Annual Report
वार्षिक रिपोर्ट
2020-2021

North Eastern Space Applications Centre
Department of Space, Government of India
Umiam, Shillong, Meghalaya
www.nesac.gov.in

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Compiled and Edited by

Editorial Team

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Reviewed by

Shri P.L.N. Raju, Director, NESAC

Vision

To play catalytic role in holistic development of North Eastern Region of India by providing Space Science and Technology support at all possible levels.

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Organisation: North Eastern Space Applications Centre

Address: Department of Space,
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has been assessed and found conforming to the following requirement

Standard: ISO 9001:2015

Scope: Providing Value Added Services for Natural Resource Management and Disaster Management Support using Space Technology

Certificate No.: IRQS/200100548

Original Certification Date: 05/04/2017

Continuation Granting Date: 20/04/2020

Current Date of Granting: 23/09/2020

Expiry Date: 03/04/2023

Indian Register Quality Systems NABCB QM 006

Shashi Nath Mishra
Head IRQS

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Head Office: 52A, Adi Shankaracharya Marg, Opp.Powai Lake, Powai, Mumbai - 400 072, India.

Mission

To provide data, information, knowledge, and services to the society, industry, and government by scientific and systematic studies on natural resource management, infrastructure planning, healthcare, education, satellite communication, and disaster management support, and to set up a space and atmospheric science research hub.

Director's preface

North Eastern Space Applications Centre (NESAC), under the aegis of the Department of Space, Government of India has been making sincere effort in harnessing the benefits of space technology to provide overall developmental support to all 8 states of NER.

During the year 2020-21, NESAC has increased the scientific activities of the centre significantly with a number of new projects and activities have been taken up covering all the 8 states of NER, while completing a number of important projects despite the COVID-19 pandemic situation.

As part of the second phase of the CHAMAN project, mapping of potential areas for the expansion of horticulture has been completed in 16 priority districts of NER. A mobile app and a dashboard system have been developed for planning and monitoring of Crop Cutting Experiment (CCE) in Meghalaya. Meghalaya Rice Information System (MeRIS) has been developed by NESAC in collaboration with the Department of Agriculture, Govt. of Meghalaya. Geotagging of assets created under the NERTPS programme of CSB in NER is in the final stage of completion.

Preparation of forest working plan for different forest divisions in Arunachal Pradesh is being carried out using remote sensing and GIS inputs. Mapping of shifting cultivation area and estimation of Jhumia population depending on shifting cultivation in the region is being executed under the ISRO-NNRMS programme. Mapping the bamboo resources for the state of Meghalaya has been initiated during the year. A study on wetland change detection in Deepor Beel, Guwahati, Assam has been carried out with funding support from North Eastern Council.

In the area of Hydrology and Water Resources, NESAC has taken up the expansion of FLEWS services to other flood prone rivers of North East India, after the successful implementation of FLEWS in Assam. FLEWS programme in Assam has achieved a success rate of about 80% for the actionable flood alerts issued at the revenue circle level with a lead time ranging from 24 to 48 hours. As part of the Assam River Atlas project, a geoportal comprising of all the generated layers, various functionalities and high resolution maps have been integrated. NESAC continues to work on monitoring and evaluation of IWMP watersheds for NE India.

As part of Urban and Regional Planning, the centre has been actively involved in the generation of GIS database layers for the Shillong Planning area under the AMRUT sub-scheme. Preparation of a draft GIS based master plan for the Shillong Planning area has been completed. In the area of Geosciences, surveying of mining lease boundaries of the Star Cement Limited, East Jaintia Hills, Meghalaya has been completed using DGPS. NESAC carried out mapping of coal mining areas for planning and restoration of areas affected by coal mining in Meghalaya with the financial support of the Meghalaya State Pollution Control Board (MSPCB).

North Eastern Spatial Data Repository (NeSDR) Geoportal with large volume of datasets covering all 8 states of NER was released in November 2020. Governance applications have been developed for the various government departments of the region and hosted in NeSDR platform. NESAC continues to work on the geo-tagging and geo-monitoring of NEC/MDoNER sponsored project sites. NESAC is utilising a number of AI/ML/DL algorithms and

tools for near real-time predictive analysis, feature extraction and pattern recognition. NESAC has also successfully completed three AI/DL based projects of DTDI, ISRO Hq.

During the year, NESAC has added Trinity F90+ VTOL UAV into its fleet, which increased the surveying capacity manifold. The centre has been providing operational UAV services in all the 8 states of NER. The work on suitable route alignment planning for the construction of Mahadev-Toloi-Pfutsero road using remote sensing & GIS inputs is in progress as per schedule.

NESAC is implementing ISRO's societal development programs like Tele-Education, Tele-Medicine and Emergency Communication System through the utilization of Satellite Communication Technology. Under the Tele-education project, all the seven HUBs cum Teaching end and 330 Satellite Interactive Terminals (SIT) were operational in all the NE states during the year. Hundreds of live and recorded programs were telecasted by these networks in 2020-21 during the Covid 19 pandemic time. A survey for the setting of internet based networks for online classes in Arunachal Pradesh has also been carried out.

In the Space and Atmospheric Science area, the major activities carried out at NESAC include vertical profiling of black carbon along Brahmaputra Valley of NER, characterization of planetary boundary layer heights over NER, Study on seasonal variation of mixing layer height over Umiam using Vaisala Ceilometer data, Validation GPM precipitation estimates over eastern Sub-Himalayan river basin, etc. In addition, the centre has taken up some more important studies such as on lightning climatology over India using in-situ lightning data, forecast of lightning activity using numerical weather forecasting model, development of thunderstorm tracking system, etc.

NESAC celebrated its 20th Foundation Day on 7th September 2020, commemorating twenty years of its dedicated services in space technology applications benefiting NER. A virtual meet on "20 years of NESAC-the journey towards excellence" was organised to mark the occasion, where the Hon'ble Chief Minister of Meghalaya was invited as the Chief Guest.

NESAC conducted its 9th Society Meeting at NEC, Shillong on 23rd January 2021, chaired by Shri Amit Shah, Hon'ble Union Home Minister & President, NESAC Society. The meeting was also attended by Dr Jitendra Singh, Hon'ble Minister of State (Independent Charge) for the Ministry of DONER; Dr. K. Sivan, Secretary, DOS and Vice President, NESAC Society; Dr. Inder Jit Singh, Secretary, Ministry of DONER; Shri K. Moses Chalai, Secretary, NEC; Chief Secretaries from six NE states; Senior government officials from NE states, NITI Aayog, and ISRO/DoS.

Even under the pandemic situation, NESAC has expanded the outreach activities by providing training programmes in online mode in the area of disaster management, satellite meteorology, satellite communication & satellite navigation, Forestry & Ecology, Agriculture, Geosciences etc. A special training program for scientists from ICAR was also conducted. Certificate course on "Basics of Remote Sensing and Geographic Information System" was also conducted online.

NESAC, jointly with the Indian Meteorological Society (IMS) organised TROPMET-2020, the annual national symposium of IMS during 14th-17th December 2020 on virtual mode with the theme "Weather and Climate Services over Mountainous Regions". The symposium had received overwhelmed response with more than 450 registrations and 315 abstracts.

NESAC has also established a 'Space Corner' at Don Bosco Centre for Indigenous Cultures (DBCIC), Shillong which was inaugurated by Chairman, ISRO on 23rd January 2021.

I convey my sincere appreciation to all the Scientists/Engineers and other staff of the centre for their commendable work and earning laurels for the centre. I also convey my appreciation to the Editorial team for bringing out the Annual Report in time.

(P.L.N. Raju)

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Director, S&T, North Eastern Council, Shillong

Invitee
Joint Secretary (F), DOS, Bangalore

Member Secretary
Director, North Eastern Space Applications Centre, Umiam

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ABOUT THE CENTRE

North Eastern Space Applications Centre (NESAC), a joint initiative of the Department of Space (DOS) and the North Eastern Council (NEC), is a society registered under the Meghalaya Societies Registration Act, 1983. The centre has provided more than 20 years of dedicated service to the eight states of the North Eastern Region (NER) of India using space science and technology. The major objectives of the centre are: 1) To provide an operational remote sensing and geographic information system aided natural resource information base to support activities on development/management of natural resources and infrastructure planning in the region. 2) To provide operational satellite communication application services in the region in education, health care, disaster management support, and developmental communication. 3) To take up research in space and atmospheric science area and establish an instrumentation hub and networking with various academic institutions of NER. 4) To enable single window delivery of all possible space based support for disaster management. 5) To set up a regional level infrastructure for capacity building in the field of geospatial technology.

Management of the Centre

All policies, affairs, business of NESAC are decided by the NESAC Society. Chairman, NEC presides over the NESAC Society and the Secretary, DOS/ Chairman, ISRO is the Vice President. Other members of the Society are - Secretary, NEC; Chief Secretaries of the eight NER states, senior scientists from DOS and NEC and academia of NER. A Governing Council (GC), under the advice of the Society, manages the activities of the Society/Centre. Secretary, DOS/Chairman ISRO is the chairman of the GC and Secretary, NEC is the Alternate Chairman. Chief Secretary, Meghalaya; representatives of the governments of the NER States and representatives of central government agencies in the region are the other members of the GC.

Scientific Programs

The scientific programs of the centre are guided by the needs of the region and are reviewed yearly by the NESAC Society and GC. During the current year, NESAC has taken up and completed several projects covering the NER states in the areas of natural resources management, infrastructure planning, health, education, satellite communication and atmospheric science research. The centre has implemented a number of application projects sponsored by user agencies in the region, National/ regional projects funded/coordinated by ISRO-DOS Centres, research and developmental projects under Earth Observation Applications (EO-A), Satellite Communications (SATCOM) programs, Disaster Management Support (DMS) program under the North Eastern Regional node for Disaster Risk Reduction (NER-DRR) and Space & Atmospheric Science Programs under the Atmospheric Science Program (ASP).

Facilities

NESAC is located at Umiam about 20 km from Shillong, Meghalaya State. NESAC Guest House and the residential complex are located about 1 km from the office complex. The centre is well equipped with state of the art facilities in the areas of Remote Sensing (RS) and Geographical Information System (GIS), Disaster Management, Satellite communication and Space & Atmospheric Science Research.

Remote Sensing (RS) and Geographical Information System (GIS)

The centre has got state of the art servers and workstations for geospatial analysis and digital image processing, very high-end systems for photogrammetry, hydrological modelling, etc., GIS and GNSS (Global Navigation Satellite System) equipment, Echo sounder, high quality output devices, etc. The centre has a rich collection of

satellite data from Indian and foreign remote sensing satellites, covering the entire NER, reference maps and other ancillary data of the region. NESAC is well equipped to process data from a wide variety of platforms to enable digital image processing, geospatial analysis and location based services. Capabilities and expertise do exist from both Commercial off-the-shelf (COTS) and open source software for data analysis. The centre also has in its possession the Digital Plant Canopy Analyzer to measure leaf area index, Spectro-radiometer to measure spectral reflectance at the close narrower interval for the creation of a spectral library.

