also performed for rice-wheat cropping system in hilly region of Palampur, Himachal Pradesh. The modeled GPP (GPPVPM) was validated with the tower GPP (GPPEC) at fortnight intervals. GPPVPM had an agreement index of 0.995, with a RMSE of 0.95 g C m-2 day-1 and a MAPE of 16.88%.

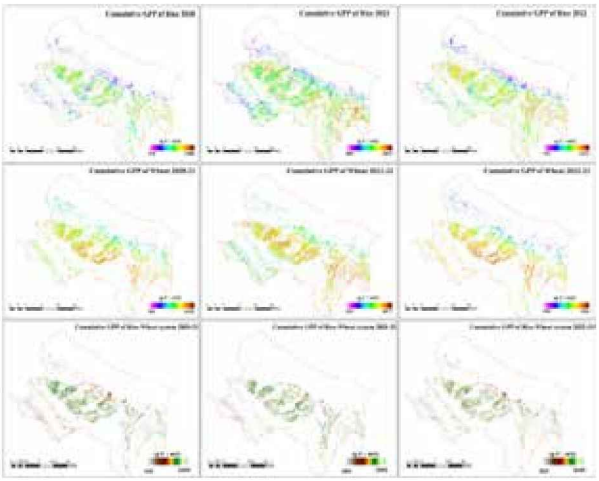


Fig.: Cumulative GPP of Rice, Wheat and Rice-Wheat system from 2020-21 to 2022-23

A process-based Biome-BGC model implemented with assimilation of time-series Sentinel based LAI data and sentinel derived land surface phenology over sugarcane cropping system and rice-wheat cropping system in order to study the spatio-temporal variability of carbon and water vapour fluxes.

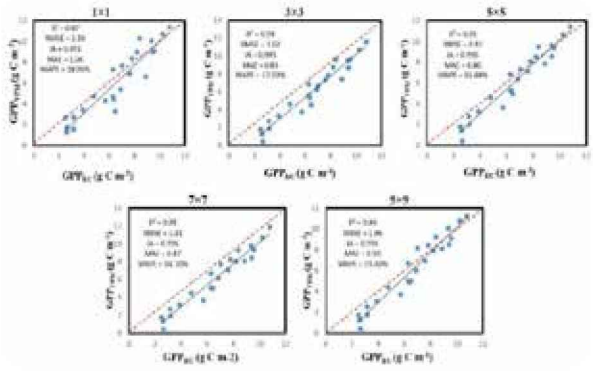


Fig.: Validation plots for different window size for fortnight mean GPP of Rice-Wheat system 2020

A study was carried out to downscale land surface temperature (LST) using machine learning techniques (random forest) for estimating ET at field scale for sugarcane crop in Saharanpur region and rice – wheat cropping system in Palampur region of Himachal Pradesh. The relationship between downscaled LST and the LST from the FLIR thermal camera was found good with an R2 of 0.73 in Palampur region and 0.80 for Saharanpur region.

Machine learning technique was used to estimate the ecosystem respiration (Reco) for sugarcane crop and rice-wheat cropping system in Saharanpur and Palampur region, respectively using Sentinel 1 and Sentinel 2 based indices. Gradient Boosting regressor was found as the best ML model to estimate ecosystem respiration with R2 value of 0.7 and 0.607, respectively. NEE was estimated using the GPP from LUE model and Reco from ML technique. The impact of 2022 heat wave on carbon, water vapour and energy cycles using half-hourly eddy covariance measurements from cropland site in Saharanpur was also evaluated. We found that net ecosystem exchange (NEE) decreased during the heat wave period, subsequently increasing the atmospheric carbon dioxide concentration in the atmosphere in comparison to the non-heat wave events.

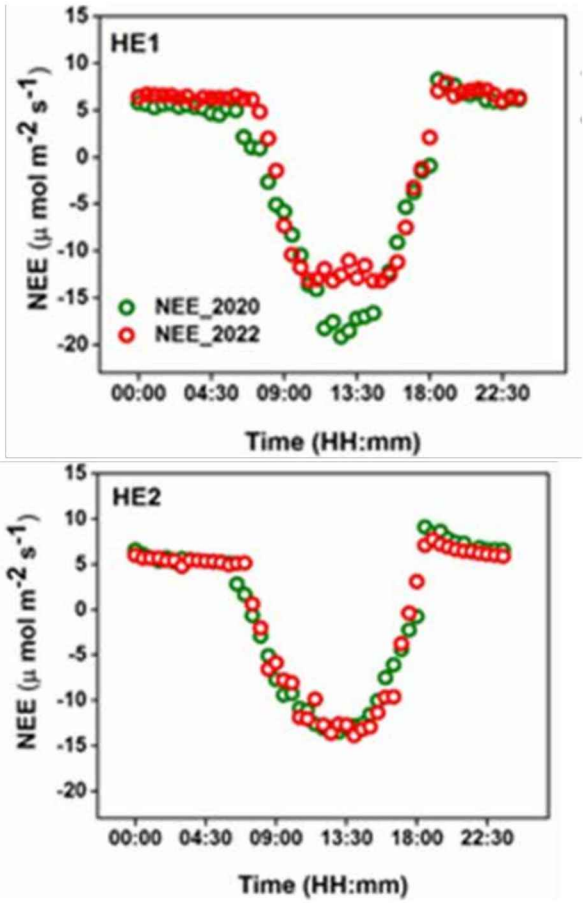


Fig.: Variation in net ecosystem exchange (NEE) during the heat wave periods for year 2020 and 2022

ii. Forestry component

The project is part of the National Carbon Project and aims to use state-of-the-art eddy covariance (EC) flux tower and remote sensing (RS) techniques to measure and monitor carbon exchange between vegetation systems and the atmosphere. The project envisaged the objectives: (i) Continuity of measurements from EC-based flux tower and other meteorological sensors for measuring energy, CO2, and water vapor exchanges over the diverse natural forest and cropland ecosystems (ii) Assessment and monitoring of carbon balance of natural forest and cropland sites (iii) Development of RS-based techniques for upscaling of carbon fluxes over large areas.

Presently, the project is operated in northwest Himalayan (NWH) foothills with four EC sites: Moist Deciduous Sal Forests (BFS-Barkot, Uttarakhand), Mixed Dry Deciduous Plantation (HFS-Haldwani, Uttarakhand), Sugarcane cropland (SFS-Saharanpur, Uttar Pradesh), and Rice-wheat cropland (PFS-Palampur, Himachal Pradesh).

The significant role that forests play in regulating the carbon and water exchange is critical to mitigate climate change. The remote sensing data and models provide good means for estimating gross primary productivity (GPP) and evapotranspiration (ET), although they seldom face issues when implemented without proper calibration. The key achievements of the project were implementaion of semi-emperical models (PRELES) for estimation of GPP and ET and estimation of water use efficiency (WUE) at two distinct forest sites. The PRELES model was calibarated for Indian moist sal forest. PRELES- predicted GPP ranged from 1.09 to 19.73 gC m-2day-1 with RMSE of 1.64 gC m-2day-1 and ET from 0.25 to 5.31 mm day-1 with RMSE of 0.65 mm day-1. It was found that PRELES estimated GPP with higher accuracy compared to TG model (a reduced RMSE of 0.68 gC m-2day-1).

To study WUE, Vegetation Photosynthesis Model (VPM) was utilized to estimate GPP, and Mapping Evapo-Transpiration at High Resolution with Internal Calibration (METRIC) approach was employed to evaluate ET. The ratio between GPP and ET was used to estimate the WUE. Study on WUE found that the area-weighted average annual WUE for dry deciduous forests was 2.13 ± 0.21 gC kgH_2O^{-1} $month^{-1}$, while it was 1.95 ± 0.95 gC kgH_2O^{-1} $month^{-1}$ for moist deciduous forests. This is the first attempt to examine the WUE pattern at fine resolution.

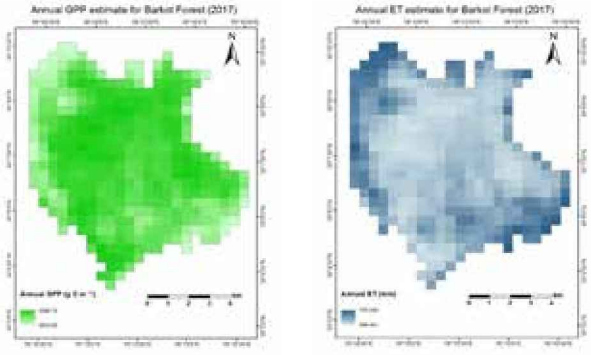


Fig.: Annual GPP (gC m^2 $year^1$) and ET (mm $year^1$) of moist sal forest in NWH foothills of India.

Spatio-temporal Variation of gaseous Air Pollutants over the Indian Subcontinent with a Special Emphasis in Foothills of North-Western Himalaya (IGBP-CAP)

Air pollution in Indian cities is a serious health hazard, particularly in the capital city of Delhi. The city is known to experience severe air pollution, specifically during post-monsoon months. The Indo-Gangetic Plain (IGP) region of North India houses more than half a billion people. This region is witnessing massive growth in construction, and industrial activities along with increased vehicular emissions. Food grain-producing states of Punjab, Haryana, and western Uttar Pradesh also witness post-harvest paddy stubble burning during post-monsoon months. Large amounts of gases and aerosols are thus produced that are transported to downwind regions of high population density.

A source attribution study of surface-level carbon monoxide (CO) was conducted to ascertain the contribution from various sectors towards the total CO concentration over North India. Weather Research and Forecasting model with Chemistry (WRF-Chem) was used to simulate the CO spatio-temporal distribution from 28 October 2021 to 16 November 2021. This period was chosen based on increased agricultural fire counts observed by VIIRS in North India. The WRF-Chem model was run in tagged tracer configuration to distinguish the sector contribution from anthropogenic, biomass burning, biogenic sources, photochemical production, and lateral transport of CO into the model domain. Model outputs were compared to the Measurement of Pollution in the Troposphere (MOPITT) retrieved CO observations. WRF-Chem was found to be in good agreement with the satellite observation with a mean bias of around 100 ppbv and a correlation coefficient of 0.87.

The emissions from anthropogenic activities (mostly industry, transport, and domestic) were found to be the highest contributor of CO (around 40%) in North India (Figure). This was followed by emissions from the crop residue burning (around 35%). Lateral transport of CO is responsible for around 11% of the total CO. Remaining sector contribution was less than 5%.

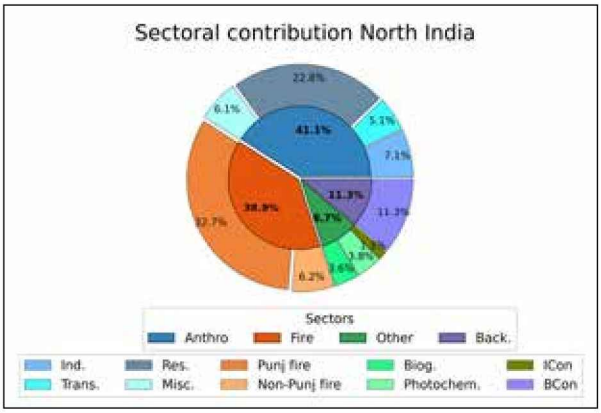


Fig.: Pie-chart showing percentage contribution from different sectors to total surface level CO concentration over North India

Continuation of Long Term Surface Energy Balance Studies for North-West Himalayan Agro-ecosystem using Large Aperture Scintillometry (2020 -2023)

Accurate measurement and estimation of surface energy fluxes are the essential keystone for understanding earth's climate system and further mass, heat and momentum between surface and atmospheric boundary layer. Precise estimation of evapotranspiration (ET), water use and water availability at local to regional scale are quite crucial for quantitative assessment of water resources. Estimation of turbulent heat fluxes (sensible and latent heat fluxes) with define accuracy is the most tedious task to be done at field scale, which is ultimately used for assessment of energy fluxes variation as well as for agricultural water management. To understand this process and functioning, augmentation of Large Aperture Scintillometer (LAS) and Micrometeorological Tower was done at crop research farm of GB Pant University of Agriculture & Technology, Pantnagar (Udham Singh Nagar, Uttarakhand). This site may develop as Super Site of Validation for ISRO-CNES Mission-Trishna as well as future upcoming satellites related to agricultural theme. LAS transmitter and receiver was installed at the height of 5 meter on the platforms, which are at the path length of 1020 meter with integration of Automatic Weather Station (AWS) on receiver end side within sugarcane cropland. Along this, micrometeorological tower was augmented at the receiver end integrated with two-height temperature-humidity probe, four components (CNR4) net radiometer instrument, soil heat flux plate, wind speed and direction sensors and atmospheric pressure sensor on 5 meter tower set-up. These all sensors are the fast response sensor working at 10 Hz frequency, which format the datasets in 5 min integrated files.

Fig.: LAS and Micrometeorological Tower Integrated ET Station at GBPUA&T, Pantnagar

Sugarcane crop has the high water requirement as compare to other crops. Terai region of Uttarakhand is the significant region for production of sugarcane crop. Thus, the motivation of this research study was to analyze and compute the crop water requirement and crop water use by sugarcane crop at seasonal and annual scale. The surface energy fluxes (SEF) of sugarcane field was observed by LAS and analyzed to define the SEF at monthly scale, represented in Fig 2. Since October 2021 to 2024, the surface energy fluxes are observing constantly, where the yearly crop evapotranspiration was 1500 mm approximately for 2023. This observation was also used in validation of remote sensing energy balance model named METRIC ET model for 2022-23 and 2023-24.

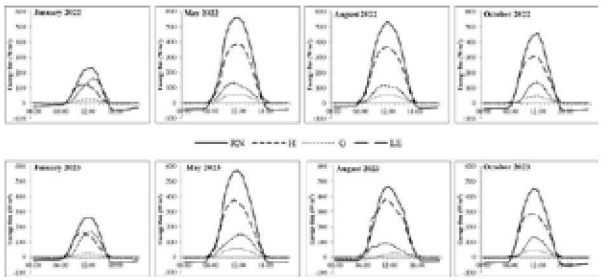


Fig.: Diurnal pattern of monthly averaged LAS observed surface energy fluxes at different month of four seasons

Automated detection of rock glaciers in western Himalaya, India

The northwestern (NW) Himalayan region, which has a semi-arid to dry climate, is climatologically very fragile and susceptible to future drought conditions. The limited agricultural land and its dependence on the diminishing meltwater reserves have severely impacted local communities. Even though indigenous peoples that rely on glaciers and snowmelt have evolved peculiar water management and agro-pastoral techniques, their fate in the future will heavily rely on the climatically more resilient rock glaciers (RGs. In this project focusing on the NW Himalaya. A total of 3082 intact RGs covering an area of ~1466.6 km2 has been identified and analyzed. Following the classification of the International Permafrost Association, out of these 3082 RGs, 1205 were glacier connected (GC), 1043 talus connected (TC), 568 debris-mantled slope-connected (DC), and 266 glacier-fore-field connected (GFC) RGs. Field work has been carried out in parts of Ladakh to understand the geomorphological features of rock glaciers.

Fig.: The Google Earth Images (a, c) and the field photo (b,d) of rock glaciers in Ladakh

Understanding the Impact of Climate Change and its Variability on Hydrological Fluxes vis-à-vis Water Availability for Sustainable Development (IGBP-CAP)

ISRO Geosphere Biosphere Programme is focused to understand the Land- Atmosphere-Ocean interactions through Geosphere-Biosphere-Atmospheric mass and energy exchange processes that contribute to the overall understanding of parameters responsible for climate change. Under this initiative, many projects were taken-up in the past to address the issues related to monitoring and generation of data for Land, Atmosphere and Ocean. However, there is a need for understanding/modelling the impact of climate change and changes in utilization of resources on the availability

- Remote sensing and land surface model based generation of Land Surface Parameters (LSPs)
- Water resources assessment of a river basin and its long term change analysis
- Assessment of water resources availability and demand with reference to sustainable development goals

The atmosphere and land process are interlinked through a complex feedback mechanism. The change in climatic parameters will have varying impact on land process, especially the hydrological fluxes. In the proposed study, the attempts are made to model and understand the impact of climate change on the hydrological fluxes. The hydrological fluxes and other related Land Surface Parameters (LSPs) have been generated through remote sensing based retrieval and Land Surface modelling (LSM) approach. In this study the Variable Infiltration Capacity (VIC) hydrological model was used as the LSM. The estimation of LSPs in forecast

mode has also been done using downscaled climatic data through well calibrated LSM. The entire Ganga River basin (GRB) including trans-boundary contribution, has been selected as the study area. Further, an attempt has been made to improve the performance of the VIC model adapting the data assimilation (DA) technique. The simultaneous assimilation of two satellite derived surface hydrological parameters i.e., soil moisture and snow cover area has been done using the Kalman filter and direct insertion DA techniques, respectively. The results derived from VIC after DA outperformed the traditional setup of model.

The trends of input hydro-meteorological parameters (precipitation, temperature and wind-speed) along with the simulated discharge were analysed at monthly, seasonal and annual scale. This was done using Mann Kendall and Sen's slope test. It was observed that changing hydro-meteorological parameters with climate change has a significant impact on the behaviour of surface water discharge. Similar analysis was also performed for the seasonal and monthly time-step. The threshold discharge values for identifying the hydrological extremes were estimated by applying Gumbel's and Inverse Gamma cumulative density function on past simulated discharge.

The future hydrological responses from 2025-2100 were also simulated using calibrated VIC model for different Shared Socioeconomic Pathways (SSPs). The trends in the simulated future discharge along with the hydro meteorological variables were analysed. The annual significant increasing precipitation trend of magnitude was observed at the outlet under SSP 126, 245, 370 and 585 respectively. The overall increasing trend in maximum and minimum temperature was also observed at the outlet under the above climatic scenarios. The probable future extremes were identified using the derived threshold (using past data) and the frequency were also mapped at monthly and annual scale. The result shows that the frequency of hydrological extreme events under the changing climatic patterns will intensify in the near future. It can be concluded that the use of DA in hydrological modelling has proven to be a vital approach that demonstrated its aptness in more realistic representation of the ground conditions.

Finally, the quality-controlled, and spatially and temporally consistent, LSPs; and input datasets for LSM from the available observations and model outputs is planned to be hosted on geo-web-portal of IIRS/ISRO to support modelling, planning and management activities. The deliverables of this project will support to achieve UN sustainable development goals: SDG 13- Climate Action, SDG 2 - Zero Hunger, and SDG 6- Clean Water and Sanitation.

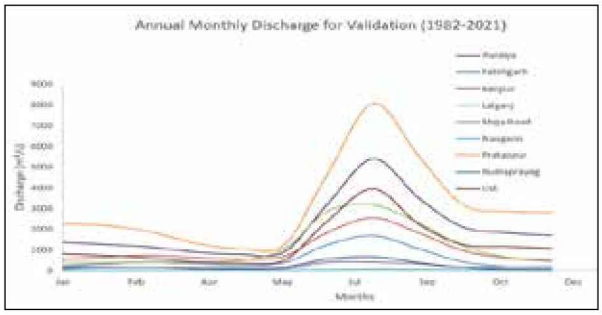


Fig.: The estimated discharge at various outlets using the VIC model in DA mode

Proximal Remote Sensing for Digital Soil Mapping of Nutrients and Heavy Metals

Soil information, including their spatial variability is vital for devising various soil and land management policies and strategies as well as assessing the environmental impact of different land use changes as well as industries. Similarly, extensive and detailed spatial soil information is essential for answering research questions on earth

system/process modelling, climate change as well as ecosystem services. Absence of good quality spatial soil information may adversely affect proper crop and soil management that may result in increased risk for sustainable development. However the conventional/traditional soil survey and laboratory based analytical techniques are laborious, destructive, and expensive as well as time consuming thus limiting the number of samples which could be analysed. Proximal remote sensing/proximal soil sensing approaches employing various advanced sensors aid us in acquiring spatial as well as temporal soil data/information at much cheap rates in very short time period and with reduced chemical usage and less effort.

Among the various proximal sensing devices used for rapid and timely estimation of different soil properties, portable X ray fluorescence (pXRF) spectrometry has increasingly been used for the last few years in various studies related to soil properties and their mapping. Portable X-ray fluorescence (pXRF) spectrometry has gained in popularity as a quick, inexpensive, reliable, non-destructive, and environmentally-friendly method to determine multi-elemental content in different matrices like rocks, soils, metals, water etc. during the past few years, under both in-situ and ex-situ conditions.

PXRF offers a wide dynamic range of elemental quantification from low mg kg−1 to high percentage levels, with no need for dilutions or re-standardization. Lastly, PXRF analysis is multi-elemental, providing simultaneous analysis of more than 20 elements including micronutrients as well as heavy metals. X-ray fluorescence has been principally used to assess metals in contaminated soils, soil physicochemical properties/soil fertility, descriptions of soil morphology/ differentiation of soil horizons, estimation of calcium content / gypsum requirement as well as to infer differences in soil development weathering indices. Applicability of pXRF for environmental quality assessment with respect to heavy metal contamination in peri-urban agriculture was also reported.

However, only very few attempts have been made in India to explore this technique for estimation of various soil parameters. This project aims to develop a methodology and models for prediction of various soil nutrients and heavy metals and their mapping based on advanced sensor based proximal soil sensing approach.

Geodynamics of Himalaya and Earthquake Precursor Studies

Approximately 200 million years ago (Mya), the supercontinent Pangea began to break up into various plates viz. African, Australian, Antarctica, Indian, etc. About 55 Mya, Indian plate drifting towards the Eurasian plate collided with it. Subsequently, this collision set up a continuous under thrusting of the Indian plate beneath the Eurasian Plate over the Main Himalayan Thrust (MHT) resulting in shortening along more than 2500 km long Himalayan arc. Presently, this persistent motion involves the gradual northeastward movement of the Indian plate with an annual rate of ~5 centimeters, coupled with a slight anticlockwise rotation of 0.5 degrees per millionyear. Various approaches are used to understand the geodynamic regime and related seismicity of Northwest Himalaya. Analysis of CORS/GNSS data, optical, SAR data, earthquake data and active fault data is a new domain of geoscientific investigation critical to understand the crustal deformation, seismicity and to some extent solid earth geophysics. Additionally, earthquake precursor studies are carried out to understand the seismogenic activity utilizing GNSS and Earth Observation datasets. This multi-technique approach is

envisaged to understand the contemporary geodynamics and seismic hazard potential of the Northwestern Himalaya.

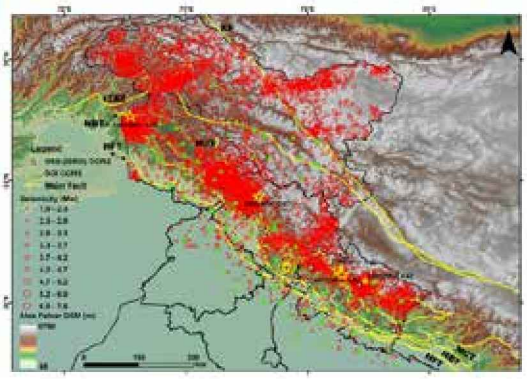


Fig.: Continuously Operating Reference Station (CORS) network installed by IIRS and SOI in and around the NWH region alongwith major faults and seismicity (Mw) took place between 1905 to 2024 period. The yellow color star showing the epicenter of the megathrust and medium earthquake location. (Source: ISC catalog)

Mountain Ecosystem Project-Strengthening Vegetation Phenology-Productivity and Climate Linkages in North West Himalaya

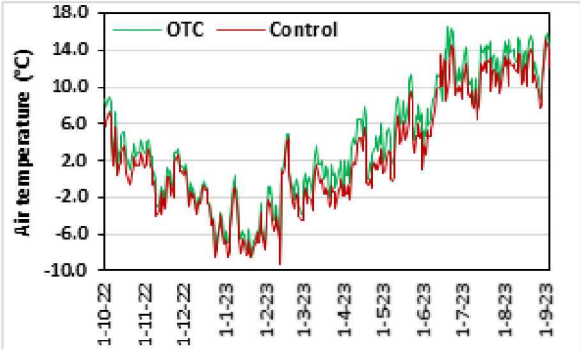
The northwest Himalayan (NWH) region is highly diverse in terms of topography and climatic conditions. The Himalayan region is significant in climate research due to its high biodiversity, high species endemism, and great importance of its ecosystem services to adjacent plains. The study aims to gain insights into the phenological patterns, functional traits, productivity, and impact of climate change on the vegetation of the Himalayan forest. The objectives of the project are to: (i) Assess the phenophase using satellite and phenocam imagery, long-term changes in vegetation phenology and identify drivers of change; (ii) To generate plant functional traits database, plant functional types map and simulate intra-inter annual trends in vegetation productivity and (iii) To study the response of alpine vegetation to experimental warming.

PhenoCam was installed to monitor the phenology of Lagerstroemia speciosa. Simultaneously, SFM1x sap flow meter was installed on the trunk of the same species and phenology and sap flow rate were monitored from February to November 2023. Decline in sap flow rate was observed from the mid of February, whereas Green Chromatic Coordinate (GCC) obtained from PhenoCam image showed more or less consistent values throughout the senescence period, only decreasing during the time of complete leafless stage. This indicates that sap flow observations can help us overcome the limitations of proximal remote sensing observations. Sap flow meters were installed on shisham, kanju and khair as well in dry deciduous forests and on palash at IIRS campus, to understand water use strategies of successional tree species of tropical deciduous forest ecosystems of Himalayan Foothills.

For functional trait studies, canopy carotenoid content of sal and chir pine forest were retrieved using in-situ observations and PRISMA Hyperspectral data through partial least square regression model. The MODIS GPP product for the last twenty years was analysed to find out the variation in GPP across forest types of NWH and detect any anomaly. The highest mean annual GPP was seen for Himalayan moist temperate forest and sub-tropical pine forest. GPP was compared with meteorological and biophysical parameters such as Fraction of Photosynthetically Absorbed Radiation (FaPAR), Standardised Precipitation Index (SPI) and mean annual temperature and rainfall.

Data on vegetation composition, structural traits and microclimatic data collected from OTCs as well as control plots. Soil samples were also analysed for moisture, pH and nutrients. OTCs increased the mean annual temperature by 1.33 °C. Accumulated Growing

Degree Days (GDD) (March to October) also increase within OTC (1612°C) as opposed to control environment (1311°C). Vegetation within OTCs showed increased shoot length (49.04% to 60.44%), leaf area (13% to 19%) and biomass (39.29%).



Daily average air temperature within OTCs and in the control plots measured using temperature data loggers

Soil Erosion Estimation based on Radio Tracer Technique and Soil Quality Assessment in Mountainous Landscape of North-West Himalaya

Assessing soil erosion is essential to quantify the loss of soil and nutrients, which diminishes the potential of soil ecosystem services. It is also critical for mitigating the impacts of climate change on food security. The Himalayan landscape consists of mosaic of hillslopes characterized by steep, rugged terrain, which hinders the assessment of soil erosion using conventional and modeling methods. 137Cs, a radionuclide from nuclear fallout (FRN), has found extensive application as an environmental marker in investigating soil redistribution processes. Nevertheless, it appears that there is a significant lack of 137Cs-based soil erosion studies in the Himalayan region. In this context, we assessed the potential of the fallout radionuclide (FRN -137Cs) method in quantifying soil erosion rates and validating erosion processes in the hillslope Higher Himalayas.

In the higher Himalayas, there is currently no direct erosion measurement available; only predictions or potential assessments of soil erosion rates have been made (Borrelli et al. 2021). Previous studies on soil erosion in the Himalayan region have primarily relied on approximations based on sediment yield at the watershed or catchment scale, or they have used erosion models to make predictions. Also, there is a significant lack of reliable information regarding soil erosion rates using FRN-137Cs (Evrard et al. 2020). Hence, this study represents the first-ever attempt to quantify soil erosion in various land use systems on a typical steep hillslope in the higher Himalayan region. The present study was undertaken to quantify and understand soil erosion rates and processes on a typical hillslope characterized by very steep (approx. 50° slope) topography and an elevation of 2500m above mean sea level.

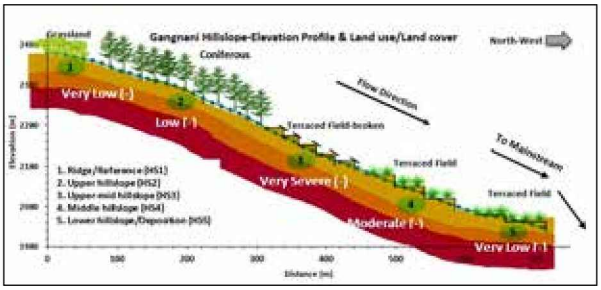


Fig.: Soil erosion class at various hillslope positions

The study demonstrates the potential of FRN (137Cs) in measuring soil erosion rates and to verify the soil erosion processes over the typical steep hillslope of Higher Himalayas for the first time. Very high erosion rates for cultivated sites, with a maximum of up to 39 t ha-1 yr-1 from the upper-mid hillslope position requiring urgent conservation measures. The steep hillslope forest exhibited a very low soil erosion rate of 9.5 t ha-1 yr-1 indicates the ability of forest to resist soil erosion even with steep slopes. In steeply sloping cultivated land, this value is four times higher than the soil erosion rates of the very steep forested slopes, posing a threat to agricultural soil resources. The study

confirms that forests can effectively preserve soils in the upslope sections of the region, and encouraging agro-forestry systems may serve the dual purpose of soil conservation and meeting the needs of farmers.

Monitoring of Hydrological Processes in Glaciated and Non-Glaciated Watersheds of North-West Himalaya

Monitoring hydrological responses vis-à-vis available water is very important for better water resources management for various stake holders in North-West Himalaya (NWH). All the major rivers of this region are fed by contribution from snow and glacier melt during non-monsoon season. This area has unique hydrological system, due to significant precipitation contributions from both Southwest and Northeast monsoon systems, rugged and steep mountainous topography, sparse ground observations, weather extremes, variable hydrological processes such as snow-glacier melt runoff, large spatio-temporal and elevation based changes in hydro-meteorological parameters and variable water use/demand patterns. In addition to this, the changes in land surface and climatic inputs can also result in changes in various components of hydrological cycle such as infiltration, evapotranspiration, surface runoff and base flow (snow melt, glacier melt and ground water) of the major river systems of NWH mountain ecosystem. In view of that, the objectives of the project are to (i) Establish instrumented experimental watersheds at different altitudes of NWH; (ii) improve monitoring and estimates of various hydrological processes and parameters of high altitude watersheds using RS-GIS and (iii) study the response of glaciers on hydrology of high altitude watersheds through on-field observations and modelling approach and upscaling to basins level through hydro-glaciological modelling.

As part of the Project, 05 non-contact type water level recorders and 02 discharge stations were installed in selected watersheds during 2023 - 2024. Selected watersheds are being monitored using installed instruments for water level, sediment concentration (for Aglar watershed) and discharge. Satellite based and reanalysis data is used to monitor precipitation, evapotranspiration, surface water, snow cover properties, glacier extent and melt-freeze analysis. As data quality analysis, satellite/reanalysis hydrological land surface parameters validation is under process. Hydro-glaciological models (SpHY, SWAT, MIKE-SHE) have been setup and calibrated for available limited datasets in selected watersheds. the Spatial Processes in Hydrology (SPHY) model to mimic recent changes in local climatic conditions and evaluate how these changes affect river hydrology. SPHY is a water balance model and is applied on a pixel-by-pixel basis. This model is used in this present study because it includes most hydrological processes, can be used from catchment scale to basin scale, can easily be implemented, has a flexible spatial resolution, is open-source, it only requires temperature and precipitation as a climatic parameter. This model can easily incorporate remote sensing data as its input parameters. SPHY was created with the express purpose of simulating terrestrial hydrology at a variety of scales and under a variety of land use and climate circumstances. The primary terrestrial hydrological processes are conceptually characterized so that variations in storage and fluxes may be accurately monitored over time and space. The PCRaster dynamic modeling framework is used to write SPHY, which is developed in Python. At present the model has been setup for the Bhagirathi, Jhelum and Tawi watersheds. The model resulted

in the partitioning of the different runoff contributions – snowmelt, glacier melt, rainfall runoff and total runoff. The analysis supported to understand the hydrological processes of these glaciated and non-glaciated watersheds. The snowfed and glaciated (Bhagirathi & Jhelum) watersheds are showing more snow melt contribution along with some from glacier melt. The snow melt starts in the early spring season, on the other hand glacier melt mostly beings in the month of June. Whereas, the non-glaciated watershed shown highest rainfall runoff contribution. The initial results are given below with contribution of each runoff component. Some of the watersheds where cal/val has been achieved in acceptable range is up-scaled to sub-basin scale (Bhagirathi and Yamuna).

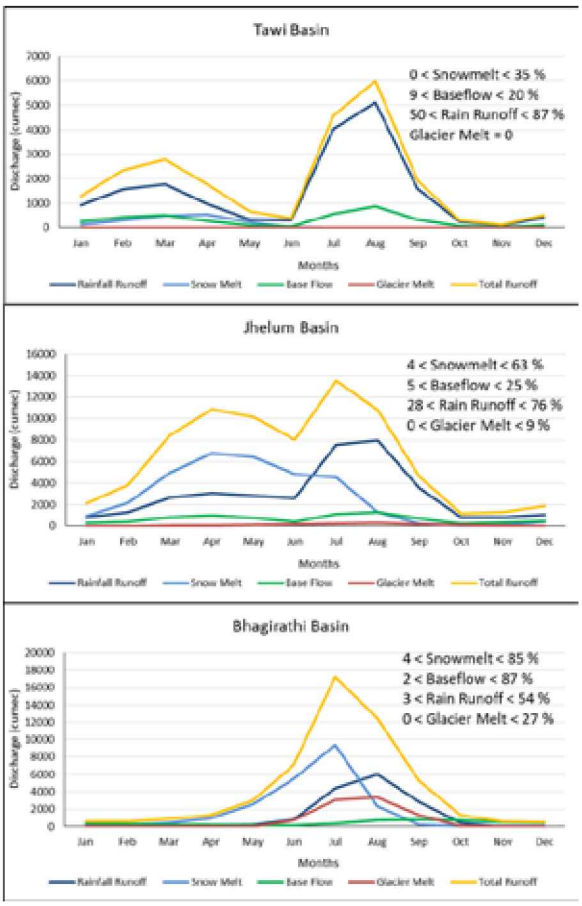


Fig.: SPHY model estimated different components of runoff for different watersheds

Modeling Temporal & Spatial Growth of North-West Himalayan Cities

The urban growth modelling initiative for Shimla, driven by its irregular terrain and ecologically sensitive areas, utilized the CA-ANN model to project growth patterns for 2034 with a notable accuracy of 87%. The model incorporated various parameters, including a 3x3 kernel for training and a neuron count formula of 2n+1 based on input layers for optimal configuration. The Master Plan for Shimla 2041 identified 17 Green Pocket areas as no-construction zones, which were excluded from the growth simulation to protect environmentally sensitive regions.

The analysis combined simulated growth patterns with hazard mapping to evaluate if projected development aligns with hazard-prone zones. By overlaying the Annualized Composite Risk Map with simulated built-up density data, the study assessed the overlap of projected growth with high-risk areas. Key findings from the analysis include:

- In very high-risk zones, high-density development is projected to cover 12 hectares, medium density 11 hectares, and low density 7 hectares.
- In high-risk zones, high-density development is expected to cover 4 hectares, medium density 24 hectares, and low density 16.5 hectares.
- Medium-density development is projected to align with moderate risk zones, covering 31 hectares, with other density categories also present.

These insights help quantify the potential exposure of future development to various hazards, informing more resilient urban planning strategies for Shimla.