Information Technology and Computing facilities

NESAC has state-of-the-art IT facilities comprised of high-end workstations and servers for providing computing needs of various scientific/technical staffs and academic outreach programmes. The robust web hosting infrastructure available at the centre is being actively used for providing IT operational services in NER for different user groups. The Local Area Network (LAN) with 1 Gbps Ethernet backbone is used to connect all the scientific groups and laboratories, administrative departments and other facilities in a secure way. The Internet connectivity having 1 Gbps bandwidth availed through National Knowledge Network Optical Fiber Cable (OFC) is being used to provide internet services to NESAC office and Outreach buildings, including 24x7 operational services for providing data and applications. Apart from providing internet services, the NKN with 1 Gbps bandwidth is being used extensively for conducting online meetings, discussions and short courses. ISRO's private Space-net connectivity is used for attending official meetings and secure streaming applications within the ISRO/DOS network.

The centre is well equipped with all relevant GIS and Remote Sensing tools such as high end systems and software for performing remote sensing information retrieval and data analysis, large scale mapping and ground trothing activities. Latest map plotters, printers, GPS systems and cameras including GAGAN, NAVIC and DGPS for professional grade surveys and ground thruthing are part of the IT infrastructure that support mapping activities by various groups in the centre. Sufficient numbers of software, both in the form of proprietary and open source, for carrying out image processing and GIS projects have been procured and are being upgraded as necessary.

The centre now houses multiple high-end servers including redundant servers, storage and sophisticated communication networks guarded by application-aware firewalls for the live hosting of numerous user-centric applications and data sharing gateway in a secure manner. Important data-centric applications such as North Eastern Spatial Data Repository (NeSDR) for centralised repository and delivery of standardized quality geospatial data to multiple users across NER, Geotagging and Geomonitoring based applications for project monitoring of all physical projects and Geotagging of assets in pan India and other critical applications for disaster management are some of the major applications, which has been successfully made operational from the centre. NESAC also maintains a separate hosting infrastructure exclusively for disaster risk reduction activities in the region. All data delivery and dissemination pertaining to all forms of disaster mitigation are being hosted from this infrastructure. The infrastructure also has a High Performace Computing Cluster (HPCC) configured to run process-intensive activities such as weather forecasting, flood prediction models and numerous other R&D models. It has one master node (20 cores) and ten compute nodes (152 cores) with 20 TB storage (SAN). The system is interconnected with high bandwidth InfiniBandswtich. The HPCC is further being augmented with additional 50 TB storage to accommodate the parallel running of multiples data-intensive applications. Additionally, a number of scientific models and software tools

like weather research and forecasting (WRF) to support flood early warning system (FLEWS), Regional global climate model (REG GCM), WRF Elec for forecasting lightning along with other open sources tools/library like FORTRAN and C compilers and Python, etc. Agisoft PhotoScan software was also installed in a clustering environment to process and generation of 3D data acquired by UAV/Drones.

Recently, the centre has been equipped with a state-of-art GPU facility to perform advance big data analytics on remotely sensed imagery. Several AI/ML models have been built to automate general remote sensing pipelines for feature extractions. Operationalisation of such models are being undertaken for quicker yet precise delivery of user-centric data products for effective decision making.

Satellite Communication

NESAC has got advanced satellite communication facilities to support various developmental programs in eight states of NER. The facilities available are: SATCOM studio for content generation in various subject matter; Spacenet system for video conferencing and data transfer activities amongst DOS/ISRO centres, ISRO DMS-VPN node, transportable VSAT system and satellite phones for communication support under disaster conditions. NESAC has hosted one of the four ground stations to have NAVIC/ data reception and monitoring facility on a 24X7 basis as part of the satellite navigation programme of ISRO. The centre also has various equipment like Beacon receiver, Radiometer, Laser Precipation Monitor (LPM), rain gauge, etc. to conduct the Ka-band propagation experiment in collaboration with SAC, Ahmedabad and ONERA, France. The centre also has various equipment under the NAVIC SPS-GPS receiver experiment.

Space and Atmospheric Science Research

The centre has a dual-polarised S-band Doppler Weather Radar (DWR) installed at Sohra (erstwhile Cherrapunjee), Meghalaya, for studies in early warning of hydro-meteorological disasters, convective systems, cloud and precipitation physics, etc. A network of 17 automatic weather stations (AWS) has been set up to support flood forecasting activities. The group operates and manages three multi-instrumented aerosol observatories (at NESAC, Umiam; Tawang, Arunachal Pradesh; and Lachung, Sikkim) set up in collaboration with Space Physics Laboratory, Thiruvananthapuram, for Spatio-temporal characterisation of aerosols and its impact on weather and climate over the Himalayan region.

The centre hosts a Multi-Wavelength Radiometer (MWR), Sunphotometer, Aethalometer, MicroAeth, Integrating Nephelometer, Electric Low Pressure Impactor (ELPI), etc. for physical and optical characterisation of aerosols. To study the atmospheric boundary layer Physics and dynamics, the centre has Dr. Pisharotysonde (GPS based) launching facility with hydrogen gas filled balloons and a 32 m tower with fast response 3D sonic anemometer and other meteorological instruments at four levels (at the heights of 6 m, 10.5 m, 18 m, and 30 m). A Cloud Condensation Nuclei (CCN) counter, Disdrometer, and one Ceilometer has been installed to study cloud microphysical properties and the aerosol-cloud interaction over the NE region. A tethered balloon launching facility is established for vertical profiling of aerosol using lightweight instruments. The group also has a high performance parallel computing system with several numerical weather prediction models installed along with necessary compilers, libraries, and post-processing tools.

Library

NESAC Library aims at providing "Anytime, Anywhere access" with state-of-the-art expertise, infrastructure and services, caters to the information requirements of the user community of the organisation and houses varied subject collections in both print and online formats.

During 2020-21, the library had added 1833

resources, including 1527 eBooks, 4 books, 103 e-Journals, 203 journal/magazine/newsletter issues and 23 technical reports. The total catalogued records of the library are now increased to about 17 thousand including all items. The library continues to have access to IEEE/IET Electronic Library, Springer Nature & Scientific American e-Journals through Antariksh Gyaan (ISRO Library Consortium) and 19 periodicals through the library subscription. Access to 102 Wiley e-Journals, 970 Springer Engineering collection (2020) eBooks and 557 Earth & Environmental Sciences Collection (2020) eBooks through AntarikshGyaan were added to the existing collection during this period.

During the year 2020-21, total physical footfalls to the library were recorded to be 854. The library had registered 31 new members and a total number of 1600 circulation transactions were carried out during the period. The library homepage continued to be the gateway to all kinds of information resources. Soft copies of all the student reports/ theses and technical reports were uploaded to the Digital Repository of the library. The library has also subscribed to Drillbit plagiarism checking software during this period.

Unmanned Aerial Vehicle Facility

NESAC has expanded the spectrum of activities in the field of UAV systems and its applications in the field of Remote Sensing, Disaster Management, Security & Surveillance, Payload delivery etc. At present, more than ten different types of UAV platforms are operational & in the experimental stage, which include multi-rotors, fixed wings, and VTOL Fixed wing UAV at NESAC. NESAC is also having a large no of payloads such as RGB cameras (12-42 Mps), multiband multispectral sensors (5/10 bands), thermal sensors, etc. The centre has been providing end-to-end UAV services for various user communities in the NE region and in the country. The centre is well equipped with state-of-art data processing facilities (both hardware and software with automated and semi-automated systems) for high-quality products like 3D Mesh, Point Clouds, Digital Surface Models, RGB/MX/Thermal Orthomosaics, etc. The centre has conducted 28 UAV surveys in the year 2020-21 for different user departments in NER. NESAC has also registered all its UAVs on the Digital sky portal and trained persons as Remotely Piloted Aircraft System (RPAS) pilots as per DGCA norms.

The centre is also extensively involved in research and development activities related to UAV systems, payload mechanism, mission planning etc. and has an advanced UAV lab with different tools & equipment. With the advancement of 3D printing technology in NESAC, in-house mini UAVs for the experimental purpose has also been developed. UAV R&D team has successfully developed and demonstrated the concept of tethered UAV for continuous surveillance, drop mechanism for dropping of medicine, food and relief material at the time of the disaster, etc. The team has also integrated NAVIC based VTS (vehicle tracking system) for monitoring of UAVs and PPK (Post-Processing Kinematic) module for improving the accuracy of data.

Sports and Recreation Facilities

NESAC Recreation Committee organised many events throughout the year. Various recreational programs were organised as part of the Foundation Day Celebration of NESAC on 7th September 2020. A month long event of various sports competitions was organised prior to the celebration. Badminton, Table Tennis, Squash, Volleyball, Cricket, Football, etc. were among various indoor and outdoor sporting events. Competitions were also organised in Creative Writing, Drawing, etc. Prizes were distributed to various winners of these competitions on 7th September 2020. Due to the ongoing COVID-19 pandemic, recreational events could not be organised as part of celebrations of Independence Day on 15th August 2020 and Republic Day on 26th January 2021. NESAC Staff have used various recreational facilities of NESAC including Gymnasium, Squash Court, and Badminton Court facilities, etc. during the period. The newly constructed state-of-the-art Squash court was inaugurated by Shri Conrad K. Sangma, Hon'ble Chief Minister of Meghalaya on 7th September 2020.

AGRICULTURE & ALLIED AREAS

Mapping of potential areas for horticultural development under CHAMAN program

Considering the paramount importance of the horticulture sector for the holistic development in NER, NESAC was given the responsibility of coordinating the CHAMAN (Coordinated Horticulture Assessment and Management using GeoiNformatics) project in 8 states of NER by the Ministry of Agriculture and Farmer's Welfare in collaboration with the State Remote Sensing Application Centres (SRSACs) of NER. The CHAMAN project is being executed by Mahalanobis National Crop Forecast Centre (MNCFC), New Delhi under the Mission for Integrated Development of Horticulture (MIDH).

After the successful completion of the first phase of the CHAMAN project, where site suitability analysis was carried out for selected horticultural crops in 8 selected districts of NER (one district for each state), a similar study for the second phase was approved by MNCFC. In the second phase, additional 16 districts of NER (1 priority crops per district) were selected for the site suitability study.

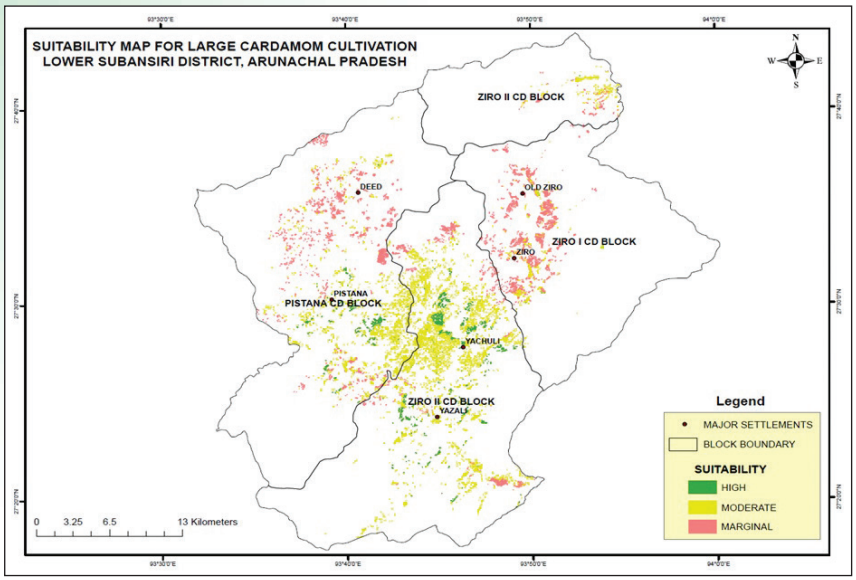
Multi-criteria Decision Making (MCDM) tools viz. Weighted Overlay Analysis (WOA) was used to access suitable areas for cultivating horticultural crops. Multi-temporal and multispectral satellite imagery of RESOURCESAT-II Linear Imaging Self Scanner Sensor-IV (LISS-IV) for the period of 2017-2018 was used for the identification of culturable wastelands following visual interpretation technique. Soil map of 1:50,000 scale has been used for extracting required soil physical and chemical parameters. Digital Elevation Model (DEM) generated from stereo-pair of IRS-P5, CARTOSAT-1 satellite imagery (CARTO-DEM) was used for delineating physiographic parameters. For potential site selection, physiographic factors, soil and culturable wastelands data were integrated into GIS software. The rank weighted overlay technique has been used for the identification of suitable areas.

Unmanned aerial vehicles (UAV) available with the SRSACs (Model: DJI Matrice 100) assisted in covering inaccessible areas such as steep slopes and deep gorge areas.

UAV image of Jaintia Hills district of Meghalaya showing Turmeric and other crops

UAV survey for Pineapple plantations near Tamaram Village, Senapati district, Manipur

Required crop parameters in terms of physiography, soil, land use and climate were considered for identifying three categories of site suitability viz., highly suitable, moderately suitable and marginally suitable. Among 12 selected crops, pineapple crop was selected for maximum 4 districts and found 4.6% to 13.2% of the total geographical areas (TGA) of the selected districts are suitable for growing this crop. Jaintia Hills district of Meghalaya selected for turmeric crop has the highest suitable areas in terms of geographical coverage (131956 ha). A wide range of orange varieties grown



Suitable sites for large cardamom cultivation in Lower Subansiri District, Arunachal Pradesh

in NER and identification of suitable areas for the orange crop was carried out in three districts, viz., Kamle (Arunachal Pradesh), Tamenglong (Manipur) and Wokha (Nagaland) and delineated 9.18%, 3.05% and 18.02% of the TGA of the districts as suitable areas. Kiwi crop is emerging as a promising crop in the region and suitable areas have been delineated that represent 1.43%, 14.95% and 0.11% of TGA in Ukhrul (Manipur), Phek (Nagaland) and East Sikkim. Another newly introduced crop viz., dragon fruit has been found to bear a lot of promise with 18.44% and 3.47% of the TGA in Serchhip and Aizawl districts of Mizoram are found suitable for growing this crop. Other selected crops like large cardamom for Lower Subansiri (Arunachal Pradesh) and West Sikkim, Assam Lemon for Nagaon (Assam), potato and areca nut for East Khasi Hills and East Garo Hills districts of Meghalaya has 2-18% of TGA suitable for growing these crops. UAV based ground truth collection shows acceptable accuracy in the delineation of the potential areas for growing of selected horticultural crops.

The study reveals that there is a large extent of areas suitable for expansion of commercially important horticultural crops in the selected districts ranging from 0.11% to 35.35% of the total geographical area of the district. The site suitability studies undertaken, using geospatial technology provides excellent scope for harnessing large areas lying unutilised and underutilised, which are otherwise suitable for growing economically important horticultural crops.

Geospatial technology for acreage estimation of selected crops and development of a mobile app for planning and monitoring of CCE in Meghalaya

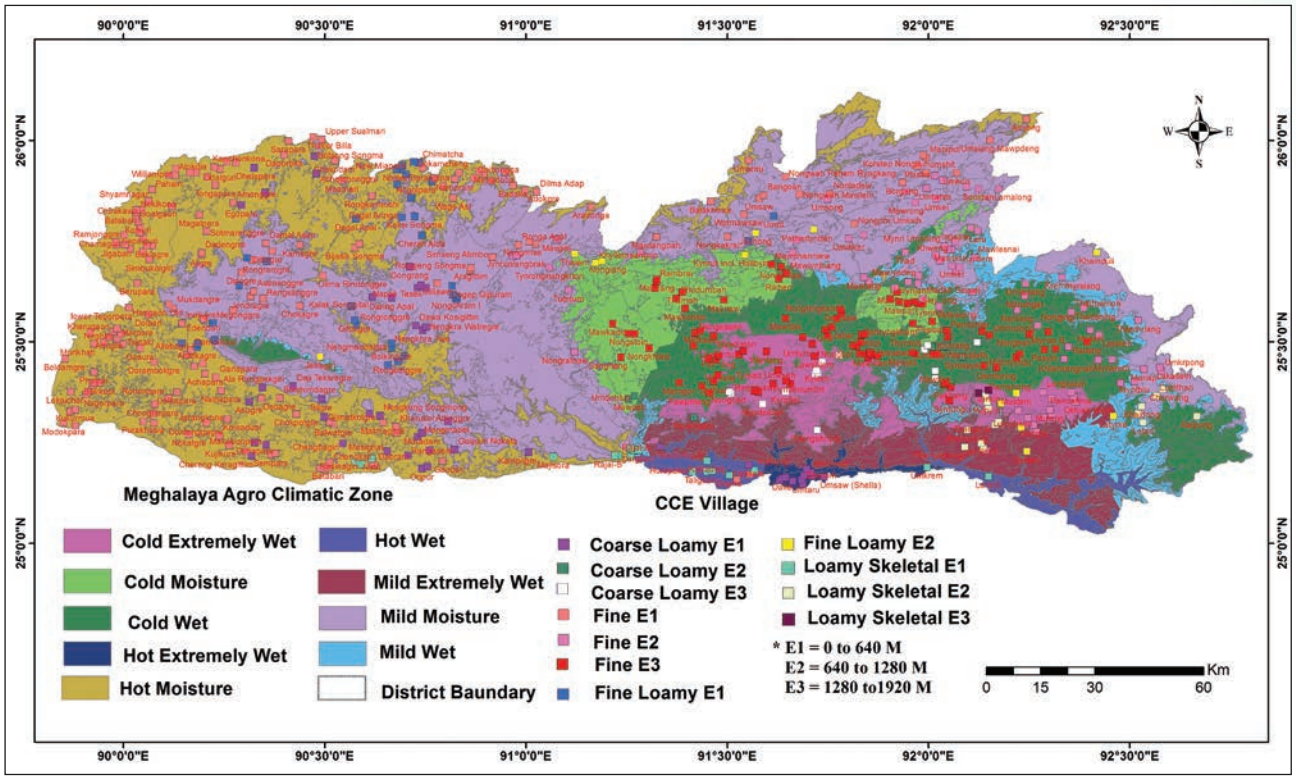
Agriculture plays the most vital role in the economy of our country and an accurate and precise estimate of the yield of the principal crops is very important. A pilot study for estimating the area and production under major crops in Meghalaya has been taken up using geospatial technologies with a view to improve the existing system of crop acreage estimates. The pilot study has been taken up as a part of SSS (Support for Statistical Strengthening) programme of the Ministry of Statistics and Programme Implementation (MOSPI), Govt. of India.

Seven crops namely winter paddy, autumn paddy, summer paddy, maize, summer potato, winter potato and rubber have been selected for this study. The study on winter paddy, autumn paddy, summer paddy and maize will be for the entire state, whereas the study on summer & winter potato will be carried out in East Khasi Hills district. The study on the rubber, on the other hand, is being carried out in West Garo Hills District. The estimates on these crops are more of satellite based estimates, whereas the estimates of other minor crops covered under CCE (Crop Cutting Experiment) will be based mostly on the field survey.

Acreage estimation of the field crops is being made using high resolution satellite data (LISS-IV, Sentinel-2) supported with field surveys.

Synthetic Aperture Radar (SAR) data (Sentinel-1 and 2, C-band) have been used to delineate the crop fields during the Kharif season when cloud free optical data are not available. Temporal SAR data are taken from July onwards till November, covering sufficient phenological spacing in order to identify Kharif crops.

A GAGAN (GPS aided Geo-augmented Navigation) based mobile app for Android operating system has been developed to make CCE exercise more efficient and effective. The App has the advantage of acquiring real time data by immediate transfer (upload) of data to the web interface. Moreover, geo-tagging, photography and time stamping improve the data quality for effective monitoring



Distribution of CCE villages over agro-climatic zones, soil types and elevation

Ancillary data (soil types, elevation map, village location, agro-climatic zones) were utilised for preparing a stratified map of different rice ecosystems of the state so that an optimum sampling plan can be made for CCE. UAV surveys (October 21-31, 2020) were conducted with multispectral and RGB sensors in selected sample locations (27 villages in 8 districts) covering different strata of rice ecosystems. The collected data were processed in Pix4D Mapper Software and various indices were generated to correlate with CCE field data. This has led to the development of yield models for yield assessment of the selected crops. These models require more trials and validation for operational use.

of CCE. The CCE mobile application is designed to operate both in the online and offline mode, taking the poor internet connectivity in the rural areas into consideration.

Meghalaya Rice Information System (MeRIS)

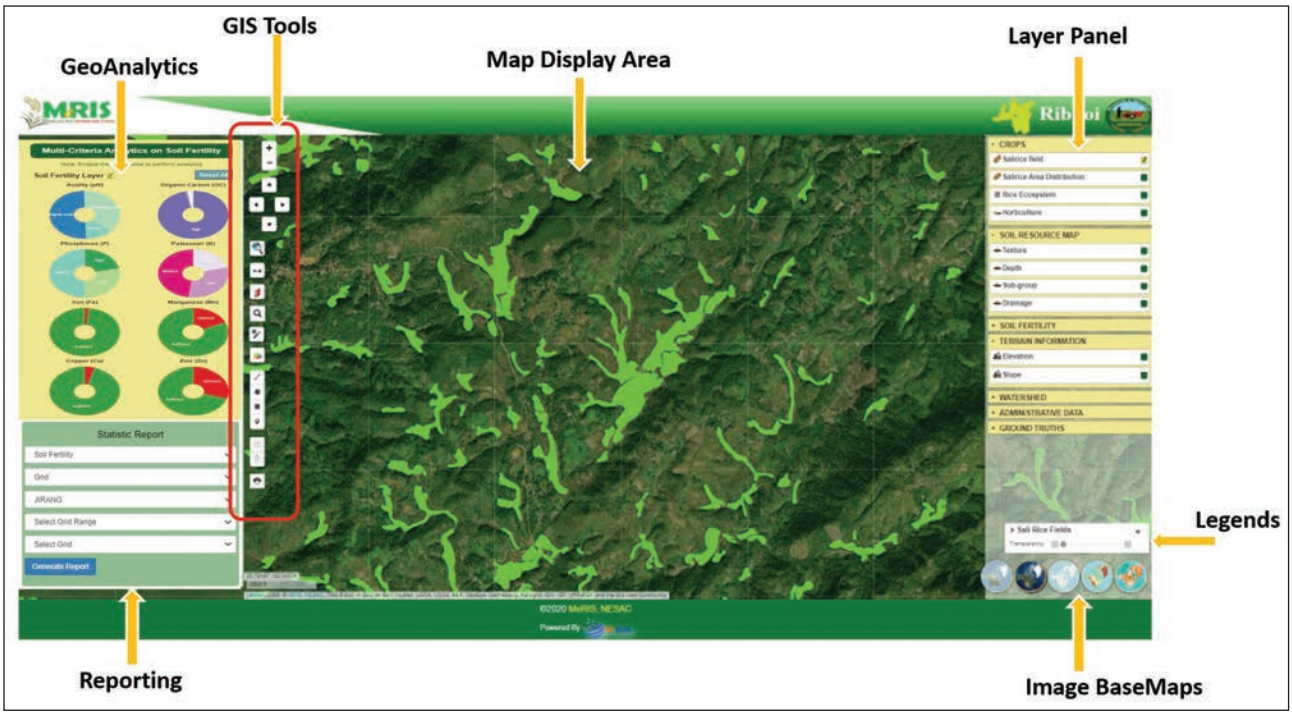
Based on the requirement of the Directorate of Agriculture, Govt. of Meghalaya, NESAC has completed three projects on i) Mapping of boro paddy areas in the State of Meghalaya including suitability analysis to extend the potential areas under boro rice and ii) Identification of block wise sali paddy (winter rice) areas in Meghalaya using remote sensing, GIS and ground based