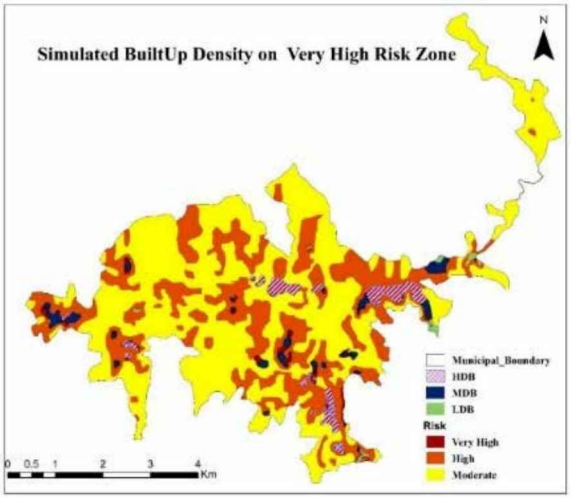


Fig.: Simulated Built-Up density on very high risk zone

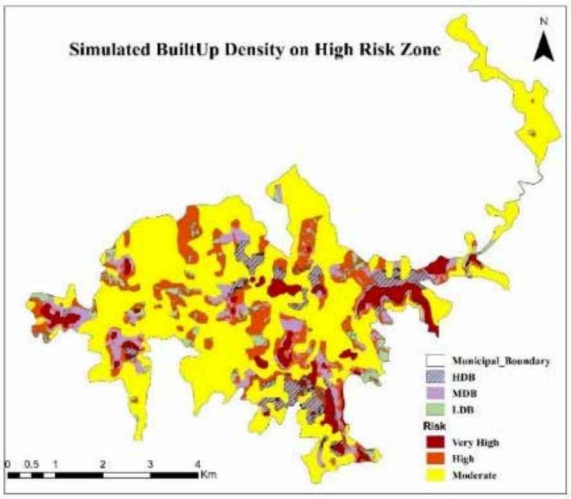


Fig.: Simulated Built-Up density on high risk zone

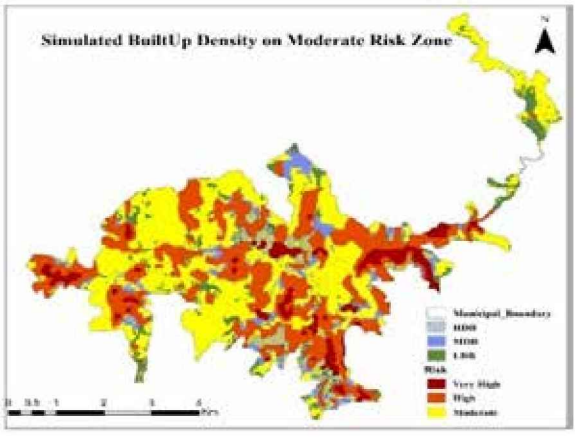


Fig.: Simulated Built-Up density on moderate risk zone

Comprehensive study of extreme rainfall events using model simulations and remotely sensed observations

In the present work, a detailed examination of extreme rainfall events (EREs) has been carried out using weather research and forecasting (WRF) model and remotely sensed observations over the Northwest Himalayan region. We performed high-resolution model simulations and studied EREs in association with fine-resolution Indian National Satellite System (INSAT-3D) observations. Remarkable variations noted in the remotely sensed outgoing longwave radiation and rainfall in association with model simulations during the formation of cloudburst events may be utilized to give an alert over the locations potentially affected by the EREs. We found that the fine-scale structure of various physical quantities during the formation of the cloudburst events endures remarkable variations in close agreement with the satellite-based observations. Results obtained in the present study show a promising pathway for the study, analysis and now-casting of extremely heavy rainfall events based on model simulations in conjunction with remotely sensed observations.

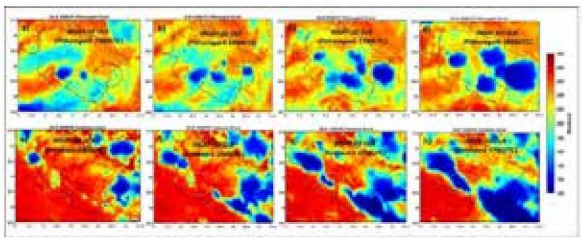


Fig.: (a–d) OLR from INSAT-3D for the Pithoragarh event; (e–h) OLR from INSAT-3D for the Kotdwara event

Impact of Hyperspectral Infrared Sounding Observation Assimilation on Regional NWP Model Forecasts

The initial state of the atmosphere needs to be as precise as possible for the numerical weather prediction (NWP) model to generate an accurate forecast. The first important step in enhancing the initial state of the atmosphere is the incorporation of more and higher-quality satellite observations into the NWP model. Hyperspectral sensors are able to detect and measure absorption of molecules more precisely than multispectral sensors because they make use of hundreds or thousands of successive spectral bands. The improved spectral resolution resulted in a significant improvement in vertical resolution and precision while estimating the temperature and moisture fields. The use of such type observations can significantly improve the forecasts form NWP model. In the present study, two sets of experiments have been conducted; the control experiment, in which only conventional observations (denoted as Control-Run) are assimilated and IASI experiment, in which conventional and Infrared Atmospheric Sounding Interferometer (IASI) hyperspectral observations are assimilated (denoted as IASI-Run) using WRF model through Gridpoint Statistical Interpolation (GSI) based data assimilation system with three-dimensional variational (3D-VAR) scheme. The experiments are carried out over the study region from 50°E-100° E and 0°N-40° N for the entire month of May 2022. Domain averaged relative humidity (RH) forecasts for 31 days are verified against fifth generation ECMWF reanalysis (ERA-5) data. It is noted that, IASI-Run produced higher correlation in the day-1 RH forecasts (shown in figure). The vertical profile of relative humidity forecasts from IASI-Run and Control-Run are compared with radiosonde observations. In comparison to Control-Run over New Delhi, it is observed that IASI-Run relative humidity improved in the day-1 forecast.

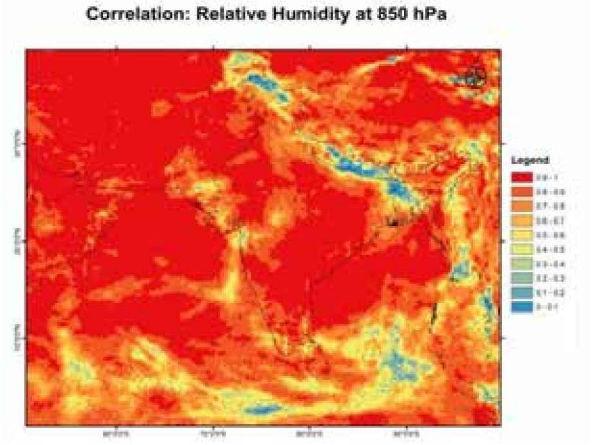


Fig.: Spatial plots of correlation for IASI-Run day-1 relative humidity forecast at pressure level 850 hPa for May 2022.

Spatial Data Infrastructure (SDI) Geoportal with allied Database Development for UT-Ladakh

i. Integrated Studies for the Assessment of Water Availability, Water-Ice Harvesting and Flood Hazard Mapping having following objectives:

In previous year, the objectives on water availability and food hazards assessment were addressed. This year, the emphasis was on site suitability analysis for water-ice structures using geospatial tools. Water deficit is a major challenge for the farmers of Ladakh region, especially during the sowing season when the demand for irrigation is high. The conventional sources of water, such as rivers, streams and glaciers, are either frozen or insufficient to meet the needs of the crops. This affects the productivity and livelihood of the farmers, as well as the food security of the region. One possible solution to this problem is the ice-water harvesting system, which involves creating artificial glaciers or ice stupas that store water in the form of ice during the winter and release it gradually as the temperature rises during the spring and

summer. The ice-water harvesting system can provide a reliable and sustainable source of water for irrigation, as well as other purposes such as drinking, sanitation and hydropower. The ice-water harvesting system can also help in mitigating the effects of climate change, which is causing the natural glaciers to melt faster and reduce the water availability in the long run.

As identifying suitable site for ice-water harvesting requires consideration on various thematic layers, a multi-criteria decision making (MCDM) approach was used. The most widely used analytic hierarchy process (AHP) was adapted. In this analysis the following thematic layers were considered: Aspect, Curvature, Hill Shade, Runoff, Potential Incoming Solar Radiation (PISR), and Topographic Wetness Index (TWI). The layers were classified and weighted overlay analysis was performed on all the layers giving suitable weightage to each layer. Using techniques of analytical hierarchy process and pairwise comparisons, the relative weight of each factor was estimated. The most common methodology for performing comparisons is the Saaty's (1980) comparative scale. According to this method, the comparative scale consists of integer numbers from 1 to 9, where 1 means that the factors are equally important and 9, that a factor is extremely more important than another. The comparison process was done separately for natural and anthropogenic factors, and the relative weight of each factor was assessed for both categories. Further, in order to check the discordances between the pairwise comparisons and the reliability of the obtained weights, the consistency ratio (CR) was computed. The map obtained after performing weighted overlay was validated with field data of cascading structure and site was found suitable. In first attempt, this method was tested for Leh-Nang catchment and later applied for entire Ladakh UT area.

Layers	Weights (%)	Rank
Hillshade	3.2	7
Curvature	4.3	5
Water yield	33.7	1
Aspect	3.6	6
Slope	12.6	3
TWI	31.6	2
PISR	11	4

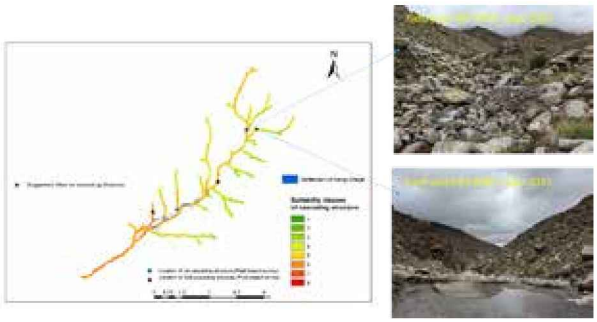


Fig. Final map generated after performing overlay analysis for Leh-Nang catchment

The results and methodology are finally shared with the officials of the Ladakh UT for all the objectives through the Geo-Ladakh Portal.

Prioritizing Suitable Sites for Agroforestry Expansion and Conservation/ Restoration of Key Plant Species of Ecological and Livelihood Importance

Ladakh, nestled amidst the majestic Himalayan and Karakoram ranges, boasts a distinctive socio-economic life shaped by its unique geography, culture, and historical legacy. Anchored in traditional agrarian practices, Ladakh's economy revolves around barley cultivation and the rearing of livestock, with nomadic herders playing a pivotal role. The region shows remarkable seasonal variation in climate creating a highly fragile ecosystem with limited natural resources. The project aims to conserve the unique ecosystem by mapping the key phytoresource species and pastures for better management for improvement of the livelihood of the local people of UT-

Ladakh. The objectives of the project are to (i) Mapping Sea Buckthorn to support bio-enterprise development and carbon trading; (ii) Assessing the status of rangelands and pastures for grazing management and eco-restoration; (iii) Assessing habitats of selected endangered and high-value plants for conservation planning. The project objectives were fulfilled and report was submitted to the Govt. of UT of Ladakh.

The study revealed that Sea buckthorn (SBT) exhibits a widespread distribution along the Indus, Suru, Nubra, Shyok, and Zanskar rivers in the Leh, Kargil, Nubra, and Zanskar valleys of Ladakh. In these four valleys, the cumulated area under SBT is 9,624 hectares, including the Kargil district (2,795.80 hectares) under Indian control. Overall, in Ladakh, the total area mapped under Sea buckthorn (SBT) cover is 35,299 hectares, including the Gilgit-Baltistan region.

The mapping of alpine pasture has been performed using Copernicus Sentinel-2 data at 10 m spatial resolution. In total four categories of pasture and 9 categories of non-pasture classes were mapped. The total area under the pasture was 1,25,768 km2 which is ca. 74.7 % of the total area of Ladakh UT. The western part of the UT Ladakh's landscape is more humid as compared to eastern-part hence, influence the distribution of the pasture types. Moist pastures are more extensive in Kargil and Gilgit-Baltistan region while dry pasture predominate in Leh.

Four medicinal and economically important plant species, Arnebia euchroma, Lancea tibetica, Primula macrophylla, and Rhodiola heterodonta were selected for the assessment of the potential areas for cultivation. Study demonstrated the potential of ecological niche modelling in conservation prioritisation. The habitat suitability maps would help in planning the targeted species surveys, establishment of nurseries at suitable location/altitute, re-introduction of plant in the wild, establishment of medicinal and aromatic plant conservation areas (MPCA) etc.

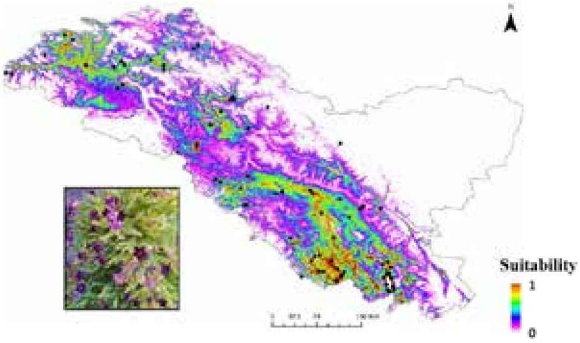
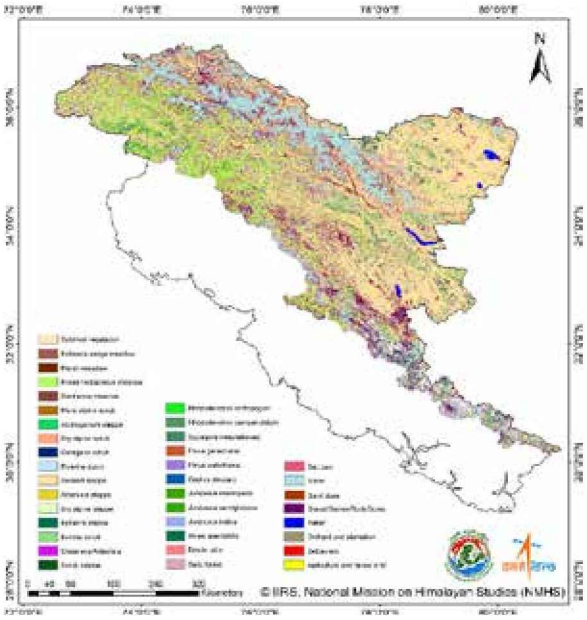


Fig.: Predicted habitat suitability of Arnebia euchroma in Ladakh

Himalayan Alpine Biodiversity Characterisation and Information System-Network (NMHS-MoEF&CC)

The project activities in 2023 were focused on: a) Developing vegetation classification scheme and classification and mapping of the vegetation of the Trans-Himalayan region; b) Field data collection from the gap areas and analysis of the data for diversity patterns; c) Refining predictive models of species richness and diversity; d) Parametrisation of UAV-Hyperspectral imager and acquisition of the data; d) development of the web-portal.

The vegetation classification map at the community and species level was generated for the Trans-Himalayan region and 31 vegetation classes were mapped using the Random Forest machine learning algorithm on Sentinel-2 data. Collected field plot data was analysed to determine the diversity patterns. A total of ~8300 quadrats were laid to inventory alpine biodiversity across 792 1ha sites distributed along environmental gradient. A total of 701 plant species belonging to 297 genera and 77 families were recorded in the sample plots.



Vegetation community classified map (31 vegetation classes) for the subalpine-alpine region of the Trans-Himalaya

Geospatial cum statistical modeling for predicting alpine plant richness was done for the entire Western Himalaya. Alpha diversity map of the study area prepared along with uncertainty. Beta diversity map was prepared and 10 distinct floristic zones were identified and mapped in the study area. Phylogenetic diversity and endemism maps were prepared for UT of Ladakh.

UAV parametrization and sensor calibration was done after conducting several test flights. Development of Himalayan Alpine Information System is undergoing with capabilities to visualize the spatial and non-spatial data and queries based search on different fields of alpine plant diversity.

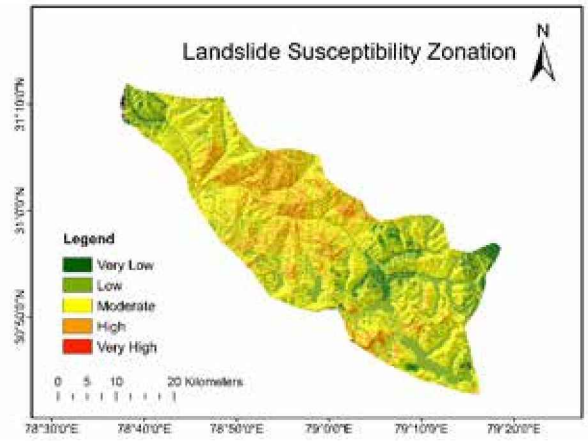
The portal hosts spatial databases developed on environmental variables, topography, classified vegetation map, diversity maps as well as species information recorded in the sampling along with grid-level information.

Satellite Based Mountain Hazard Assessment and Monitoring (MHAM) in Uttarakhand

The Uttarakhand State Disaster Management Authority (USDMA) has signed a Memorandum of Understanding (MoU) with the Indian Institute of Remote Sensing (IIRS-ISRO) to conduct various satellite-based studies as follows:

i. Landslide and Avalanche susceptibility zonation

The aim of the study is to set up a satellite-based system to monitor glaciers, glacier-fed lakes, potential debris flow, avalanche, landslides and assess their impact on the surroundings in terms of hazard potential and disseminate the information to stake holders to take appropriate measures to minimize loss of life and property. Landslide related component consisted of generation of satellite based Inventory map & Landslide hazard zonation completed for three study areas viz. parts of upper Mandakini, Bhagirathi & Alaknanda basin. The study shows change in the glaciers and glacial lakes from 2020 to 2023 as observed from satellite datasets. Basin wise statistics reveal that the glacier area decreased from from 2020 to 2023. The recession rates of the glaciers are calculated to be 0.22%/years, 0.7 %/year and 0.11%/year for Bhagirathi, Mandakini, and Rishiganga basins respectively. The monitoring of glacial lake extent for all the basins were performed for pre-monsoon and post-monsoon season for all the basins, which is observed to be increasing throughout the time period. Project is in its final stage and results have been periodically communicated (through GEOHIM web portal) for web hosted display at USDMA node.