observations iii) Creation of District-Wise Soil Fertility Maps for Meghalaya. In addition to these projects, NESAC has prepared/procured soil map of 1:50,000 scale for the entire Meghalaya which are being utilised for finding suitable sites for different crops and also for other planning purposes. The databases created under different projects can be integrated as geo-spatial layers, through a single geo-portal which can be utilised by the department of agriculture for planning, targeting and increasing production and productivity of different crops in order to promote food security goals of the State. Therefore, Directorate of Agriculture, Govt. of Meghalaya requested NESAC to develop a geoportal (webportal with spatial database) where all databases related to rice and soil will be available through one single window. In response to the request, NESAC has taken up this project and completed the work and the web portal is available in public domain.

developed for interactive visualisation, navigation, perform GeoAnalytics and multi level reporting at district, blocks, village and grid on different rice crops in Meghalaya for immediate use in the planning process. We have used state-of-the-art web, mobile and geospatial technologies for storing, managing, publishing and analysing the maps on the web.

Preparation of Agro-climatic Atlas under FOCUS Project in Mizoram & Nagaland

Food and Agriculture Organization (FAO) is providing technical assistance to the Governments of Mizoram and Nagaland on the "Fostering Climate Resilient Upland Farming Systems in the North East (FOCUS)" project. The objective of this technical assistance is to strengthen capacities of government institutions and extension services in Nagaland and Mizoram to support local communities in improved jhum management,



MRIS Application with various map functionalities

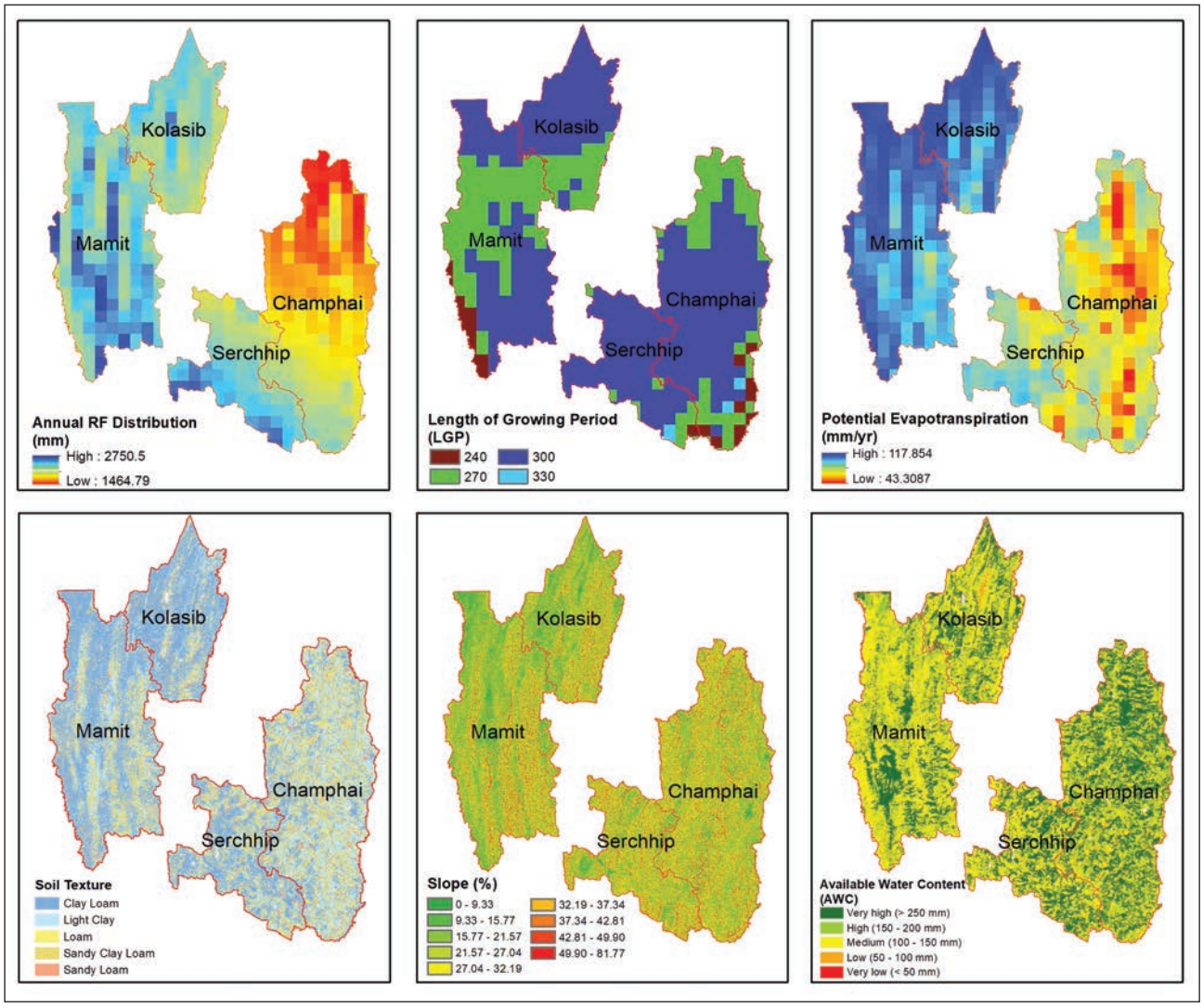
The MeRIS would ensure the availability of all geospatial data related to rice and other associated data in a single-window platform and all the data are being served as interoperable OGC data services. The application has been designed and

land-use planning (fallow management and community conservation area), Sloping Agricultural Land Technology (SALT), settled agriculture, livestock management, and monitoring and

evaluation. FAO has entrusted NESAC to prepare agro-climatic atlas for four FOCUS districts of Mizoram (Kolasib, Champhai, Mamit and Serchhip) and eight FOCUS project districts of Nagaland (Mon, Mokokchung, Longleng, Wokha, Zunheboto, Kohima, Kiphire and Phek) to present the jhum cycle, land-use at different levels of elevation, important climatic information; and to support the state governments in use of agro-climatic atlas in land suitability studies. Preparation of terrain and spatial map of climatic parameters have been completed for 4 FOCUS districts of Mizoram and 8 FOCUS districts of Nagaland. Different agro-climatic indices have been worked out using climatic parameters. The values refer to the agro-climatic indices which express the relationship between climate and agricultural production in quantitative terms.

Maize acreage estimation in NER under SUFALAM

A pilot study on developing remote sensing based methodology for acreage estimation of Maize crop has been taken up under SUFALAM (Space technology Utilization for Food Security, AgricuLtural Assessment and Monitoring) Programme coordinated by Space Applications Centre (SAC). The project is carried out in two selected districts; one in the state of Assam (Valley area) and another in the state of Meghalaya (Hilly area). For the state of Assam, the Darrang district has been selected, while for the state of Meghalaya,



Spatial map of agro-climatic indices and terrain parameter

the Ri Bhoi district has been selected. UAV based surveys for crop condition assessment has also been a major component of the project.

Sentinel-1A (SAR data) and Sentinel-2A (Multispectral) data of different seasons are downloaded from ESA Sentinels Scientific Data Hub and analysed using SNAP 7.0 and ENVI 5.4 software. The training samples needed for the analysis were taken from various locations of the Darrang and Ri Bhoi districts.

phenological stages. The NDVI and EVI vegetation indices were determined in various growing stages of maize to compare the phenology with other crops.

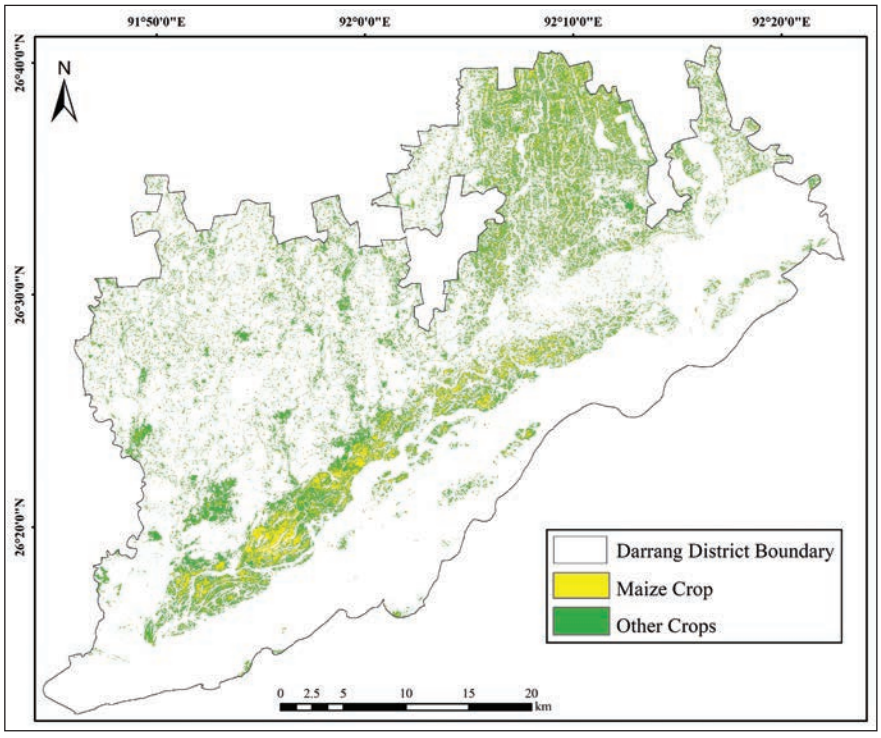
There has been a significant difference in the acreage estimation brought out by using the selected classification algorithms. More ground truth verifications are being made to improve the classification accuracy. Among all the classification algorithms, SVM and SAM are found to exhibit higher post-classification accuracy.

Dataset with date of acquisition from different satellite sensors

Dataset	Date	Resolution	Source
Sentinel-1A	December 2020 to March 2021-Rabi season	5 m×20 m	ESA Sentinels Scientific Data Hub
	April 2020 to August 2020-Kharif season		
Sentinel-2A	December 2020 to march 2021-Rabi season	10 m×10 m	
UAV data	August 2020 and March 2021	Field scale	Field survey
Ground truth	January and March 2021	Field scale	Field survey

Six different types of classification algorithms were employed for acreage estimation of maize viz. MLC (Maximum Likelihood Classifier), MDC (Mohalanobis Distance Classifier), SAM (Spectral Angle Mapper), SVM (Support Vector Machine), NN (Neural Network) and RF (Random Forest).

Data collected by UAV surveys were used to check the post-classification accuracy and also to study the phenological stages of maize crop. UAV data has helped to identify the mixed cropping pattern and discrimination between the crops based on their different



Maize crop and other crop areas delineated using SAM classification algorithms for Darrang district

Mapping of district wise soil fertility status of Meghalaya

Soil Health Card (SHC) contains the nutrient status of soil with respect to 12 parameters, namely pH, EC, OC (Chemical parameters); N, P, K (Macro-nutrients); S (Secondary-nutrient) and Zn, Fe, Cu, Mn, Bo (Micronutrients). The SHC gives the information for a particular location (latitude, longitude) which is collected by using GPS. This location specific information can be interpolated and maps can be generated for each village/block/district/state under GIS environment. Based on direction from the Department of Agriculture, Co-operation & Farmers Welfare under the Ministry of Agriculture & Farmers Welfare, Govt. of India, Directorate of Agriculture, Govt. of Meghalaya has requested NESAC to prepare district wise soil fertility maps for Meghalaya. In response to the request, NESAC has taken up this project and completed the work for the entire state.

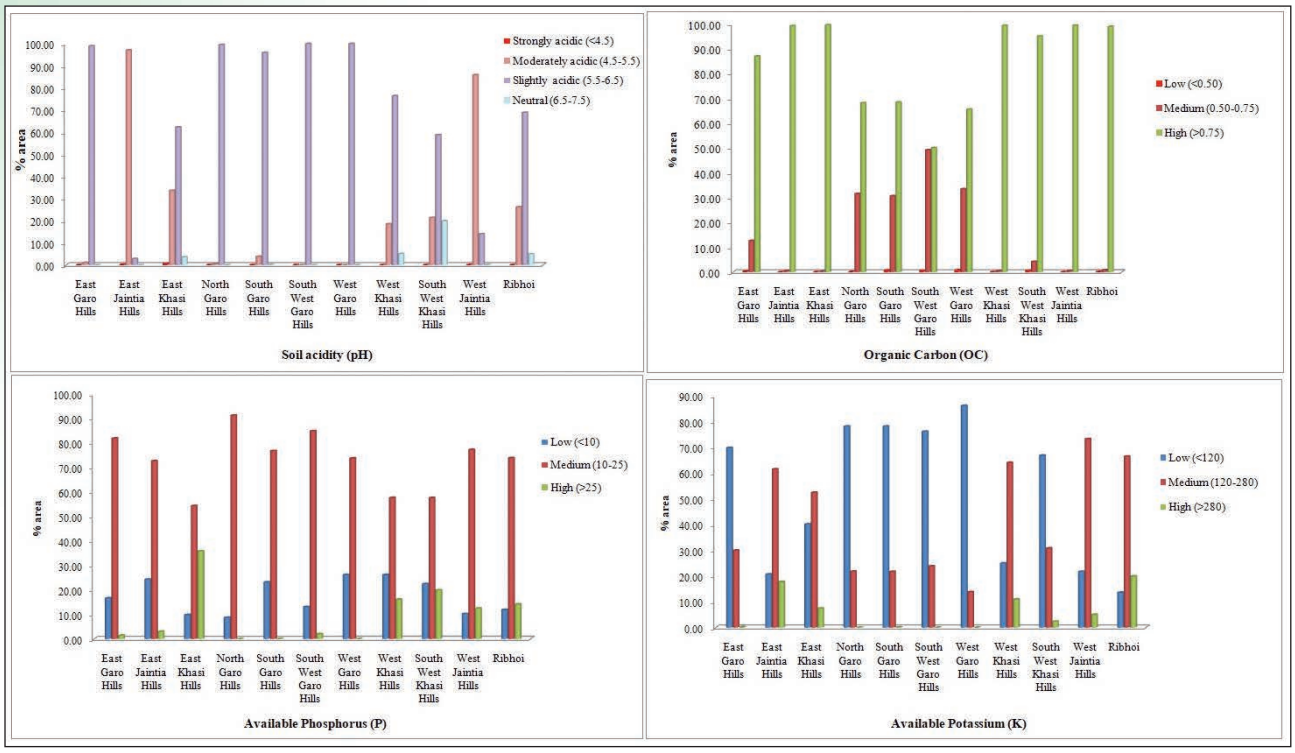
For the preparation of soil fertility maps, soil health data have been collected from SHC portal https// soilhealth.dac.gov.in. From the soil health card dashboard, grid wise soil health data have been downloaded and edited to make it compatible in GIS environment. One point layer is generated by using soil sample location (latitude, longitude) information under GIS environment using ArcGIS 10.3 software. The point layer contains soil sample numbers, village name and soil sample analysis results. It has been found that in the SHC portal, only 5 parameters are available for the state.

The available five parameters are pH, EC, OC (Chemical parameters) and P, K (Macro-nutrients). These five soil parameters have been used for the generation of five fertility maps. The fertility maps have been generated by using the Spatial Analyst tools of ArcToolbox. Inverse Distance Weighted (IDW) interpolation technique has been applied to generate fertility map of unknown locations based on information of known locations. The road network map has been prepared by using high resolution satellite imageries. It is found that in Meghalaya, the village boundary map is not available. Therefore village location map has been prepared by using Soil Health Card data, SIS DP database / Google map and Census data.

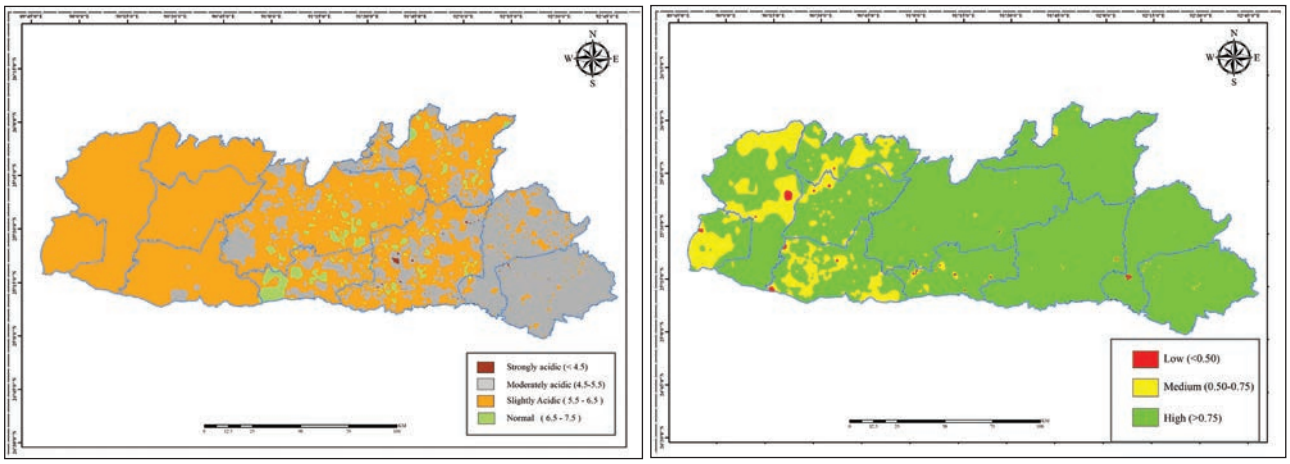
From the study, it is observed that soils of Meghalaya are non saline, acidic in nature and contains high organic carbon. It is found that 69.61% area of the state is slightly acidic in nature followed by moderately acidic (27.25%), neutral (3.05%) and strongly acidic (0.09%) soils. Soils of the state are high in organic carbon that covers 88.22% area followed by medium and low that covers 11.52% and 0.26% area respectively. The study showed that available phosphorus is medium in 69.89% area followed by low and high phosphorus content that covers 18.73% and 11.38% area, respectively. Soils of

	Parameters	Class	Area(ha)	% area
Chemical parameters	pH	Strongly acidic (<4.5)	2007	0.09
		Moderately acidic (4.5-5.5)	611264	27.25
		Slightly acidic (5.5-6.5)	1561246	69.61
		Neutral (6.5-7.5)	68386	3.05
	OC (%)	Low (<0.50)	5939	0.26
		Medium (0.50-0.75)	258280	11.52
		High (>0.75)	1978684	88.22
	EC	Non Saline	2242903	100.00
Macro-nutrients	P (kg/ha)	Low (<10)	420014	18.73
		Medium (10-25)	1567550	69.89
		High (>25)	255340	11.38
	K(kg/ha)	Low (<120)	1061978	47.35
		Medium (120-280)	1021465.88	45.54
		High (>280)	159459.41	7.11

Area under different fertility classes in Ri-Bhoi district



District-wise distribution of pH, OC, P and K classes



Soil acidity and organic carbon map of Meghalaya

the state are low in available potassium that covers 47.35% area whereas medium and high potassium is found in 45.54% and 7.11% area, respectively.

Assessment of Soil Fertility in Ri Bhoi district of Meghalaya using Hyperspectral Spectroscopy

This project was initiated with financial assistance from the Technology Development Programme (TDP) of Dept. of Space, Govt. of India with an objective to assess soil fertility in Ri Bhoi district of Meghalaya using hyperspectral spectra.

Spatial stratification of 21 different classes was generated from Land Use Land Cover (LULC) map prepared by the National Remote Sensing Centre and soil order map prepared by the National Bureau of Soil Survey and Land Use Planning. Five random soil sampling sites were selected from each stratum and recorded the spectral signature of soil in the field. A composite soil sample at 0-10 cm depth was made from 10 random soil samples from each stratum. Soil fertility parameters viz. pH, organic carbon (OC), available nitrogen (N),

available phosphorus (P_2O_5), available potassium (K_2O) and available zinc (Zn) were determined in the laboratory following standard procedures. Spectral Vista Corporation (SVC)-HR 1024 field portable hand held Spectroradiometer having spectral range of 350 to 2500 nm was used to record diffuse reflectance spectra of soil in the field. Again, ASD FieldSpec 4 Hi-Res spectroradiometer was used to record the diffuse spectra of soil in the dark room. Halon white reference (Spectralon®) was used to optimize and calibrate the sensor. Soil properties were predicted using Partial Least Square Regression (PLSR) and validated using Ratio of Performance to Deviation (RPD).