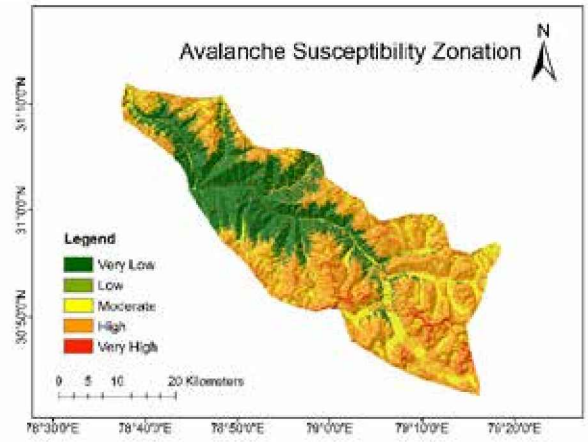


Fig.: Landslide and Avalanche susceptibility zonation maps in parts of Upper Bhagirathi Valley

ii. Hydro-Meteorological Hazards Assessment

IIRS-ISRO supported USDMA in monitoring critical areas prone to mountain hazards in Uttarakhand, such as glacier lakes, glaciers, landslides, floods, and avalanche risk zones. Over a span of two years, this collaboration has enabled the timely dissemination of information regarding potential disasters, allowing the state to proactively manage and mitigate risks. The Mountain Hazard Assessment and Monitoring (MHAM) project focuses on three key valleys in Uttarakhand: the Alaknanda, Mandakini, and Bhagirathi River basins. Within the theme of hydro-meteorological hazards, the project aims to generate extreme flood hydrographs and inundation maps for extreme rainfall events using hydrological-hydrodynamic modelling.

Additionally, Glacier Lake Outburst Flood (GLOF) simulations were conducted for glacial lakes such as Kedar Taal, Masar Taal, and Dhauliganga Lake. Figure 1 illustrates the hydrographs generated for various 24-hour extreme rainfall events in the Bhagirathi basin using hydrological modeling. Figure 2 shows the flood extent and depth corresponding to these events as simulated using hydrodynamic modelling.

By leveraging satellite technology, the project aims to provide decision-making tools through catastrophic maps, enhancing preparedness for natural calamities. This contributes to the overall resilience of Uttarakhand against recurrent hazards. The technical expertise provided by IIRS has significantly bolstered the state's disaster management capabilities, equipping stakeholders with valuable insights to effectively address the multifaceted challenges in the identified study regions.

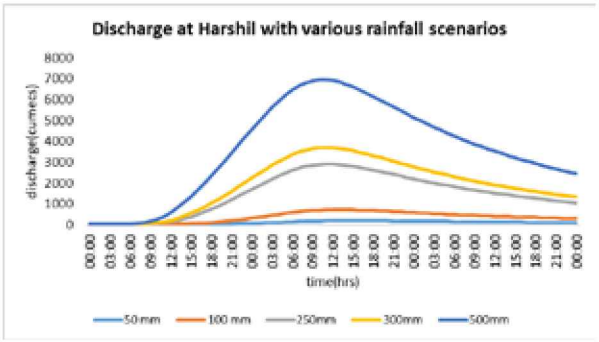


Fig.: Graph depicting Maximum discharge at Harshil corresponding to various rainfall intensities in 24-hour period

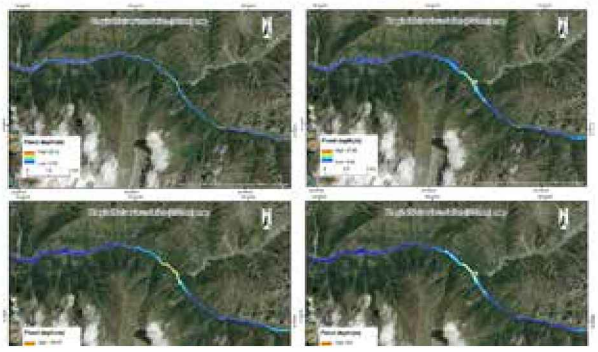
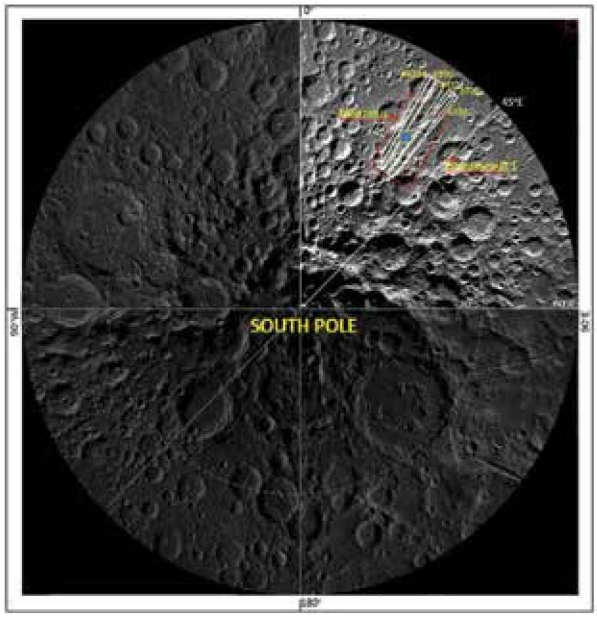


Fig.: Maps depicting flood depth in Bhagirathi river corresponding to various rainfall intensities in 24-hour period

Additional R&D Activities

Lunar Science: Chandrayaan-3 Landing Site Analysis using Chandrayaan-2 IIRS Data

In this study, the Chandrayaan-3 Vikram lander landing site near the lunar south pole (69.360S, 32.340E) have been analysed for mineralogy using Chandrayaan-2 Imaging Infrared Spectrometer (IIRS data) that was used to derive representative spectra of crater ejecta and lunar soil for mineralogical analysis. The landing site was further analysised with Chandrayaan-1 Moon Mineralogy Mapper data (M3) also. Chandrayaan-2 IIRS payload with 80m spatial resolution and spectral range 800 - 5000 nm in 256 contiguous bands after processing, thermal correction and calibration was used to detect and characterise the surface composition of the landing site whose spectral analysis results alongwith Chandrayaan-1 M3 reveals the presence of low calcium pyroxenes and lunar water based on their characteristics absorption features.



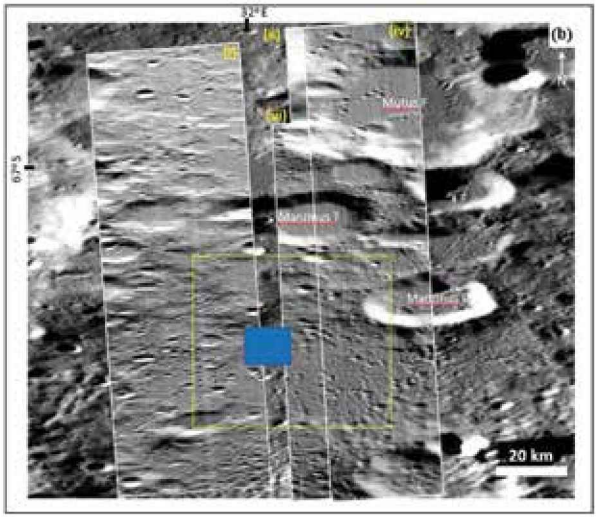


Fig.: (a) Location and close-up view (b) of the available Chandrayaan-2 IIRS strips coverage over the LROC-WAC mosaic of south-pole of the Moon.

Chandrayaan-1 M³ data for understanding the Mineralogy of Aristoteles Crater

Crater Aristoteles (51°N, 17°E) is 90 km diameter complex crater located NE of Mare Imbrium region of the Moon with diverse lithological entities. Mineral chromite through remote sensing have been detected only on Sinus Aestuum region of the Moon and therefore it makes the crater Aristoteles unique due to the detection of olivine-chromite exposures reported from its crater rim. Detailed mineralogical analysis of this crater reveals the presence of mafic exposures of gabbro, norite and olivine-bearing lithologies from its rim and central peak. The region has been analysed using Level 2 Chandrayaan-1 Moon Mineralogy Mapper (M³) data and the results have been discussed considering the regional geological events and the tectonic setup of the area.

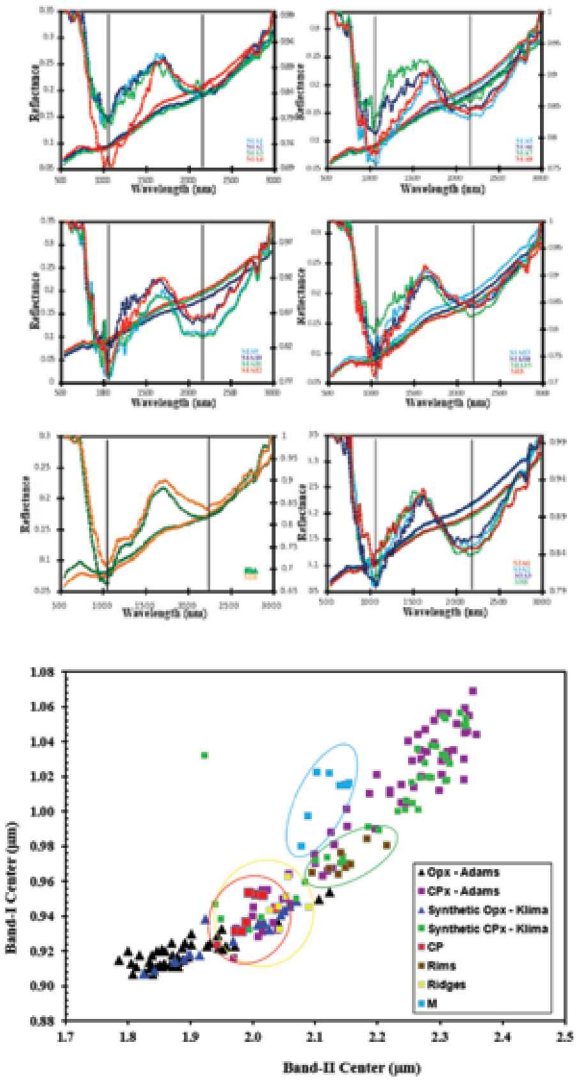


Fig.: (a) Normal and Continuum removed spectra of olivine-chromite acquired from Chandrayaan-1 Moon Mineralogy Mapper data for crater Aristoteles from the crater rim

(b) Band-II/Band-I centre ratios results for the pyroxene spectra acquired from central peak, rim, and crater floor of Aristoteles analysed for the type of pyroxenes.

Ancient Megafloods of Mars: Interpretations from MOM MCC Data and Hydrodynamic Simulations

Recent studies have brought attention to the enormous megafloods and the considerable amount of water found on and beneath the surface of Mars. These ancient megafloods have not only carved out Martian surface, but also altered its climate. In the present study, ancient flooding of four Martian water channels (Mangala, Kasei, Ravi and Mauadim) has been examined. The MCC dataset of MOM and MOLA-HRSC DEM were utilised to identify and estimate the hydraulic parameters of the channels. The estimated parameters were used in empirical equations to determine the flood velocity and discharge of Mangala (9.7 x 106 to 1 x 108 m^3/sec), Ravi (6.5 x 107 to 9.6 x 108 m^3/sec) and Mauadim Valles (1.0 x 108 to 1.5 x 109 m^3/sec). Estimated discharge magnitudes were in line with previous studies, except for Kasei Valles (2.6 x 108 to 5.3 x 109 m^3/sec) where over-estimation was observed. The two-dimensional simulations of full-bank floods were performed using the hydrodynamic model to generate scenarios of palaeo-megafloods in the four valleys. The estimated discharge is approximately 100 to 10,000 times the maximum discharge in large-scale terrestrial river basins such as Ganga, Brahmaputra, and Amazon.

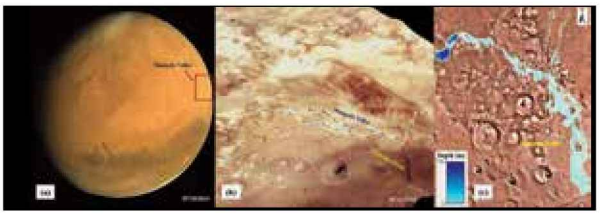


Fig.: (a) Full disk image taken on October 07, 2014 from Mars Color Camera (MCC) on board mars orbiter mission (MOM) (b) Mangala Valles image taken on December 02, 2014 from MCC drapped over MOLA-HRSC Digital Elevation Model (c) Visualisation of megaflood in Mangala Valles

Evidences of Climate Change from the Higher Himalaya, Lahaul, Himachal Pradesh

The accelerated expansion of glacial lakes in the higher Himalaya is not just the expression of glacial melting to climate warming, but poses a serious threat in terms of glacial lake outburst floods (GLOFs).The present

investigation focuses on a moraine-dammed pro-glacial lake (MDPGL) in the Kadu Nala valley (Lahaul, western Himalaya, India) that has evolved in less than a decade and has been expanding at an alarming rate since 2014. The data show that the actual development of the lake started in 2010 and has expanded to ~0.18 km^2 in 2021. It was noteworthy to observe that between 2014 and 2021, the lake's area increased by 134% in just seven years. The glacier associated with the lake was discovered to be retreating and lost 4% of its area between 2008 and 2021, exemplifying Himalayan glaciers' response to warming through melting ice, resulting in lake formation and exacerbating further glacier ice loss. Any breach in the moraine dam would immediately drain the entire lake, carry the loose sediments available in this glaciated valley and transform into a catastrophic hyper concentrated debris flow/flood.

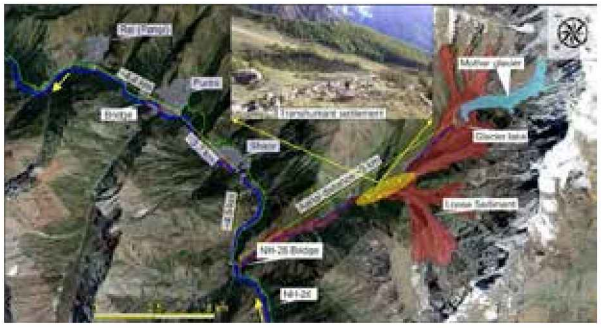


Fig.: The location of the Kadu Nala Lake with respect to the downstream settlements and road shown on the Google Earth Imagery, dated 1 September 2022. The inset field photograph shows the transhumant settlement en-route to the Kadu Nala Lake

Study of Rock Glaciers and Permafrost in Northwestern Himalaya

Rock glaciers are landforms characterized by the presence of rock debris intermingled with ice, resulting in the formation of a frozen mass that moves downslope due to gravity. Rock glaciers are usually found in permafrost areas, where the frozen ground serves as a natural barrier to water movement, forcing it to accumulate and freeze among the rock debris. Ice build-up causes the rock debris to become unstable and slowly flow downhill, producing the distinctive tongue-like morphology. The resilience of these ice rich bodies to climate change makes them a key water management resource, with implications for future fresh water management if the glacier ice volume shrinks by about 77% (expected) by the end of the century. A total of 3093 intact RGs were identified using high resolution images available through Google Earth Pro covering an area of ~1425 km^2.

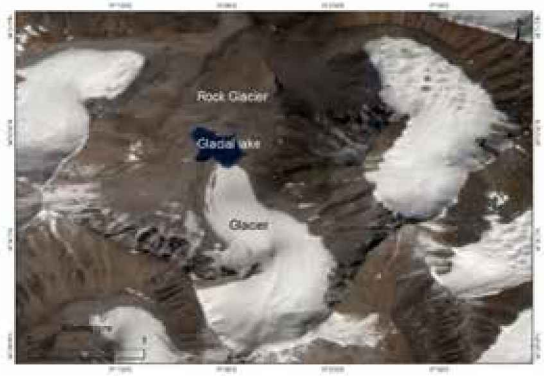


Fig.: IRS LISS IV image showing a rock glacier formed in the front of a glacier in the northwestern Himalaya

Determination of Mineralogy of Chandrayaan-3 landing site using Chandrayaan-1 and Chandrayaan-2 hyperspectral data

The Chandrayaan-3 Vikram lander landed near to the south pole region of the Moon on 23rd August 2023 at around 18:04 Hrs IST. The landing location lies between the Manzinus and Boguslawsky craters at 69.36°S, 32.34°E. The landing site region in and around the

Vikram lander is mineralogical unexplored so the region was evaluated for the mineral distribution using hyperspectral data from Chandrayaan-1 and 2 mission. Spectral information provided by Chandrayaan-1 Moon Mineralogical Mapper (M^3) and Chandrayaan-2-Imaging Infra-Red Spectrometer (IIRS) helps to understand the surface composition of the target site. The Ch-1 M^3, provides data with spectral coverage from 400-3000 nm in 84 spectral bands and 140-280m/px spatial resolution. The Ch-2 IIRS provides an extended wavelength coverage from 800-5000 nm in 256 contiguous spectral bands at 80m/px spatial resolution. This spectral range covers both the reflected and thermal emission component of solar radiation with ~20 nm spectral sampling. Radio metrically and dark noise corrected, geometrically tagged Level-1 radiance data acquired in exposure 1 (E1) and gain 2 (G2) settings were processed for thermal corrections and reflectance generation. The spectral signatures exacted from the study region were matched with the RELAB spectral library. The spectral signatures of the minerals extracted from fresh impact craters and lunar soil regions. The spectroscopic analysis shows the spectral signatures of low calcium (Ca) clinopyroxene (absorption features between: 900-1000nm, 2000-2100nm) at the rim of the impact craters and that of the lunar soil spectra shows the presence of the 2816 nm diagnostic absorption feature of OH/H_2O or residual adsorbed terrestrial water.