Soil pH varied from extremely acidic (3.88) to neutral (6.54) with mean value of 4.84. Again, OC varied from 0.95% to 2.88% with mean value of 1.70%. N content varied from low (215.50 Kg ha^{-1}) to medium (414.30 Kg ha^{-1}) with mean value of 291.50 Kg ha^{-1}. On the other hand, P_2O_5 content varied from low (19.90 Kg ha^{-1}) to high (68.30 Kg ha^{-1}) with mean value of 43.52 Kg ha^{-1}. Similarly, K_2O content varied from low (112.09 Kg ha^{-1}) to high (567.84 Kg ha^{-1}) with mean value of 273.68 Kg ha^{-1}. Again, Zn also varied from low (0.26 ppm) to high (1.46 ppm) with mean value of 0.64 ppm. Higher value of mean of soil attributes over median indicated no influence of abnormal values on the sampling values. CV indicated medium level of variability (< 0.12 CV < 0.62). Skewness indicated normal distribution of the data (< 3.0). Kurtosis indicated peak value of probability distribution curve is higher than normal distribution (> 0).

The study has demonstrated the usefulness of diffuse reflectance spectra of soil in prediction of soil fertility parameters viz. pH, OC, N, P_2O_5, K_2O and Zn using PLSR. Soil pH (RPD = 1.46) and P_2O_5 (RPD = 1.41) could be fairly predicted by PLSR model using field spectra indicating suitable for assessment and correlation studies. Other soil fertility parameters viz. OC (RPD = 1.76), N (RPD = 1.59) and K_2O (1.54) could be fairly predicted by PLSR model using laboratory soil spectra indicating suitable for assessment and correlation studies. Good quantitative prediction could be achieved for Zn (RPD = 1.83) through PLSR model using laboratory soil spectra. Again, very good quantitative prediction could be achieved for soil pH (RPD = 2.01) through PLSR model using laboratory spectra. The project has been successfully completed as on March 31, 2021.

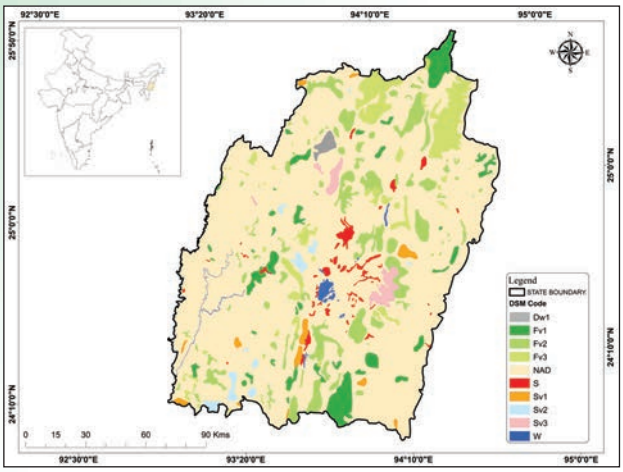
Accuracy of diffuse spcetra in predicting soil fertility parameters

Soil fertility parameter	Ratio of Performance to Deviation (RPD)	
	Field spectra	Laboratory spectra
pH	1.46	2.01
OC (%)	1.34	1.76
N (Kg ha^{-1})	1.27	1.59
P_2O_5 (Kg ha^{-1})	1.41	1.56
K_2O (Kg ha^{-1})	1.57	1.54
Zn (ppm)	1.33	1.83

Desertification and Land Degradation: Monitoring, Vulnerability Assessment and Combating Plans

NESAC is executing this national project for six states of NER (excluding Assam and Meghalaya) and West Bengal in collaboration with Space Applications Centre (SAC), Ahmedabad. Land degradation vulnerability index map at 1:50K scale has been prepared for 10 selected districts representing 6 NER states and West Bengal. Action plan for combating desertification and land degradation at 1:10K scale in one micro-watershed in each district selected for vulnerability assessment has also been prepared.

Land degradation status mapping at 1:50K for 6 NER states has been carried out using multi-temporal satellite imagery of AWiFS sensor for the period 2018-19. Forest degradation (Fv) was found to be highest in the state of Manipur (3913.82 sq.km.) followed by Arunachal Pradesh (2244.76 sq.km.), Mizoram (2074.39 sq.km.), Sikkim (789.38



Land degradation status map of Manipur on 1:50K

sq.km.) and Tripura (637.17 sq.km.). On the other hand, scrublands (Sv) were found to be highest in the state of Nagaland (1671.02 sq.km.) followed by Manipur (640.92 sq.km.), Arunachal Pradesh (477.21 sq.km.), Mizoram (420.61 sq.km.), Tripura (250.92 sq.km.) and Sikkim (12.85 sq.km.). Water erosion (Dw/Iw) in the agricultural fields has been found in the state of Tripura (1115.06 sq.km.), Nagaland (492.63 sq.km.), Manipur (78.04 sq.km.) and Mizoram (14.43 sq.km.). Sikkim (667.37 sq.km.) and Arunachal Pradesh (261.51 sq.km.) were found to have degradation due to frost shuttering (Lf). Considerable barren areas (B) were found in the state of Nagaland (240.93 sq.km.). Moreover, 930.66 sq.km. areas were found under water erosion in forest (Fw) and 16.41 sq.km. under man made degradation (Tm) in the state of Tripura.

Land degradation mapping at 1:50K for 16 selected districts representing 6 NER states and West Bengal is in progress.

Geotagging of assets created under NERTPS programme of CSB in NER

Sericulture is one of the important sectors of economy in India and plays an important role in programmes of poverty alleviation. But, the current production is not adequate to meet the demand for silk in the country. At the same time there is tremendous scope for enhancing the production and quality of silk through expansion of areas under host plants, improved method of information collection, processing and dissemination with the use of geospatial technology. The Central Silk Board (CSB) under the Ministry of Textiles has been implementing a number of programmes to increase the silk production in the country. A major project was taken up by CSB to identify and map additional potential areas for development of silkworm food plants for 178 priority districts from 26 states in the country.

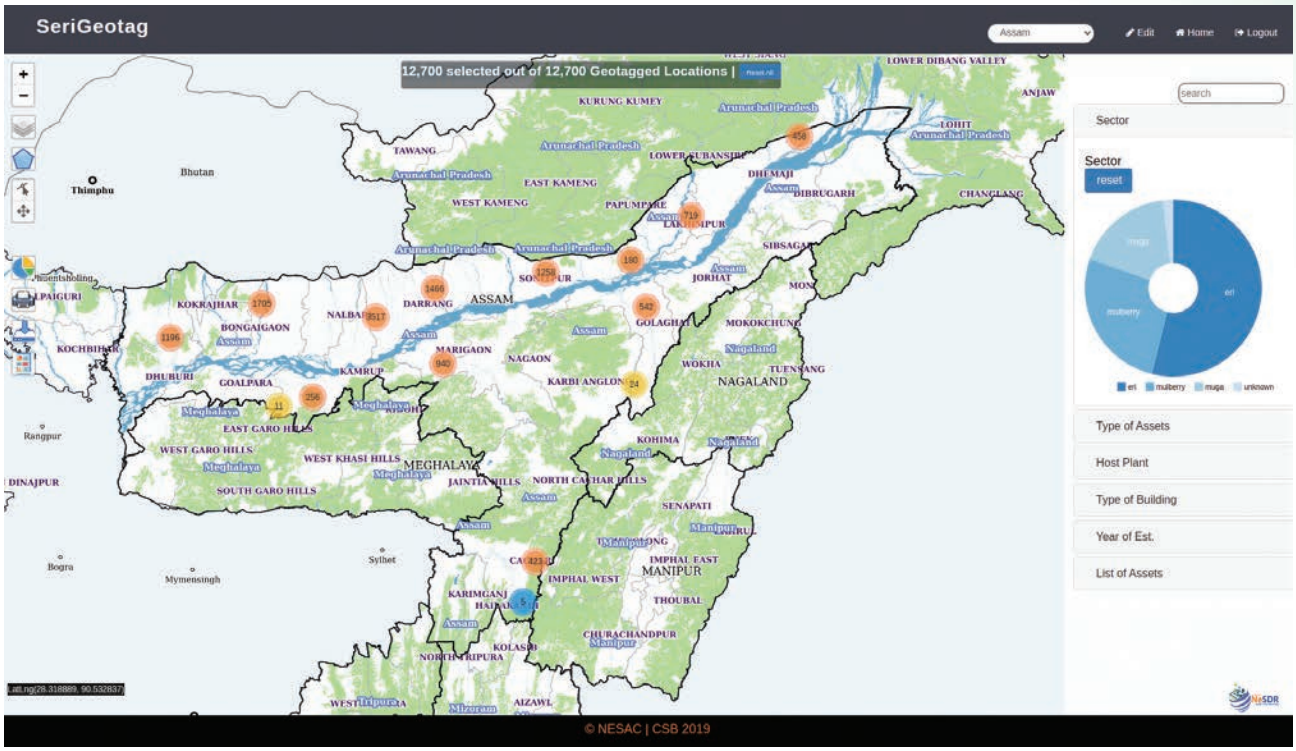
Ministry of Textiles, Government of India rolled out a scheme called North East Region Textile Promotion Scheme (NERTPS), an umbrella scheme to promote textiles industry in the north eastern region (NER) of India by providing infrastructure, capacity building and marketing support to the industry (http://texmin.nic.in/schemes/). The scheme covers all sectors and subsectors of the value chain of textiles, handloom, handicrafts, sericulture, jute, etc. The scheme is implemented in a project mode with region-specific flexibility in project design and implementation. Following the implementation of the scheme a large volume of assets have been created across 8 states in the NER covering about 46000 beneficiaries. For effective monitoring of project implementation covering these large numbers of assets, it is required to develop an effective system with space based inputs.

A GAGAN based mobile app has been developed to geotag all assets divided into two broad categories, viz, Buildings and Plantations. Building includes assets like rearing house, reeling house, mounting hall, etc, while plantations include host plants for four different types of sericulture viz., Mulberry, Eri, Muga and Oak Tasar. It was also envisaged to develop a dashboard system using open source tools and techniques for visualization and monitoring the status of the assets created under the scheme.

The exercise was carried in north eastern region of India comprising of 8 states viz., Arunachal Pradesh,

Assam, Manipur, Meghalaya, Mizoram, Sikkim and Tripura. The assets from Assam were divided into two regions as Bodoland Territorial Council (BTC) is a separate administrative region having its own Directorate of Sericulture.

has been developed using open source geospatial tools and services to visualise the geotagged assets and to perform required analytics. The application comprises of a 3-tier architecture 1) Database, 2) GIS server 3) Web/client mapping.



SeriGeotag dashboard for monitoring and visualization of sericulture assets

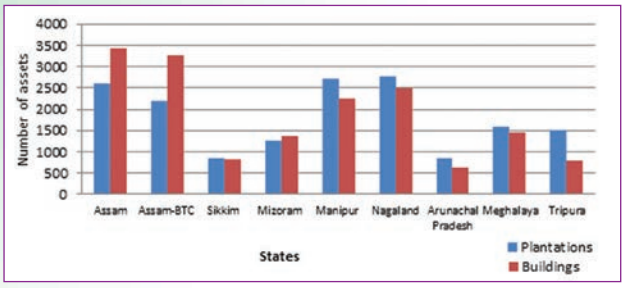
116 Project Assistants were recruited from all the states and provided required hands-on training on the operation of the GAGAN-GPS dongle for geotagging of the assets. The geo-tagging exercise was carried out during the period of March, 2020 to November, 2020 amid COVID-19 pandemic situations taking required precautions.