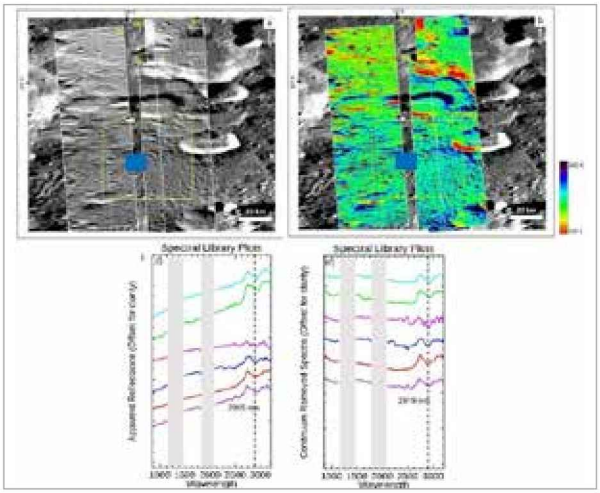


Fig.: The available Ch-2 IIRS data strips overlain on the LROC-WAC mosaic. The analyzed region near the landing site (marked by a blue box) is highlighted by a yellow box. b) The temperature map generated from the available Ch-2 IIRS strips c) Ch-2 IIRS Spectral profile at the landing site and (c) (i) Normal and (ii) Continuum Removed.

Machine learning-based approach on PRISMA data for Mapping Nidar ophiolites, Ladakh and their study as Martian analogues

This study classifies the major litho-units present in the Nidar ophiolite complex exposed towards South East of Ladakh (32o45'-33o35'N & 78°-79°E) to observe mineral diversity and associated alteration products. Given the complex mineralogy of the target rock assemblages in the given study area and present status of limited work that exists on exploration of ophiolites using high-resolution hyperspectral remote sensing, the study has attempted to apply machine learning (ML) based classification techniques on data obtained from recently launched (March, 2019) PRISMA mission to assess their accuracy in the lithological mapping of Ophiolites. ML algorithms, namely Artificial Neural Network (ANN), Extreme Gradient Boosting (XGBoost), Random Forest (RF) and Support Vector Machine (SVM)

have been used in the present classification based on mineral composition. They have been applied to one of the hyperspectral data image tiles of the PRISMA sensor available for the study regions. The downloaded level 2 reflectance product (L2D) of PRISMA data tile was georeferenced and layer stacked in ENVI®. After processing for noise removal and extraction of pure endmember spectra, training data was prepared based on the dominant lithological units/classes of the region. The results were analysed based on per-pixel-based classification approach followed by performance and accuracy assessment.

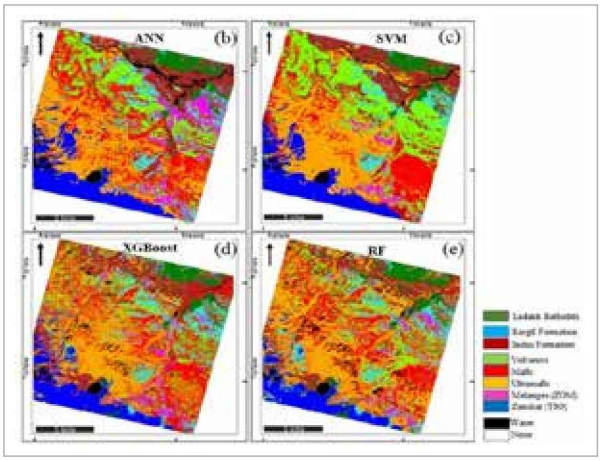


Fig.: Outputs from ML-based classification algorithms using PRISMA data for Nidar ophiolite applying methods (b) Artificial Neural Network, (c) Support Vector Machine, (d) XGBoost and (e) Random Forest.

Spectral Calibration of Chandrayaan-2 Imaging Infrared Spectrometer (IIRS) data and analysis of South Pole region of the Moon

The Chandrayaan-2 Imaging Infrared Spectrometer (IIRS) sensor is providing high-resolution data with a wider wavelength range (0.8-5µm). The scientific goals of IIRS sensor are to identify and map minerals and completely characterize the surface hydration feature of the Moon. After thermal corrections it further demands for photometric correction and calibration of Ch-2 IIRS data with the wavelength range 0.8-3.3µm to generate photometrically corrected reflectance product. Spectral calibration of Chandrayaan-2 IIRS reflectance data for ground truth correction using a standard reference were applied to rectify the issues related with absolute reflectance. Ch-2 IIRS calibrated spectra acquired from different locations of the South Pole region of the Moon was analysed. The reflectance spectral curve and its continuum-removed spectra for different locations of the Moon (i.e., highland, mare and polar regions) from the available strips acquired by Ch-2 IIRS were analyzed. All the analyzed regions selected to capture variability both in terms of underlying lithology as well as topography. The results were compared with their corresponding Chandrayaan-1 Moon Mineralogy Mapper (M^3) strips for the same locations with the assumption that the surface should have received the same signal under similar conditions to reveal the correction accuracy of IIRS level 2 data.

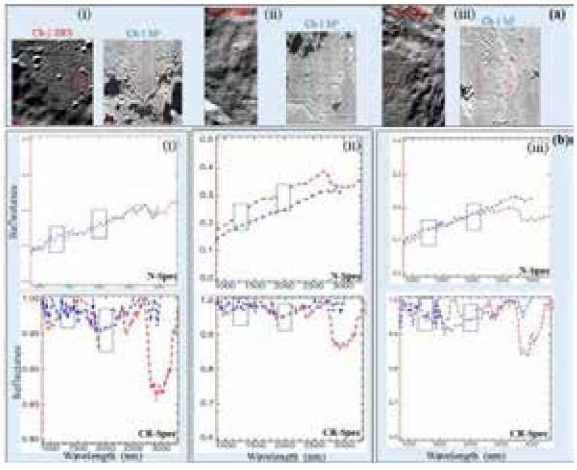


Fig.: Comparative reflectance Spectra from Ch-2 IIRS and Ch-1 M3 acquired from South Polar region of the Moon (a) (i) Left of Malapert A crater (ii) North of Moretus crater (iii) Floor of Moretus crater (b) (i)-(iii) their corresponding Normal and continuum removed spectra.

Limit equilibrium based slope stability and landslide hazard assessment in parts of Mandakini river basin

The current study focuses on landslide susceptibility mapping (LSM) in the Rudraprayag district, specifically around the Mandakini river valley. The methodology involves the application of the Analytical Hierarchy Process (AHP) integrated with twelve causative factors, including slope, lineament density, drainage density, land use land cover, lithology, Normalized Difference Vegetation Index (NDVI), geomorphology, curvature, topographic wetness index (TWI), Normalized Difference Water Index (NDWI), aspect, and stream power index (SPI). The AUC_ROC curve for the study area yields a satisfactory result of 78.9%. The outcomes indicate that 2.12% of the area is at very low risk, 27.12% is at low risk, 45.37% is at moderate risk, and 25.39% falls within the high to very high-risk zone. The numerical simulation assessment, conducted using the limit equilibrium method, determines the factor of safety (FoS) for seven vulnerable slopes situated in the very high-risk zone of LSM. All seven slopes were found to be unstable, with the maximum FoS recorded as 0.67. In light of these findings, it is recommended to conduct strategic slope stability assessments in various vulnerable sections of the Himalayas and similar regions. This proactive approach is crucial for implementing effective and sustainable measures toward disaster mitigation.

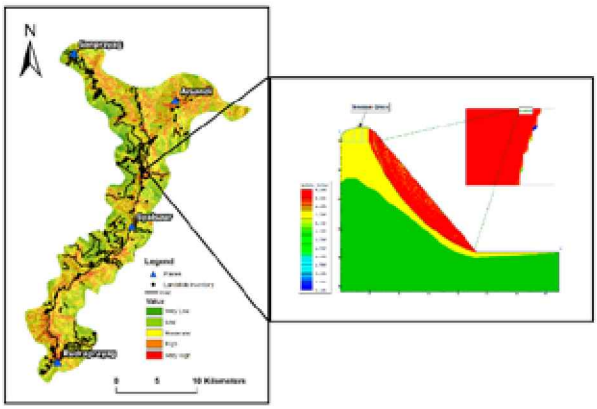


Fig.: Landside hazard zonation map with slide locations and 2D spatial variation of factor of safety along a selected vulnerable slope

Spectral Characterization of minerals in parts of the Bhukia Area, Banswara District, Rajasthan using Hyperspectral Data

Hyperspectral Remote Sensing has been a key technology in mineral exploration and mapping for some time now. In this study, PRecursore IperSpettrale della Missione Applicativa (PRISMA) data is utilized to identification of minerals in Bhukia region of Banswara district, Rajasthan. The rock spectra obtained from the surface reflectance hyperspectral datasets after applying the processing techniques were compared against USGS spectral library and the field/ laboratory spectra to identify the diagnostic spectral features.

For this study, 200 out of 234 bands in PRISMA were used for processing and a total of 14 bands were selected out of 200 input bands based on eigenvalues. Spectral Angle Mapper (SAM) algorithm was applied to the dataset and PRISMA identified kaosmectite, phlogopite, and dolomite minerals. The score of the minerals matched with the USGS spectral library is and the classified mineral map of PRISMA is shown in and table given here.

Furthermore, absorption band parameters were estimated and interpreted to corroborate the chemistry of the rock which resulted in the differentiation of limestone based upon Al^{3+}/ Mg^{2+} content.

Rock Name	Mineral Name	Score
Dolomite	Dolomite	0.536
Phyllite	Kaosmectite	0.577
	Phlogopite	0.535

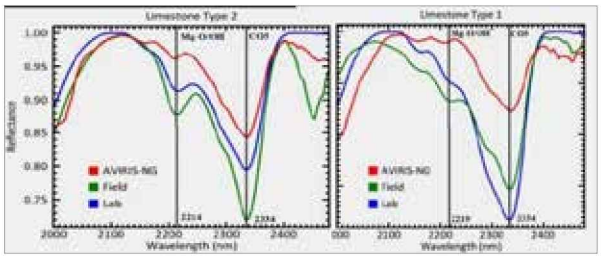


Fig.: Spectral variation vis-à-vis Limestone types

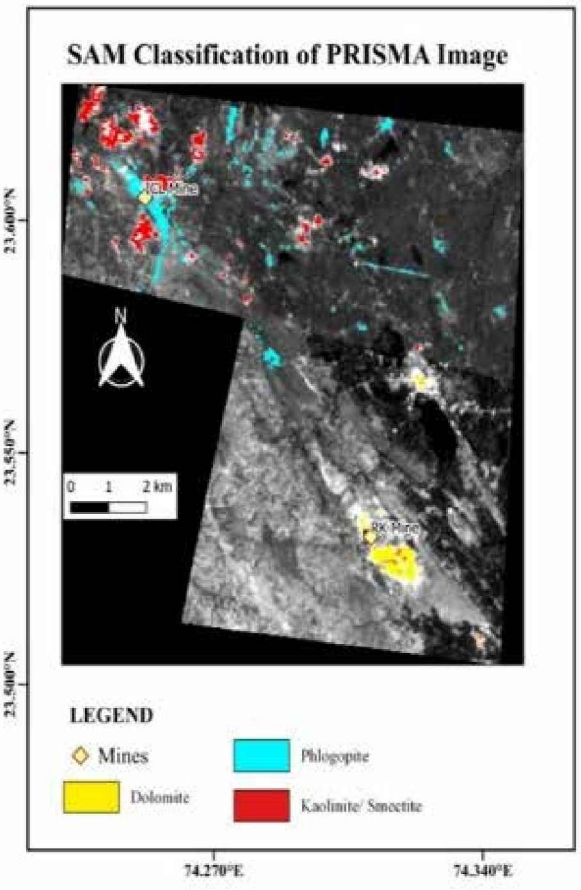
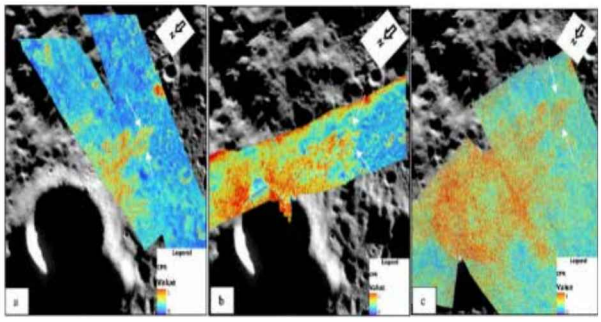


Fig.: SAM classified map using PRISMA data of Banswara area

Morphological, CPR and Ejecta Facies Analysis using Radar and Optical data at selected sites across the Lunar surface

SAR data from MiniSAR, DFSAR and Mini-RF instruments onboard Chandrayaan 1, Chandrayaan 2 and NASA's Lunar Reconaissance Orbiter (LRO) were utilized in this study. LROC-NAC and LROC-WAC optical data were also used. The sites selected were craters Aristarchus, Thales on the Nearside; Giordano Bruno, Stearns, Das, Tharp on the Farside; Whipple near the Lunar North Pole; parts of the South Polar Nearside Region and craters Kocher and Idel'son. The derived information about the lunar surface/ subsurface at these sites was integrated with that from optical datasets for a comprehensive and detailed analysis of a diverse set of impact craters across the lunar surface. Comprehensive and detailed morphological maps showing various features such as hummocky floor unit, impact melt flows, boulder/block units, channeled flow walls, melt veneer, melt ponds etc. for non-permanently shadowed craters were generated. The extent of proximal (continuous) ejecta blanket was mapped, the different types of ejecta facies based on their radar and optical signature were distinguished and extensive melt flows that were only sensitive to radar wavelengths were also observed. Observations were made regarding the impactor and the possible pre-impact topography. A statistical CPR analysis was conducted and variations were plotted across the test sites. Higher values for the DFSAR L-band dataset than both the S band counterparts in spite of the lower incidence angles were observed, possibly due to greater penetration capability.



Dataset	CPR Values	Standard Deviation
Melt flow (DFSAR L Band)	0.60	± 0.25
Melt flow (DFSAR S Band)	0.51	± 0.21
Melt flow (Mini-RF S Band)	0.56	± 0.51

Fig.: Multi frequency CPR investigation of the Whipple melt flow feature in a) DFSAR L band full pol., b) DFSAR S band full pol., c) Mini-RF S band Hybrid pol. images. The white arrows denote the extent of the melt flow. The table shows the mean CPR values and standard deviation for the feature (All datasets are present for this region with S-band data of both Mini-RF and DFSAR along with DFSAR L band data)

Application of CORS data in the study of subsidence crisis at Joshimath, Northwest Himalaya

The sinking crisis in the Joshimath region has flustered the local people's daily routine with a peek of curiosity and concern among the researchers. Data from the CORS station JOSH (located in Joshimath, installed by Survey of India, Dehradun) have been analyzed. Along with JOSH, four other CORS stations PURO, CHAM, BHEL, MAND (installed by IIRS, ISRO, Dehradun) and 20 IGS stations data (located on Indian and other neighboring plates) have been analyzed in GAMIT/GLOBK software in three components (North, East & Vertical) with respect to ITRF2014. The data analyzed have been recorded at 1 sec sampling interval and 24 hrs observation from 1st January 2022 to 30th March 2023. The total displacement (mm) and average displacement (mm/day) have been estimated for this period at four time intervals in North, East and Vertical components. The time series (1st October 2022 to 07th February 2023, 1st January 2022 to 30th March 2023 and 20th January 2023 to 30th March 2023) showing changes in displacement at these three components explains the reason for this alarming natural disaster (figs). From this perspective, it can be stated that GNSS data measurements can be executed in the study of subsidence at the Joshimath region.

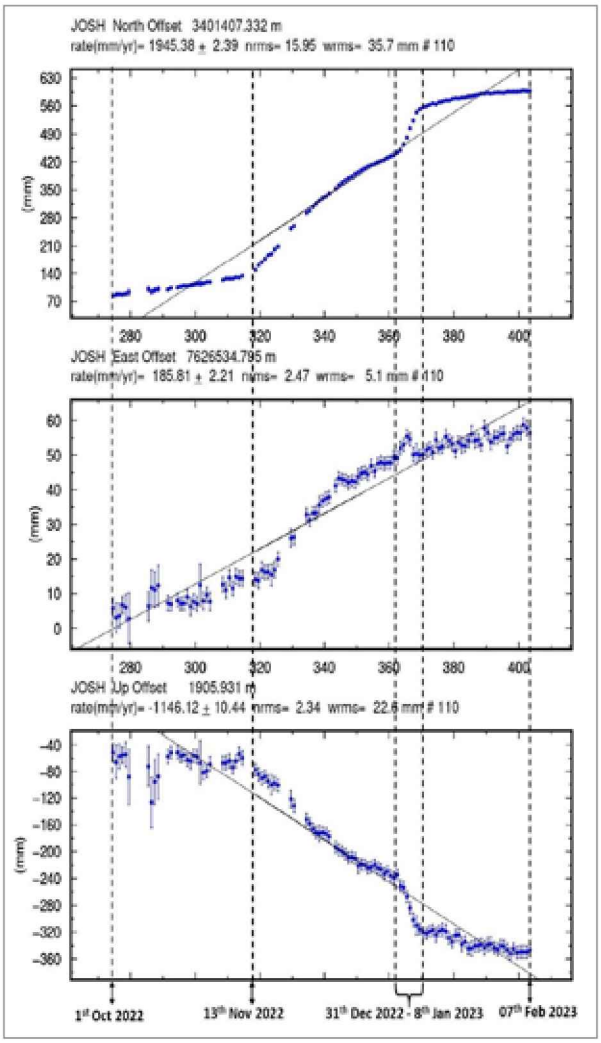


Fig.: The time series at JOSH GNSS station illustrates the displacement estimated in the three components, North, East & Vertical, to study the subsidence crisis at Joshimath region from 1st October 2022 to 7th February 2023.