The GAGAN based mobile app provided a platform for crowd sourcing and geo-tagging, where Project Assistants deployed in the districts geotagged the photographs of the assets and posted along with details about the assets to the SILKS web portal. This app also provided the option for saving the data in offline mode in case of lack of internet connectivity in the remote villages.

A dashboard web application named 'SeriGeotag'

The database of the application is hosted using MySQL database, which is chosen as it offers rich library of queries, with ability to provide role specific privileges. The geotagged assets are published in a Well Known Text (WKT) format and served as per OGC standards along with other geospatial layers.

It was observed that out of total 46000 assets covered under the NERTPS scheme with various categories of financial assistance, a total of 22270 beneficiaries have created physical assets in terms of construction of building or raising of sericulture host plants. Among the states, Sikkim state recorded with most successful implementation of the scheme with creation of targeted assets, which was 99.66% followed by Assam (97.42%) and Nagaland (97.22%). BTC area recorded the least number of assets created with 75.56%.



State-wise details of geotagged assets

The dashboard system also provides interactive visualisation of detail of the assets, links to download the mobile application, and provides a window to access state dashboards. The state dashboards allow multi-dimensional querying. It also provides options to visualise multiple geospatial base maps and overlay maps along with option to compare the status of geotagged asset with satellite images of different time periods. This helps the concerned authorities to verify the status of the plantations with regards to plantation time, growth stages and vigour of the plantation. The assets can also be queried based on sectors, year of plantation.

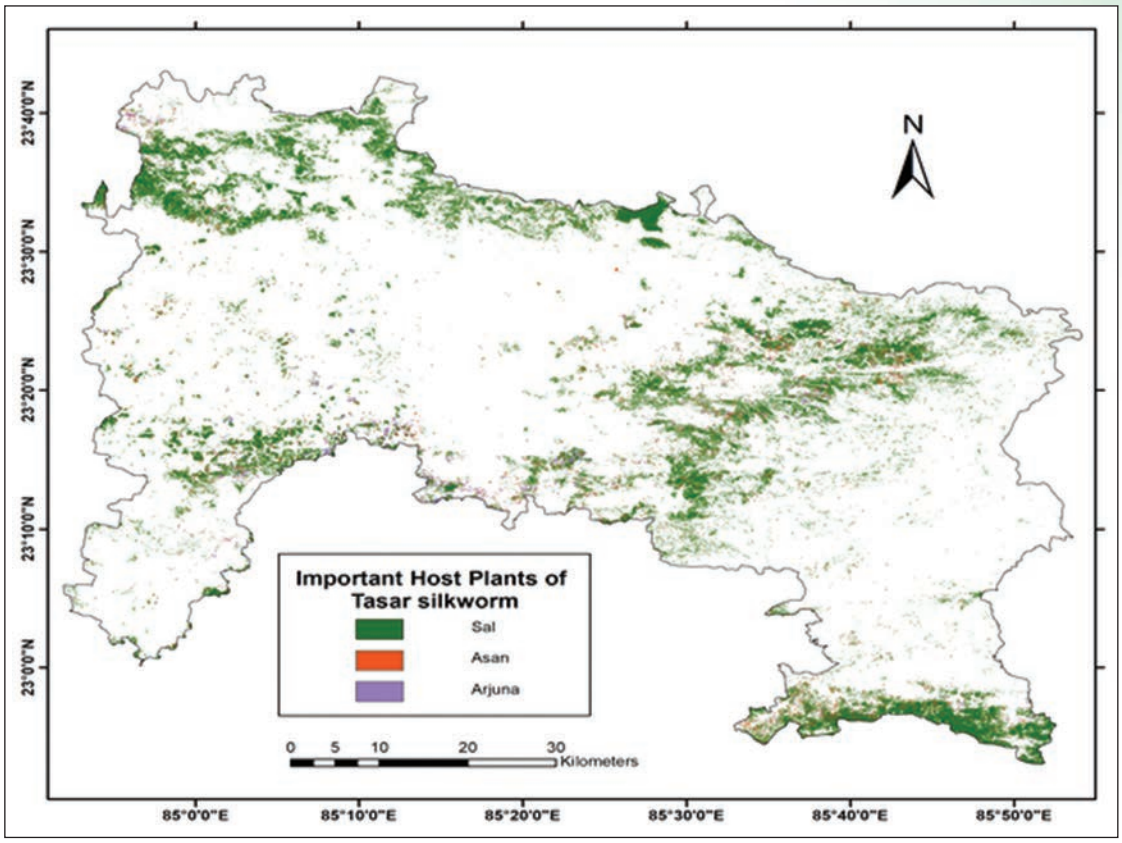
It is expected that the Mobile App and the dashboard system will be of immense help to the concerned authorities for effective monitoring of the assets created for sericulture development in the north eastern region of India.

Study on existence of tropical silkworm ecoraces and their subsist places with the help of geospatial technology

This project is a collaborative effort between Central Tasar Research and Training Institute (CTR&TI) and NESAC, which aims at complete documentation of available ecoraces of *Antheraea mylitta* Drury and implementation of appropriate in-situ conservation plan. Out of 44 ecoraces of tropical tasar silkworm known so far, the current status of many are not known. The project aims to explore the current status of all the available ecoraces in tropical regions of India through systematic survey, phenotypic/ morphological characterisation, analysis of niches structure of the respective habitat areas and spatiotemporal distribution of various tropical tasar silkworm ecoraces in our country through ground inventory and geospatial technology.

As an effort to delineate the habitat of Tasar ecoraces, delineation of forest cover has been completed for the Jharkhand region using cloud masked/cloud free Sentinel-2 MSI (Level-2A) satellite imageries from the year 2020. NDVI was used to extract the forested area from the study area. The extracted forest cover was further subjected to classification in order to identify the host plants of Tasar silkworm, mainly Sal (*Shorea robusta*), Arjuna (*Terminalia arjuna*) and Asan (*Terminalia tomentosa*) within the forested areas. For training the classifiers, ground truth information was supplemented with inputs acquired from Survey of India (SOI) toposheets and vegetation type map prepared by IIRS (https://bis.iirs.gov.in). Random Forest (RF), Support Vector Machine (SVM), Spectral Angle Mapper (SAM) and CART classifiers have been employed to classify the three different types of host plants. Maximum Entropy Probability distribution model has been used to map the probable habitat distribution of the three primary host plants (Sal, Arjuna and Asan) of *Antheraea mylitta* Drury using bioclimatic data acquired from Bioclim.

Project Review meeting is in progress at CTR & TI, Ranchi



Distribution Tasar host plants in Ranchi district, Jharkhand

Ground truth information was collected using the GAG dongle and the *TasarGeotag* data collection app developed by NESAC. Particulars about habitat (forest cover percentage, phenology of the forest and host plants, primary and secondary food plants found etc.), qualitative and quantitative information on cocoon/larvae, pest/predator data and edaphic data have been recorded during the survey.

Geotagging of Tasar host plants at Bhusur, Ranchi

FORESTRY AND ECOLOGY

Forest constitute about 65.05% of the total geographical area of northeastern India. This region represents 24.22% of the countries forest cover (FSI, 2019), with only 7.98% of the country's land area. During the past 21 years of existence, NESAC has been working on R&D and user-oriented application projects using geospatial technology in the field of forestry and ecology. Some of the major projects being undertaken in this field during the current year are summarised below.

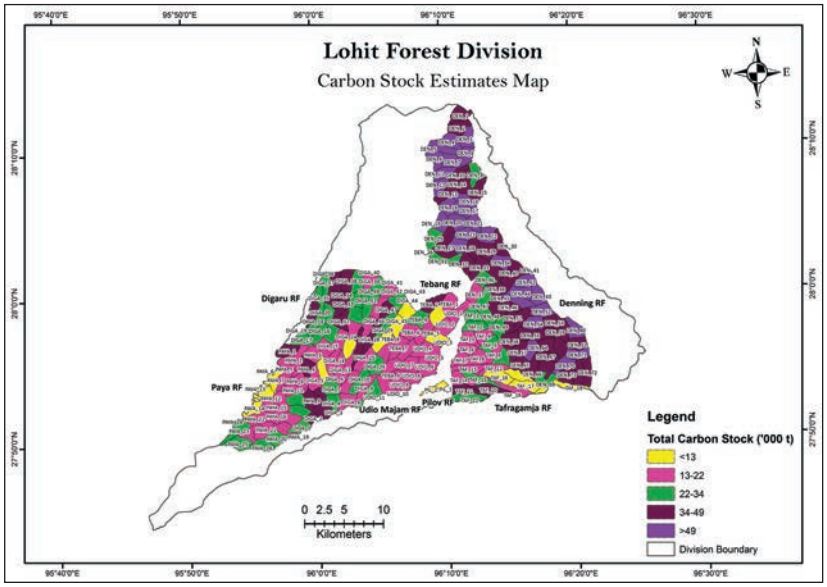
RS and GIS inputs for preparation of forest working plan in Arunachal Pradesh

This project is being carried out covering all the divisions of the state, wherein geospatial inputs and computational estimates of growing stock at compartment level are provided to the Forest Department for preparation of forest working plans for different divisions. The detailed growing stocks were estimated at range level and RF level for the divisions of Lohit and Nampong.

There are 7 Reserved Forests under the Lohit forest division. The girth class wise timber volume estimate is shown in the table below and the compartment level total carbon stock estimate (above ground, below ground, litter, deadwood and soil carbon) in colour coded compartments are shown in the figure below.