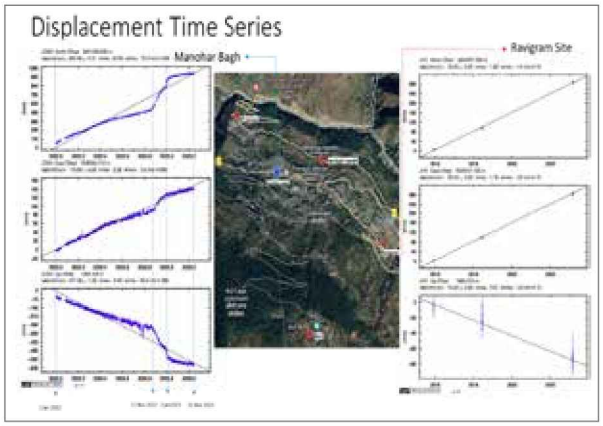


Fig.: The time series at JOSH GNSS station illustrates the displacement estimated in the three components, North, East & Vertical, to study the subsidence crisis at Joshimath region from 1st January 2022 to 30th March 2023.

RISAT-1A utilization of data

RISAT 1A MRS data (temporal) for Agra, Punjab and Palampur site analysed. For the Agra site, KVK was visited during October 2023 to collect the yield data. Crop cutting for crop biomass estimation was done. RISAT-1A based analysis carried out in the current year for both Agra site on pearl millet and JECAM site for orchards. These signatures were extracted for tea plantations too. The important cultural operations viz. picking, regrowth, picking and pruning could be depicted in the RISAT 1A derived temporal backscatter.

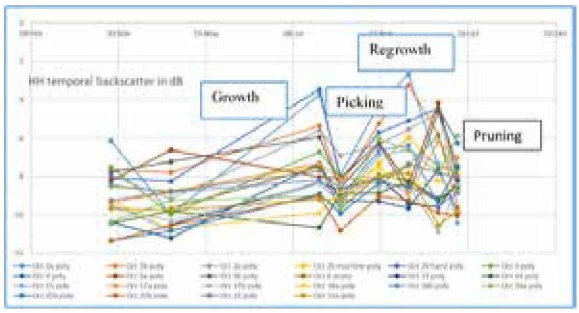


Fig.: HH temporal backscatter Signature of various Stages at the plantation

Fig.: field photograph of the tea garden (Palampur) in picking stage

Exploring effect of scale dependency in LST downscaling – using convolution neural network-extreme learning machine (CNN-ELM)

Study of diurnal phenomena like urban head island requires land surface temperature (LST) at high spatial and temporal resolutions. Coarse spatial resolution thermal sensors have a high temporal resolution while in contrast fine spatial resolution sensors have a low temporal resolution. Hence, mathematical downscaling of coarse spatial resolution LST datasets is done for generating fine spatial and temporal resolution LST datasets. In previous studies the functional relationship between LST values and downscaling variables was assumed to be scale invariant and applied uniformly to all landcovers. The present study analyzed the scale invariance of the relationship using Convolution Neural Network-Extreme machine learning (CNN-ELM) algorithm. The study was done for summer, winter and spring datasets to ensure its transferability and the results were validated using Landsat retrieved LST. The study concluded that unlike as assumed in previous studies, functional relationship that exist at a coarse resolution, do not translate to finer resolutions due to scale-dependent

effects, spatial heterogeneity, ecological factors, spatial autocorrelation and data noise. The relationship needs to recalibrated at finer resolution to account for these factors in local context. Secondly, when downscaling LST across different land covers, the downscaling variables should be unique to each land cover, instead of using the same downscaling variables for all land covers. The results of CNN-ELM and other traditional machine learning algorithms were also compared and it was found that CNN-ELM outperformed all the other algorithms.

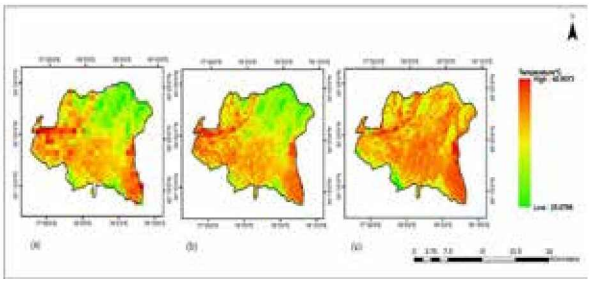


Fig.: Spatial distribution of LST(C) in Dehradun Planning area for (a) MODISLST1000 (b) MODISLST250 (C) LandsatLST30 for 05 May 2022 (Summer Dataset)

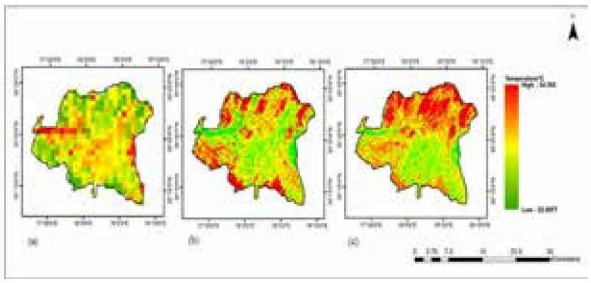


Fig.: Spatial distribution of LST(C) in Dehradun Planning area for (a) MODISLST1000 (b) MODISLST250 (C) LandsatLST30 for 16 March 2022 (Spring Dataset)

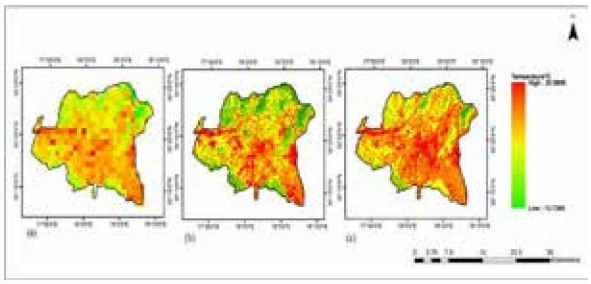


Fig.: Spatial distribution of LST(C) in Dehradun Planning area for (a) MODISLST1000 (b) MODISLST250 (C) LandsatLST30 for 07 February 2022 (Winter Dataset)

Urban Green Space Extraction from UAV Data and Machine Learning Algorithms

Urban green areas play a pivotal role in enhancing the quality of urban environments and promoting the well-being of residents. Identifying and describing these green spaces are essential for successful urban planning and sustainable development. Unmanned aerial vehicles (UAVs) have emerged as a valuable resource for capturing high-resolution aerial data, offering a detailed view of urban landscapes. The present study extracts the urban green spaces from the UAV data by employing an Object-Based Image Analysis (OBIA) technique using a multiresolution segmentation algorithm. The study area is part of Dhenkanal District, located at the heart of Odisha, India. Subsequently, the image classification was done using five selected machine-learning algorithms, namely Naive Bayes, Random Forest (RF), Decision Trees (DT), K Nearest Neighbor (KNN), and Support Vector Machine (SVM). Two different combinations of input layers were considered: the first combination included RGB and nDSM (normalized digital surface model) layers, while the second one incorporated the GRVI (Green-Red Vegetation Index) layer, which is a useful indicator for assessing the health and vitality of urban vegetation. The accuracy of the various algorithms was evaluated using generated confusion matrices. The comparison of results obtained from the five algorithms shows that the best results were resulted from KNN with an Overall accuracy of 96%, whereas the least accuracy was seen in RF, i.e. 75.3%. The results further depict that the inclusion of the GRVI layer significantly improved the accuracy of all classification algorithms, yielding a high overall accuracy, such as for RF it improved from 75.3% to 96%. This highlights the critical role of the GRVI layer in enhancing the classification outcomes and underscores its potential for

accurately identifying urban green spaces. Figure 4 and 5 shows the classified outputs using various classification algorithms for RGB+nDSM and RGB+nDSM+GRVI layers respectively. The study demonstrates the potential of UAV data in urban environments, capitalizing on the benefits of flexibility, availability, high resolution, and real-time data capture. This research serves as a valuable resource for urban planners, policymakers, and researchers, offering insights into the efficient utilization of UAV data and machine learning algorithms for identifying and mapping green spaces in urban settings.

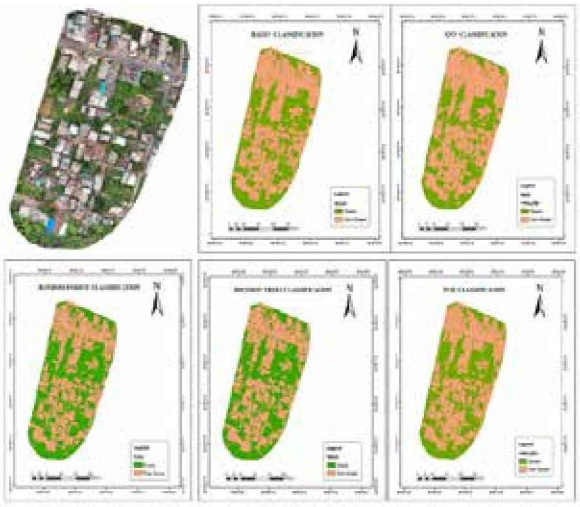


Fig.: Classified outputs using various classification algorithms for RGB+nDSM

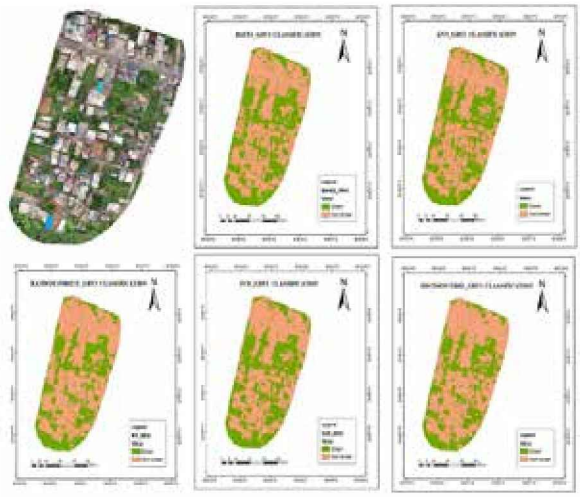


Fig.: Classified outputs using various classification algorithms for RGB+nDSM+GRVI

Comparative Analysis of CMIP5 based Monsoon Season Rainfall against Satellite based Estimations over India

The present study is designed to assess the rainfall pattern from Climate Model Inter-comparison Project Phase 5 (CMIP5) based on the satellite-derived rainfall products, Tropical Rainfall Measuring Mission (TRMM) over the Indian Region utilising daily as well as monthly rainfall data during monsoon season, ranging from 1st June to 30th September (JJAS). In this context, five best defined Global Climate Models (GCMs) that participated in CMIP5 archive along with its multi-model mean (MMM) have been analysed to investigate the rainfall pattern during JJAS in terms of spatial map and time series under the forcing scenarios i.e., Representative Concentration Pathway 4.5 (RCP 4.5) and Representative Concentration Pathway 8.5 (RCP 8.5) from 2006 to 2018 over Indian region. On the other hand, spatial maps and time series have also been generated using TRMM rainfall data at daily (TRMM 3B42v7) and monthly (TRMM 3B43v7) scales during the reference time period. Thereafter, comparative study of the JJAS rainfall pattern between CMIP5 models and TRMM products has been carried out to find out, whether the GCMs are able to simulate rainfall data reasonably well compared to satellite-derived estimates or not under various forcing scenarios over this region? Based on the assessment, it is noted that CMIP5 models have the ability to simulate daily mean monsoon season rainfall, however, it underestimates the rainfall intensity at daily scale over the north-east and south-west parts of India. Moreover, statistical analysis indicated more biases in the western coast and the north-eastern parts of India where it receives the highest amount of rainfall during JJAS. The outcomes presented here may be

useful for assessing the reliability of CMIP5 models to project the rainfall pattern in near future under the various warming scenarios over the Indian Region.

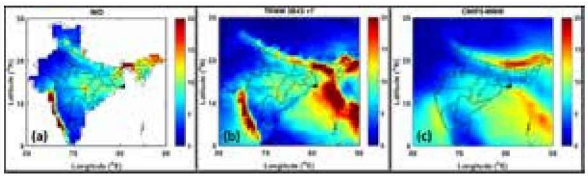


Fig.: Daily mean monsoon season (JJAS) rainfall based on the (a) IMD rainfall data, (b) TRMM 3B43 v7 rainfall product and (c) CMIP5-MMM simulated rainfall from 1998 to 2005 over the Indian region.

High-Resolution Retrieval of Fog/Low Stratus Clouds over Delhi Region

Fog is a low stratus cloud sitting on ground, which is optically thick enough to limit the horizontal visibility to less than one kilometre. The Indo-Gangetic plain (IGP) is affected with thick fog episodes during winter season and this is one of a major weather hazard. Thus, studying about fog and its effect is crucial. Due to limitation and high cost of ground based fog measurements, satellite remote sensing has been widely used to study about fog episodes and to analyse the extent of fog over the spatial domain in the affected regions of the IGP. In this study, Landsat 5 and Landsat 8 satellite images were utilized to retrieve Fog/Low stratus (FLS) clouds for the winter months – December and January over Delhi and its surrounding areas (Figure). The high resolution of Landsat is found to be very useful in retrieving the FLS at high spatial resolution of 30 m. The FLS retrieved was compared with MODIS true color composite images acquired from the Worldview website, which showed the strength of the algorithm developed for FLS retrieval. Moreover, the validation of FLS product with the METAR and SYNOP ground visibility data showed the accuracy of 68% and 85% with METAR and SYNOP data respectively, with False alarm rate of 33.3% and 25% respectively. The investigation of the FLS product for several years showed that the fog instances were relatively more in the recent years than in the past years. In addition, the fog hole phenomena could also be observed over Urban Delhi region and other towns. The FLS microphysical and optical properties such as Effective radius and Optical Depth were also estimated using Radiative Transfer Model SBDART. The mean effective radius and the Optical depth were observed to be varying between 10 μm and 16 μm, and 5 and 30 respectively.

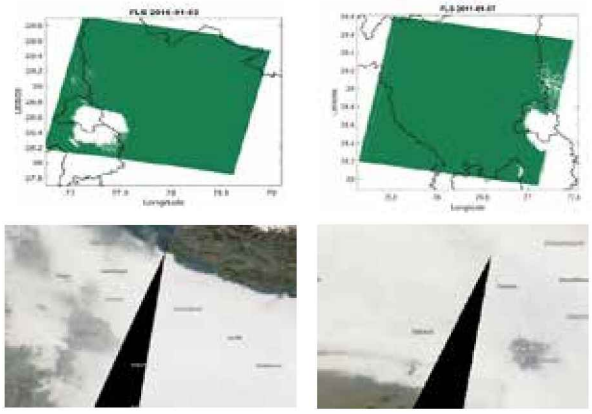


Fig.: Fog/Low stratus clouds images retrieved using Landsat data (first row); and corresponding true colour composite of MODIS (second row).

Spatio-temporal variability of surface chlorophyll and pCO2 over the tropical Indian Ocean and its long-term trend using CMIP6 models

The spatiotemporal distribution of chlorophyll and partial pressure of CO_2 (pCO2) over the Indian Ocean (IO) are investigated using satellite, in-situ, and simulations from eleven Coupled Model Inter-comparison Project phase 6 models. All the models show negative bias near the Somali region over the Arabian Sea (AS) during the southwest monsoon season. The CESMs and CanESM5 models show relatively less bias over the tropical IO except for the AS in all seasons compared to other models. The annual cycle of pCO2

shows a bimodal characteristic, with the first peak in May and the other in October over the northern IO, which the CanESM5, IPSL, and MPIs models reasonably well capture. All the models produce the phase of the annual cycle of pCO2 reasonably well for the southern IO. The pCO2 distribution and its trend decomposition are estimated using the multimodel mean from the CanESM5, IPSL-CM6A-LR, and MPIs models, suggesting that the increase in dissolved inorganic carbon is the dominant factor that contributes to about 70 % of the rise in the total pCO2 trend, and the total alkalinity and sea surface temperature have a secondary role.

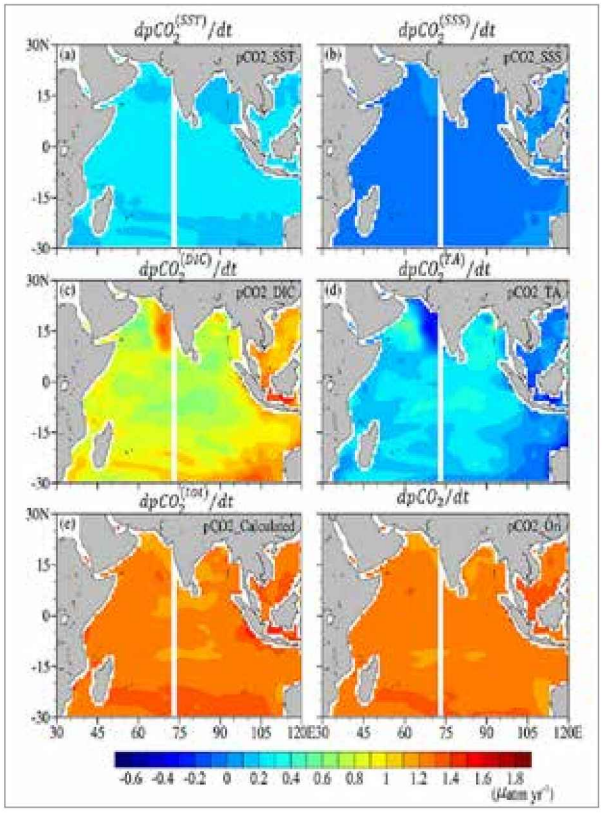


Fig.: Spatial pattern of decomposed pCO2 trend using CanESM5 model for the period 1970–2014 due to change in (a) SST (b) SSS (c) DIC (d) TA (e) total (f) actual pCO2 trend.

Mesoscale eddy variability over the Bay of Bengal in response to the contrasting phases of extreme Indian Ocean Dipole events

The present study is aimed to investigate the mesoscale eddy variability in response to the Indian Ocean Dipole (IOD) events by analysing the two contrasting phases of extreme IOD, the 2016 (negative mode) and 2019 (positive mode). The number of eddies increased and a gradual shift from anti-cyclonic to cyclonic eddies was observed during the positive IOD year. Eddies formed during 2016 had an average amplitude of 0.085m, rotation speed was around 0.345 cm/s and eddy radius, on average was found to be 81.25 km. The presence of a unique eddy feature on the east coast of Sri Lanka was observed which remained as a cyclonic eddy during the negative IOD and as an anti-cyclonic eddy during the positive IOD. The sea surface height anomaly showed a dip of -0.1 m at the core of the cyclonic eddy and a +0.4 m bulge was observed at the core of the anti-cyclonic eddy. A high negative SST anomaly of -0.5 °C was observed at the core of the cyclonic eddy. A drastic increase in the mixed layer depth was seen with the presence of the anti-cyclonic eddy. Analysis of the temperature and salinity vertical profiles showed that the anti-cyclonic eddy had a greater influence on the vertical profile than the cyclonic eddy. Eddy-induced upwelling was predominant in the cyclonic eddy whereas eddy stirring was predominant in the anti-cyclonic eddy.

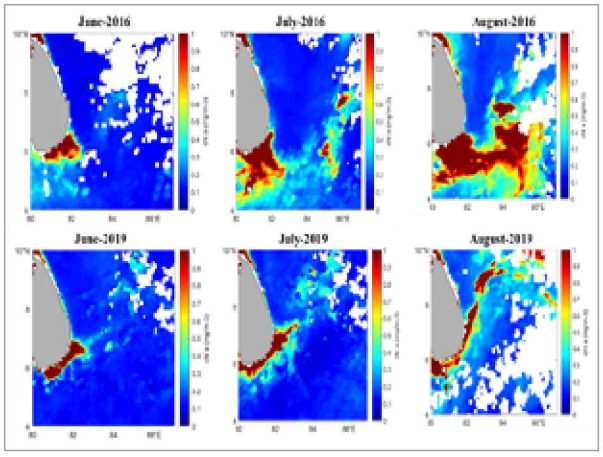


Fig.: Monthly variation of chlorophyll concentration over the Sri Lanka region during the IOD period, 2016 and 2019.

SWOT Mission and 30-years of Multi-Mission Radar Altimetry Data Unveil River Dynamics

Monitoring inland water is crucial for assessing different aspects of the hydrological cycle, as well as environmental and atmospheric processes within the Earth system. Understanding hydrological processes and managing water resources and ecosystem balance depend greatly on tracking changes in water levels. Traditionally, water levels have been observed using in-situ gauging stations; however, the global network of these stations is limited due to costs, accessibility challenges, and economic and political factors. Moreover, the number of global in-situ stations has decreased over the past few decades. Consequently, there has been a growing reliance on satellite observations for monitoring water levels worldwide. Over the last 30 years, satellite radar altimetry has proven to be a valuable method for collecting water surface elevation data.

The recently launched Surface Water and Ocean Topography (SWOT) mission (December 15, 2022), provides global measurements of water surface elevation, river width, and slope. The most awaited continuous water heights along the Ganga River stretch acquired on April 24, 2023 by SWOT Ka-band Radar Interferometers (KaRIns) is shown in the Fig.

1. A clear variation in elevation change from the main river channel to the floodplain is evident upon visual inspection near Varanasi City. The SWOT measurements brings various benefits over altimetry mission such as:

- Comprehensive global spatial-temporal coverage of continental water surfaces
- Two-dimensional water surface elevation
- Monitoring water levels across entire river reaches
- Concurrent collection of water level, water surface slope, and river width data.

Further, these derived hydrodynamic parameters can be used to estimate river discharge using various algorithms. We conducted extensive field survey over Ganga River to evaluate these satellite observations. For further details, kindly follow recently published work "River Water Level and Water Surface Slope Measurement From Spaceborne Radar and LiDAR Altimetry: Evaluation and Implications for Hydrological Studies in the Ganga River," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing".

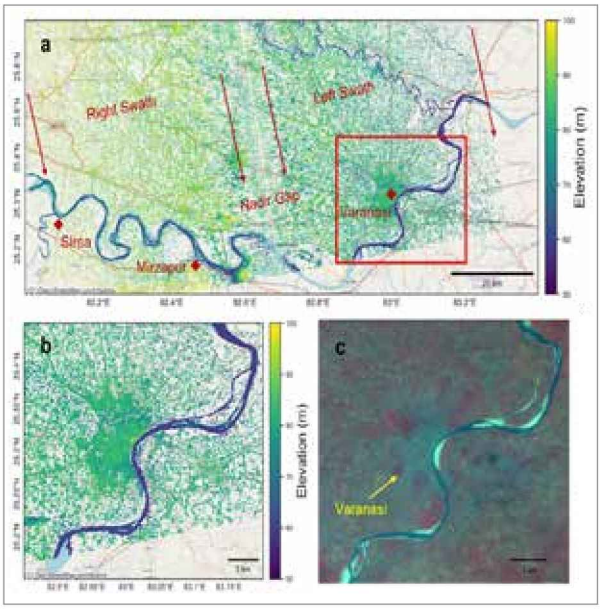


Fig.: (a) 2D water surface elevation (WSE) data along the Ganga River from SWOT, (b) 2D WSE data near Varanasi City, and (c) the area near Varanasi City captured in a LISS-IV false colour composite (FCC) image dated November 21, 2023.

Tracking changes in water levels of inland waterbodies is crucial for understanding hydrological processes and managing water resources and ecosystem balance. Traditionally, this has been done using in-situ gauging stations. However, the global network of these stations is limited due to high costs, accessibility issues, and economic and political factors, and has been shrinking over the past few decades. As a result, there has been an increasing reliance on satellite observations to monitor water levels globally. Over the last 30 years, satellite radar altimetry has proven to be a valuable method for collecting water surface elevation data. The recent launch of the Surface Water and Ocean Topography (SWOT) mission on December 15, 2022, enhances this capability by providing global measurements of water surface elevation, river width, and slope.

To work on comprehensive analysis and evaluation of satellite data (SWOT, radar and lidar altimetry) and its application for river discharge estimation, Mr. Pankaj Ramji Dhote, Scientist/ Engineer SE, Water Resources Department, IIRS was deputed as a 'Visiting Researcher' at Water Management, Uses and Actors (G-EAU) Lab, National Research Institute for Agriculture Food and the Environment (INRAE), Montpellier, France from August 06 to November 04, 2023. During his stay, he actively participated in the SWOT Science Team meeting. He shared insights into the field campaigns conducted in India, presented early results of SWOT data over calibration/ validation orbits, and outlined plans for evaluation along with its diverse hydrological applications.

Fig.: Participants of SWOT Science Team Meeting

Urban Growth in Himalayan Region with Reference to Natural Hazard

Urbanization in the Himalayan region, exemplified by cities like Shimla, presents distinctive challenges due to its susceptibility to natural hazards. This study delves into the intricate dynamics of urban development within the Shimla Municipal Area (SMA), with a focus on built-up density, growth patterns, and the impact of natural hazards. The primary objective is to furnish policymakers and urban planners with insights to cultivate resilient urban environments. Through a meticulous analysis of urban expansion trends and an assessment of the spatial distribution of built-up areas in relation to risk zones, this research aims to provide a comprehensive understanding of Shimla's urban landscape. Advanced modelling techniques are utilized to predict future urban growth patterns, particularly emphasizing their implications for high-risk zones. This predictive analysis aids in identifying areas where future development might intersect with elevated risks, facilitating proactive mitigation strategies and informed urban planning measures. The culmination of these efforts yields findings that not only enrich discussions on urban resilience and sustainability but also offer a roadmap for navigating the intricacies of urban planning in the Himalayan context. Through a blend of rigorous analysis and technological innovation, this research aims to equip stakeholders with actionable insights crucial for managing urban development and hazards in regions undergoing rapid urbanization and environmental pressures. This research contributes to the academic understanding of urbanization dynamics in the Himalayan context while furnishing practical recommendations for addressing the challenges posed by rapid urbanization and natural hazards.

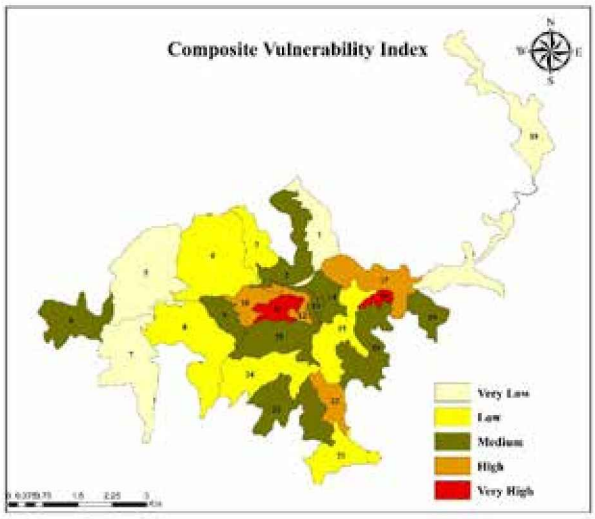


Fig.: Composite Vulnerability Index of Shimla Municipal area

JULES Compatible High resolution LULC tiles-a Collaborative Research work with NCMRWF

Land use land cover (LULC) data plays a vital role in land surface models (LSMs) by providing information about the spatial distribution and features of various land cover types. Joint UK Land Environment Simulator (JULES) is one such LSM that is used to simulate the flow of energy, water, and carbon dioxide between the land surface and atmosphere. It provides a gridded data product referred to as JULES tiles, used in LSM. The nine land surface types used in JULES model includes five Plant Functional Types (broad leaf, needle leaf, C3 grass, C4 grass, and shrubs) and four non-vegetation types (urban, water body, bare soil, and ice). The European Space Agency (ESA) provides the global LULC data through the Climate Change Initiative (CCI), but there are discrepancies in data due to lack of ground validation. A need has been felt to replace CCI LULC with a higher resolution LULC, which is compatible with JULES LSM such that it can provide improved weather prediction over Indian subcontinent. On request of National Centre for Medium Range Weather Forecasting (NCMRWF), Jules Compatible High resolution LULC tiles (five plant functional types and four non- plant functional types) were prepared and shared with NCMRWF by collating multi–source remote sensing derived data products. Resourcesat-2 Advanced Wide Field Sensor (AWiFS) LULC 250k (18 classes), LULC 50k, and Wasteland map 50k from National Remote Sensing Centre (NRSC), crop type from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and vegetation type from Indian Space Research Organization (ISRO), were integrated to create JULES compatible high resolution LULC. Figure presents the delineation of urban areas in JULES compatible high resolution LULC and CCI LULC and the difference image.

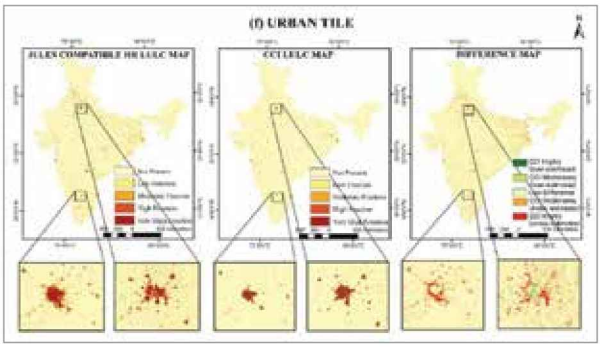


Fig.: JULES compatible HR LULC, CCI LULC and Difference image of both the LULC for urban tiles

Analysing the diurnal changes and trends in land surface temperature and surface urban heat island intensity for Lucknow, India

Understanding the patterns and possible causes of urban heat islands (UHI) effect due to urbanisation-induced anthropogenic activities is an important area in urban climatic research. The present study investigates the day/night seasonal and annual changes and trends in land surface temperature (LST) and surface urban heat island intensity (SUHII) during the

last two decades for Lucknow city. Moderate Resolution Imaging Spectroradiometer (MODIS) LST data products acquired during daytime and nighttime from 2001 to 2018 are processed and analysed for this purpose. MODIS-based aerosol optical depth (AOD) and normalised difference vegetation index (NDVI) products are used to understand the plausible reasons of change in LST and SUHII patterns. The urban (contiguous built-up) and non-urban (surrounding rural) areas are delineated by applying city clustering algorithm on MODIS Land Cover datasets of 500 m spatial resolution. Mann-Kendall and Seasonal-Kendall tests along with Theil-Sen estimator are used for trend analysis. The findings show that the diurnal temperature range (DTR) has decreased from 2001 to 2018 due to higher increase in nighttime LST as compared to daytime. Positive trends in mean annual daytime (0.003 to 0.029 /year) and nighttime (0.069 to 0.078 /year) LST are observed in Lucknow. Seasonal analysis indicate high warming rates during monsoon and summer seasons, particularly during nighttime (0.069 to 0.1 /year). Nighttime SUHII is positive for Lucknow with mean annual SUHII ranging from 1.09 to 2.55 . Decreasing trend in SUHII (-0.023 and -0.009 /year during daytime and nighttime, respectively) is observed over Lucknow due to higher rate of increase in LST in non-urban area as compared to urban area.

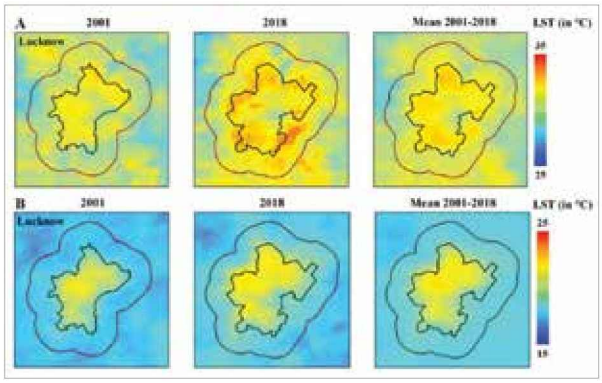


Fig.: Spatial distribution of mean land surface temperature (LST) in and around Lucknow for 2001 (annual mean), 2018 (annual mean) and 2001–2018 (mean of 18 years) for daytime (A) and nighttime (B)

Research Publications

List of Peer Reviewed Paper Publications (FY: 2023-24)

- Kar, S.K, Singh, R.M, Patra, S., Sankar, M., Suresh Kumar. and Singh, A. (2023). Implication of land use shifting on land degradation and restoration potential of conservation agriculture in India's North-West Himalayan region, Geoderma Regional 32 (2023) e00616, https://doi.org/10.1016/j.geodrs.2023.e00616
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Book Chapters/Book Published

- Book chapter titled 'Digital Soil Mapping using Geospatial Data and Machine Learning Techniques' by Justin George K et al, submitted for publication in the book 'Intelligence Systems for Earth, Environmental and Planetary Sciences ' by Elsevier.
- Book chapter published: Kumar, S., Sooryamol, K.R., David Raj, A., Kalambukattu, J.G., Mariappan, S. (2023). Advanced Techniques in Estimating Soil Erosion and Associated Carbon Loss in the Himalayan Region. In: Mishra, G., Giri, K., Nath, A.J., Francaviglia, R. (eds) Soil Carbon Dynamics in Indian Himalayan Region. Springer, Singapore. https://doi.org/10.1007/978-981-99-3303-7_19
- Book chapter published: Ellur Rajath, Justin George Kalambukattu, Dipanwita Haldar and Suresh Kumar (2024) Soil salinity mapping using multisensory data employing machine-learning technique: a case study from Indo-Gangetic plain. In: S. Dharumarajan, S. Kaliraj, K. Adhikari, M. Lalitha, N. Kumar (eds) Remote Sensing of Soils - Mapping, Monitoring, and Measurement. Elsevier, Netherlands. https://doi.org/10.1016/B978-0-443-18773-5.00013-2
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- A book title 'Climate Crisis: Adaptive Approaches and Sustainability' Dr. Suresh Kumar as co-editor was published under Sustainable Development Goals Series (SDGS) by Springer Nature, 2023.
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Deputation

» Mr. Pankaj R. Dhote visited at Water Management, Uses and Actors (G-EAU) Lab, National Research Institute for Agriculture Food and the Environment (INRAE), Montpellier, France from August 06 to November 04, 2023 to work as Visiting Researcher on application of wide-swath Surface Water and Ocean Topography (SWOT) altimetry mission in river hydrology.

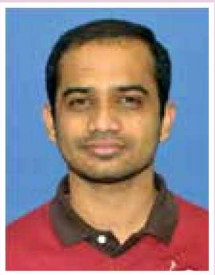
Awards

- Director, IIRS received 'Pride of Uttarakhand Award' by Doon Citizen council on November 01, 2023.
- Dr. Dipanwita Haldar has been conferred the P. R. Pisharoty award by Indian Society of Remote Sensing for the year 2023 during ISGNS held at Pune on November 28, 2023.
- Dr. Surendra Kumar Sharma, Scientist/Engineer-SD has been awarded Ph.D Degree by IIT, Roorkee for his thesis titled 3D Ranging Using Panoramic Images.
- Dr. Asfa Siddiqui, Scientist/Engineer-SE has been awarded Ph.D Degree by IIT, Roorkee for her thesis titled Application of Geospatial Technology for Urban Environment Studies: Delhi Region.
- Dr. Kamal Pandey was awarded the degree of Doctor of Philosophy in Computer Science from Doon University, Dehradun on topic "Web Service Orchestration Architecture for Online Spatial Decision Support System using Mathematical Modelling".

Transfers/ Deputation/ Superannuation/ New-Joinies

» Shri B. S. Negi, Senior Project Assistant, E.C. No. GI00936 superannuated from Indian Institute of Remote Sensing, Dehradun on 31.08.2023 (A/N)

* Shri Ankit Dhiman, E.C.No. GI03061, joined IIRS as Technician- B on 16.02.2024 through direct recruitment.



» Shri Koti Shiva Reddy, Sci./Engr-SE, E.C. No. GI03018 relieved from IIRS, Dehradun w.e.f 24.11.2023 to join NSIL, Bengaluru on Deputation as Manager, Satellite Based Services (Earth Observation).

* Shri Vikas, E.C.No. AC11029, transferred from SAC to IIRS and joined IIRS as Technician-D on 04.03.2024.

Major Events

Ambedkar Jayanti 2023

IIRS celebrated 'Ambedkar Jayanti' to honor birth anniversary of Dr B.R. Ambedkar ji, wherein an official lunch was offered to all staff members of IIRS, CSSTEAP & CISF alongwith JRFs/ SRFs on April 26, 2023.

संसदीय राजभाषा समिति

संसदीय राजभाषा समिति ने दिनाँक 25 मई, 2023 को निदेशक, भा.सु.सं.सं., मंत्रालय एवं विभाग के वरिष्ठ अधिकारियों की उपस्थिति में राजभाषा हिन्दी के वर्ष 2023 कार्यों का अवलोकन होटल हयात सेंट्रिक, देहरादून में किया गया।

World Environmental Day - 2023

World Environmental Day was celebrated in IIRS on June 05, 2023 wherein the 'Tree planting' event and 'Yuva Vaigyanik Sangoshthi' was also organised.

International Day of Yoga - 2023

International Day of Yoga was celebrated in IIRS on June 21, 2023 with active participation by IIRS Employees, Students, Research Scholars and CISF Staff wherein 'Common Yoga Protocol' practices were performed under guidance of Yoga Instructor.

Visit of Hon'ble CM of Uttarakhand

Shri. Pushkar Singh Dhami ji, Hon'ble Chief Minister of Uttarakhand visited IIRS campus in the evening on August 26, 2023 and congratulated ISRO Scientist/Engineers on the successful descend of the lander of Chandrayaan-3 on the surface of the Moon. Director, IIRS along with Dean(A) briefed him about the activities of IIRS, and team-IIRS displayed presentation material including a short-movie on journey of Chandrayaan-3 as shared by CBPO, ISRO Hqs. Senior functionaries of IIRS including GDs, GHs, HoDs, Scientist/Engineer(s) were also present on the occasion. Hon'ble CM planted a tree in IIRS campus and later interacted with students of long-term courses. Directors of prominent centres located at Dehradun including Director IRDE/DRDO; Director, DEAL/DRDO; Director ITM/DRDO; Director, IIP/CSIR; Director, WIHG and DG, UCOST also graced the occasion.

Health Talk by Cardiologist

A health talk on Cardiovascular issues & Adopting Healthy Lifestyle by Dr. Preeti Sharma, Director-Cardiology, Max Super Specialty Hospital, Dehradun was arranged on July 27, 2023. Approximately, 150 No. of Employees, Students (including researchers), and few CISF personnel actively participated in the said lecture.

International Moon Day

The United Nations General Assembly has declared 20 July as 'International Moon Day'. In continuation to the successful launches/ missions of ISRO, the International Moon Day was celebrated on July 20, 2023. IIRS has conducted space quiz and Poster/Painting competition for school students during International Moon Day-2023 during July 14-20, 2023. The event was conducted on request from CBPO, ISRO HQ.

Blood Donation Camp

In collaboration with Indian Red Cross Society, District Branch & Doon Medical College, Dehradun, organised a Blood Donation Camp at Golden Jubilee Hostel on July 28, 2023. During the camp, 48 donors including employees, CISF personnel, students and contractual personnel of IIRS have participated and donated blood voluntarily. A blood donation certificate / donor card was issued to all donors by the Indian Red Cross Society, Dehradun.

National Sports Day

National Sports Day Celebration was organised at IIRS wherein various events were conducted during Aug 21-29, 2023.

India- Bhutan Space Cooperation

Under the ongoing India-Bhutan Space Cooperation programme, a six-day training course (September 11-16, 2023) for thirty-four officials and an Executive Forum (September 18, 2023) for ministers and senior bureaucrats of Royal Govt. of Bhutan was organised at Thimphu, Bhutan by Indian Space Research Organisation (ISRO). ISRO has deputed a team of scientists from different ISRO centres (ISRO HQ, IIRS, NRSC and SAC) to conduct the training programme and also for the Executive Forum. The training and capacity building programme was organised to disseminate knowledge on key aspects of Geospatial technology and its applications, identify stakeholders needs and requirements and to discuss potential remote sensing applications across sectors. The training programme was designed to provide overview of Geospatial technology and applications, and the training was imparted on both theoretical & practical aspects. During the programme, quiz sessions were also organised. GovTech representative kept track of participants' attendance, and the attendees who had at least 90% attendance or above received the participation certificate.

Gandhi Jayanti & Shastri Jayanti

Birth anniversary of Shri. Mahatma Gandhi ji & Shri. Lal Bahadur Shastri ji, was celebrated wherein mass pledge and a cleanliness drive was organised in IIRS campus on October 02, 2023 in IIRS. Daily activities were planned & executed under Special Campaign 3.0-Institutionalising Swachhta during October 02 - 31, 2023 wherein a mass-pledge was administered by all the officials of IIRS, CSSTEAP & CISF staff and other contractual manpower with a resolution to maintain cleanliness through hygiene and sanitation practices in the workplace and residence. Besides aforesaid several other activities were organised like cleaning of rainwater drains, water bodies, water fountains, GLRs, and OHTs to ensure clean water. A cleaning drive was also organised near the auditorium, main-building wherein single-use plastics and other garbage waste were collected, segregated, and handed over to Nagar Nigam vehicle of door-to-door garbage collection. A fumigation drive in office buildings, and hostel buildings was organised to curb the mosquitos and larvae and remove harmful micro-organisms. A cleaning drive for cleaning of storm water drains was conducted by outsourced staff in the housing colony for cleaning and uprooting of rank vegetation, grass.

Vigilance Awareness Week

In this connection, a lecture was delivered by Shri. Mukund Sahai, Ex-Controller of Admn/CSIR, under the Vigilance Awareness celebrations on 13/10/2023 on topic CCS (Conduct) Rules and preventive vigilance with focus on Public Interest Disclosure and Protection of Informer (PIDPI) Resolution.

National Unity Day

National Unity Day (October 31, 2023), IIRS was organised for staff & students of IIRS.

Inter-Centre Sports Meet 2023

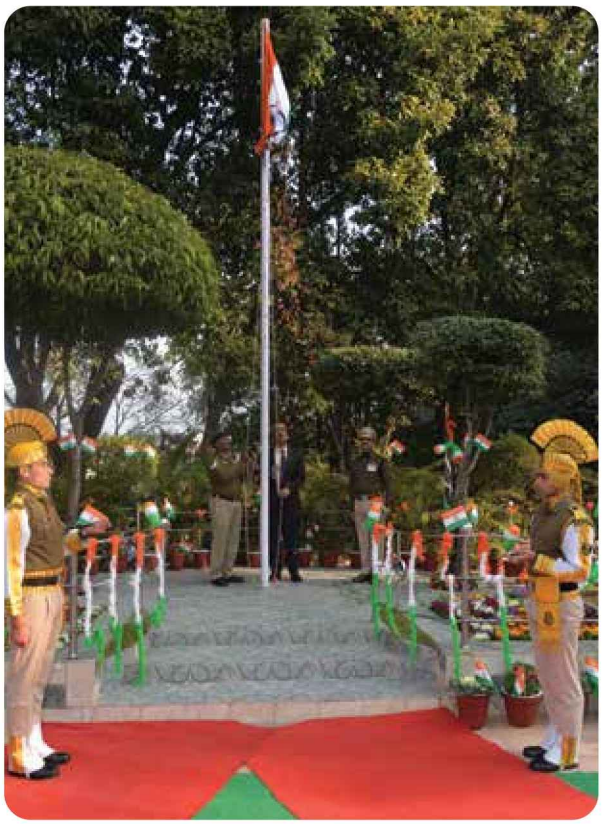
IIRS employees have participated in different events for Inter-Center Sports Meet 2023 which was conducted by NRSC, Hyderabad between 16.11.2023 - 20.11.2023 Phase-I (Athletics) and 23.11.2023 - 26.11.2023 Phase-II (Indoor Games).

Visit of CAG Officials

A meeting with team of representatives from Comptroller and Auditor General (CAG) visited IIRS, on December 05, 2023 for exploring the feasibility of conducting courses in field of RS & GIS.

Republic Day 2024

Republic day was celebrated at IIRS campus and Director, IIRS unfurled the National Flag on January 26, 2024. On this occasion number of programmes were organized in campus including events by CISF like drill, march-past, etc.'



National Voter's Day 2024

On the occasion of celebrating National Voter's Day (NVD theme: 'Nothing like voting, I vote for sure') a pledge was administered to all employees of IIRS at 15:30 HRS at IIRS auditorium on Jan 25, 2024.

Martyrs' Day

Martyrs' Day was observed on January 30, 2024 wherein two minutes' silence observed at 11.00 AM., in the memory of those who sacrificed their lives during the struggle for India's freedom.

Refresher training programme for A.O. working in DOS/ ISRO Centres / Units

'Five day refresher training programme for Account Officers working in DOS/ ISRO centres / Units ' was organized at IIRS campus during Feb 16 -25, 2024 wherein around 35 officers of various ISRO/DOS centers participated.

National Safety Week - 2024

'National Safety Week' campaign spearheaded by the National Safety Council was celebrated during Mar 4-10, 2024 in IIRS wherein staff members of IIRS along with students & contractual staff took safety pledge & participated in various events organized. Safety promotional items were also distributed on the occasion. This year safety week was observed at IIRS with the theme "Focus on Safety Leadership for ESG-Environmental, Social and Governance Excellence". The campaign is aimed at renewing the commitment of employees and general public to work safely throughout the year. Safety pledge was administered in IIRS Auditorium on 04.03.2024 and first aid kit comprising of soframycin skin cream, savlon, compound benzoin tincture I.P., cotton wool, maid grip adhesive tape, scissors and Band-Aid was also deployed at seven locations in the campus.

IIRS Academia Meet (IAM) – 2024

The IAM-2024 on theme 'Remote Sensing of Earth and Beyond @ 2047' was held during March 18-19, 2024 at IIRS. Scientific Secretary, ISRO (chief guest) & Director, NRSC (Guest of Honour) and released album on 'Understanding NWH from Space', 'IIRS CONTACT Newsletter', 'IIRS Science Portal' and 'IIRS Placement Brochure 2024'. Later they inaugurated the exhibition wherein posters on student research & departmental activities were displayed. The IAM comprised of five sessions- inaugural ceremony, a plenary session & a panel discussion wherein besides registered participants, the event was attended by Sc/ Engrs, JRFs/ SRFs, staff, students of IIRS. A feedback session was also organized on Mar 19, 2024 for outreach coordinators of DLP(~ 60 participants).

Visit of CAG Auditors

Principal Director of Audit, Scientific Departments, CAG completed the compliance audit of IIRS activities at campus during March 11 to 28, 2024.

International Women's Day - 2024

International Women's Day was celebrated in IIRS on Mar 22, 2024 wherein Ms. Hiresha Verma, founder & chairperson, Han Agrocare, UK delivered a talk. A poetry & poster competition was organized for IIRS staff. IWD was celebrated in IIRS with the theme 'Invest in women: Accelerate progress'. Ms. Hiresha Verma, Founder & Chairperson, Han Agrocare, Uttarakhand graced the event. A poetry

competition for all the employees of IIRS was also held on occasion of IWD on 21-03-2024.

World Meteorological Day

World Meteorological day was celebrated by IIRS on March 21, 2024 wherein Sri. Bikram Singh, Director, IMD, Dehradun delivered lecture titled, 'Weather Monitoring and Early Warning System'.

MoUs Signed

- An MoU was signed between IIRS & NIH, Roorkee as part of MHAM project on May 09, 2023 at IIRS.
- Director, IIRS is attending the signing ceremony of the MoU between Punjabi University, Patiala and Indian Institute of Remote Sensing, Dehradun at Punjabi University, Patiala on May 30, 2023.
- The Indian Institute of Technology (IIT) Roorkee and the Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, signed an agreement to boost advanced research and education in the field of Space Science and Technology.

हिन्दी गतिविधियाँ/OLIC Activities

भारतीय सुदूर संवेदन संस्थान में हिंदी दिवस/ पखवाड़ा का आयोजन: सरकारी कामकाज में राजभाषा हिंदी के प्रति जागरूकता तथा उसके उत्तरोत्तर प्रयोग में गति लाने के उद्देश्य से केंद्र सरकार के कार्यालयों में प्रति वर्ष हिंदी दिवस/पखवाड़ा का आयोजन किया जाता है। प्रत्येक वर्ष की भांति इस वर्ष भी भारतीय सुदूर संवेदन संस्थान में समारोह 18 से 29 सितंबर, 2023 के बीच आयोजित किया गया | संस्थान के कार्मिकों तथा उनके परिवार के सदस्यों ने दिनांक 18 से 29 सितंबर, 2023 के दौरान विभिन्न प्रतियोगिताओं जैसे निबंध लेखन, हिंदी टंकण (यूनिकोड में), हिंदी टिप्पण व आलेखन, हिंदी भाषा/ व्याकरण ज्ञान, राजभाषा प्रश्नोत्तरी, वाद-विवाद, आशुभाषण, देशभक्ति गीत आदि प्रतियोगिताओं में भाग लिया। समापन समारोह में विभिन्न प्रतियोगिताओं के विजेताओं को 27 अक्टूबर, 2023 को पुरस्कार वितरित किए गए |

वार्षिक हिंदी निरीक्षण: 13 अक्टूबर, 2023 को मुख्य नियंत्रक, वीएसएससी के द्वारा भा सु.सं.सं., देहरादून में वार्षिक हिन्दी निरीक्षण 2022-23 हुआ |

विश्व हिंदी दिवस के अवसर पर 'उपग्रहीय भू – अवलोकन द्वारा पर्यावरण एवं जलवायु का अध्ययन' विषय पर एक दिवसीय हिंदी तकनीकी संगोष्ठी का आयोजन 10 जनवरी, 2024 को किया गया जिसमे निदेशक, भारतीय मृदा एवं जल संरक्षण संस्थान (ICAR-IISWC), देहरादून मुख्य अतिथि थे।

Guest Lecture Series at IIRS

Smt. Nandini Harinath, DD, ISTRAC delivered a lecture titled 'Chandrayaan-3 Mission Operation' on December 14, 2023 at IIRS auditorium which was attended by Scientist/ Engineers from IIRS and students of various courses.

Prof. (Dr.) S. K. Nath delivered a lecture titled 'Glimpses through Extreme Events with Major Focus on Tectonic Events like Earthquake and Landslide, their Initiation, Vulnerability, Risk and Damage Potential Modelling' on November 22, 2023 which was attended by Scientists/ Engineers from IIRS and students of various courses.

Prof. R. K. Mishra Memorial Lecture was organised in IIRS on December 07, 2023 wherein Prof. Kamalnath Bawa delivered a lecture to IIRS Scientists/ Engineers & students.

Dr. A.S. Arya, Group Director, Planetary Sciences & Geosciences Group, SAC, Ahmedabad delivered lecture titled 'ndian Planetary Science Missions - Retrospect & Prospect' on January 08, 2024. Dr. Nishant Kumar, Assistant Professor of Ecology and Conservation Biology, School of Human Ecology, Ambedkar University, Delhi delivered a Guest Lecture titled 'East or West: The Future of human-animal Coexistence in Waste-full Tropical Cities' on February 02, 2024.

Dr. V. K. Dadhwal, Indira Gandhi Chair Professor of Environmental Sciences, NIAS, Bengaluru delivered lecture on 'Understanding Terrestrial Carbon Cycle of India Using Earth Observation Data' on March 21, 2024.

Dr. C.B.S. Dutt, Former, DD, NRSA & PD, IGBP, ISRO-HQ delivred lecture on 'Space Applications for Climate Change – Physical basis' on March 20, 2024.

Other Infrastructural Improvements

Facility upgradation (civil construction): Activities accomplished in 2023-24 by CMD

- Double insulated roofing system structure works of Auditorium block in New Academic Block is completed
- Construction of the Security watch tower near the International hostel is completed.
- SITC of 100kVA UPS system completed.
- Installation of Photo flashing system at security gate completed.
- Construction barrier fence beside the campus boundary wall (phase-I) is completed.
- Construction of patrolling track at North Eastern stretch of RCC retaining wall and providing GI chain link fencing
- Replacement of age-old battery bank and buyback of old battery bank of 2x120kVA parallel redundant system completed.
- Replacement of age-old Fire hydrant system.

Auditorium in NAB Block #1

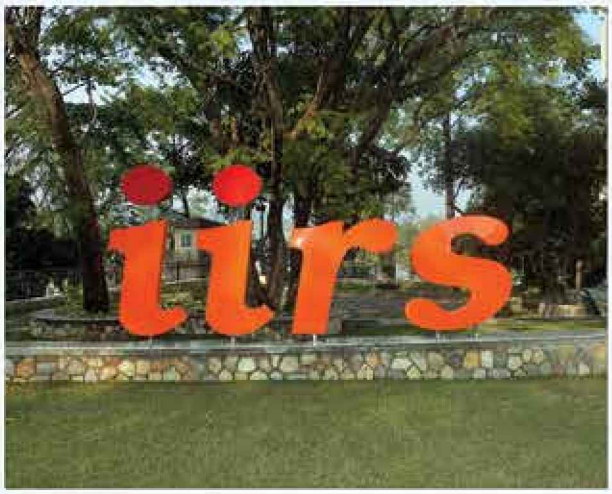
Auditorium in NAB Block #2

Watch Tower #1

Barrier fence beside the campus boundary wall

Patrolling track at North Eastern stretch of RCC retaining wall

New Fire hydrant system



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