Table: Girth class wise timber growing stock in Lohit Division

Reserve Forest	Area (ha)	Girth class timber volume estimates ('000 m^3)						Total ('000 m^3)
		G1	G2	G3	G4	G5	G6	
Denning	26930.07	97.59	160.70	236.22	336.39	263.78	683.08	1777.78
Digaru	17830.10	33.10	52.81	74.83	84.85	81.26	123.97	450.87
Pilov	219.22	0.72	1.13	1.61	1.71	1.49	1.83	8.51
Paya	8752.01	10.07	16.64	24.88	37.86	26.31	79.03	194.81
Tafragama	7557.33	11.04	17.45	25.36	30.08	25.58	49.20	158.73
Tebang	3394.52	3.50	5.02	7.57	6.84	3.83	3.83	30.62
Udio	4269.67	2.49	3.78	5.48	5.42	4.47	5.28	26.94

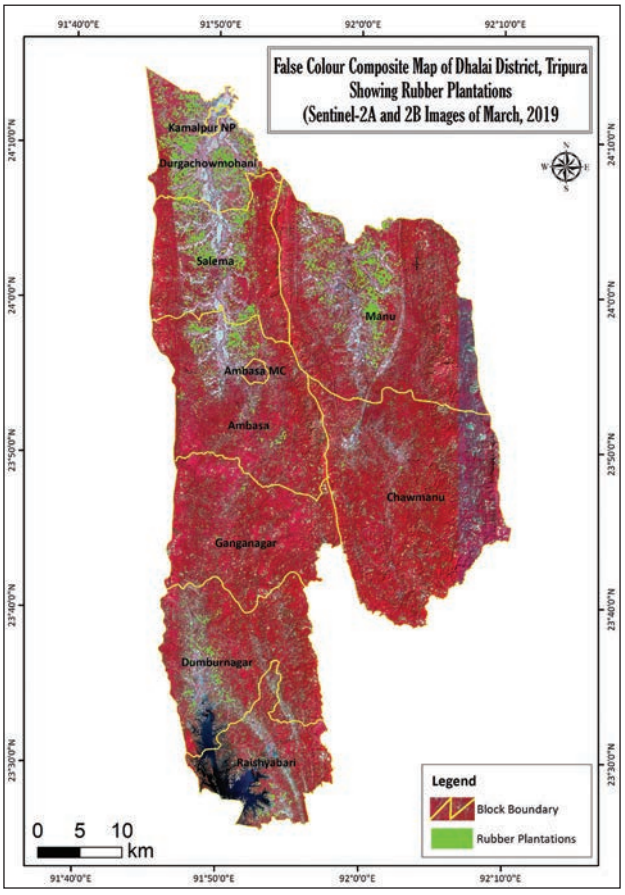


Compartment wise total carbon stock estimate in Lohit Forest Division

Mapping the distribution of rubber plantations in malaria prone Dhalai district of Tripura

A joint project with ICMR-RMRC, Dibrugarh on "Operational feasibility of additional intervention package for accelerated malaria control in areas with jhum cultivators in Tripura" is being undertaken in Dhalai district, Tripura, to understand the relationship between jhumias and the incidence of malaria infection. Jhum fields for the whole district of Dhalai has been mapped at 1:10,000 using multidate IRS LISS

IV data pertaining to March 2018 and March 2019. Other major landuse than shifting cultivation is also being mapped to understand the relationship with various other parameters of malaria incidence among the jhumias. The area under the rubber plantation has been mapped at 1:10K based on LISS IV data. Field verification of the plantations, existing and new ones have been made.



A rubber plantation in Dhalai district

Rubber area under different blocks

Blocks under Dhalai	Area under Rubber (ha)	% of TGA
Ambasa	599.69	2.02
Ambasa MC	3.25	0.46
Chawmanu	39.01	0.09
Dumburnagar	327.70	1.17
Durgachowmohani	1624.33	10.77
Ganganagar	23.52	0.09
Kamalpur NP	1.87	0.31
Manu	1803.14	3.90
Raishyabari	136.54	0.81
Salema	1284.28	5.73
Grand Total	**5843.33**	**2.53**

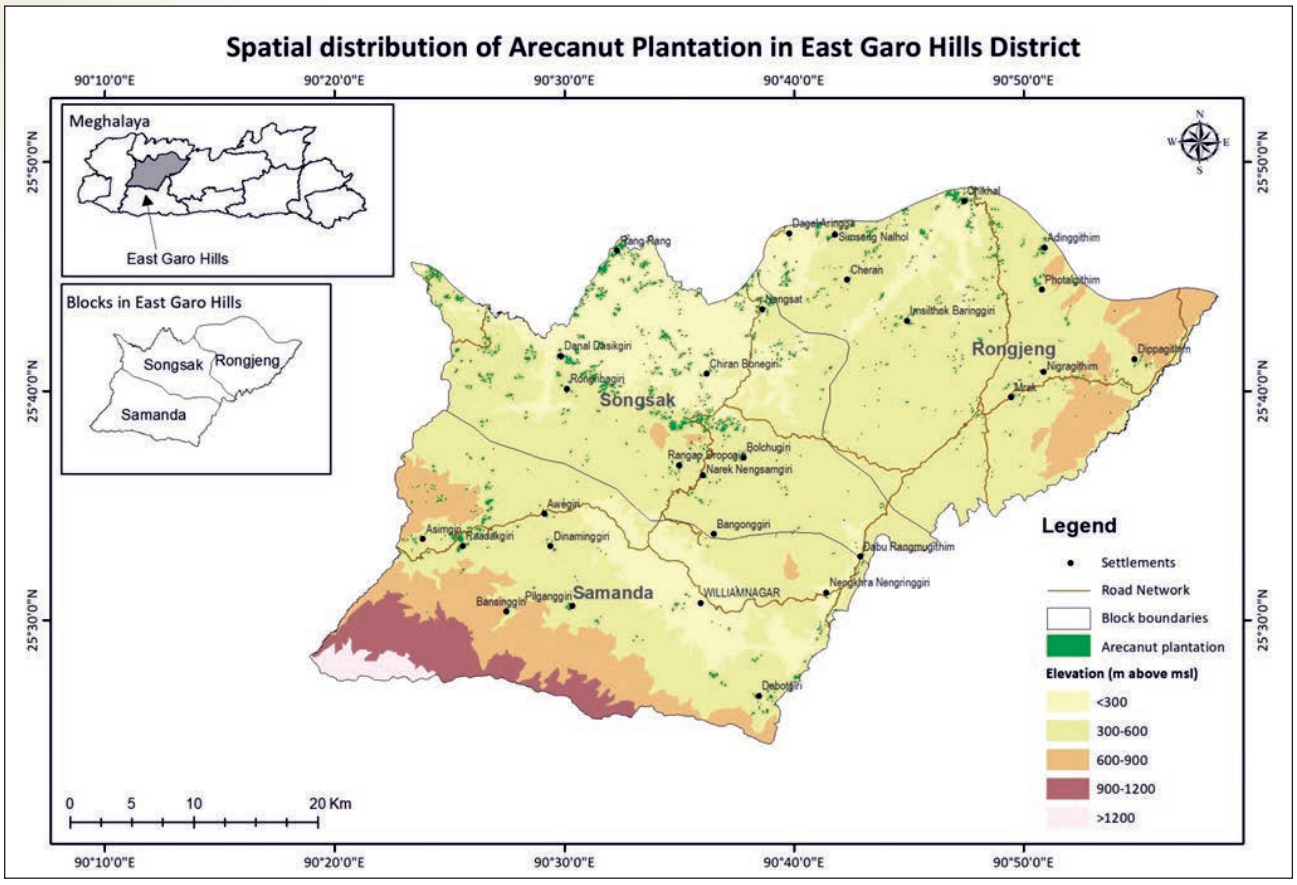
Assessment of area under areca nut plantations in East Garo Hills district Meghalaya

As per the requirement of the district administration, a preliminary assessment of the area under the Areca nut (*Areca catechu*) plantation was undertaken in the East Garo Hills district of Meghalaya. Areca nut is a monoecious palm that is found all over South East Asia and is believed to have originated in the Philippines or Malaysia. India is the traditional areca growing country and is one of the largest producer and consumer of areca nut in the world. Meghalaya ranks 5th position in the production of areca nuts according to the National Horticulture Board.

The total area under the areca nut plantation in the district was found to be 485.78 ha, with a maximum in Songsak block (56%) and least in Rongjeng block (19%). An analysis into the distribution of areca nut plantations at different elevation gradient revealed that most of the plantations are distributed in the lower altitudes (<600 m above msl).

Mapping of shifting cultivation area at 1:10,000 scale and estimation of Jhumia population depending on shifting cultivation in the NER

Shifting Cultivation or Slash and Burn or *Jhum* Cultivation has been practised in the Himalayan

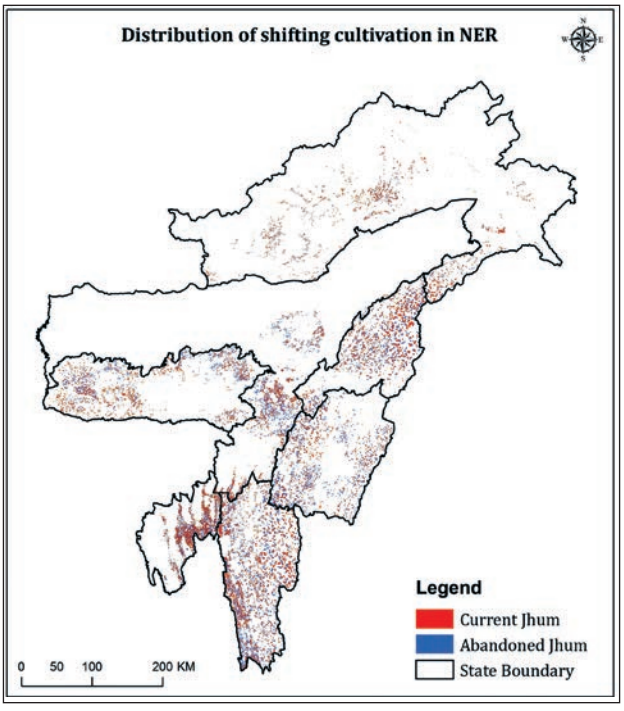


Spatial distribution of areca nut plantations in East Garo Hills district

region for a very long time. On the directives of NITI Aayog, a core group was formed by the Department of Agriculture Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare (DAC&FW, MoA&FW) as the Nodal Department together with the Department of Agricultural Research & Education (DARE, MoA&FW) and Ministry of Environment, Forest & Climate Change (MoEF&CC) and NESAC is a member of the Core Committee.

The committee found that there was a major gap in the availability of reliable information on the current area under *jhum* and the estimated number of *jhumia* families depending on *jhum* cultivation. The committee entrusted NESAC with the task of providing/generating information on this gap area and funding for executing the project under the ISRO-NNRMS programme.

Under this project, *jhum* maps at 1:10,000 scale were prepared for selected sample districts to supplement the maps prepared at 1:25,000 scale.



Distribution of shifting cultivation in NER

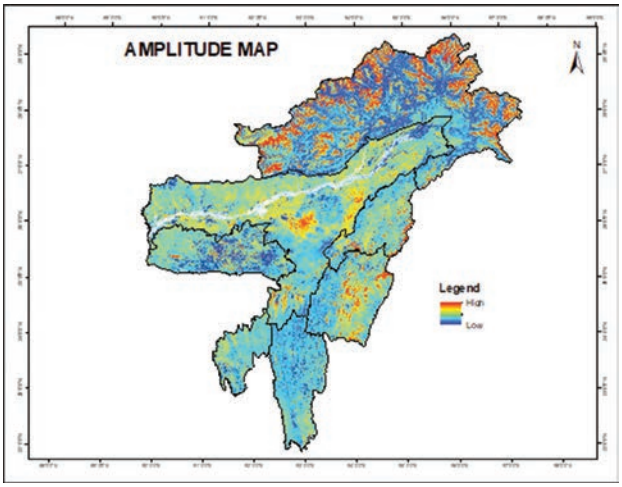
Field surveys and ground truth verification have been completed and preparation of the final report is in progress.

Area under jhum in different NER states

States	Current *Jhum* (ha)	Abandoned *jhum* (ha)
Arunachal Pradesh	13298	25354
Assam	10507	23969
Manipur	17864	36134
Meghalaya	11549	22749
Mizoram	39395	76635
Nagaland	34467	58342
Tripura	12401	22171
Total	**139481**	**265354**

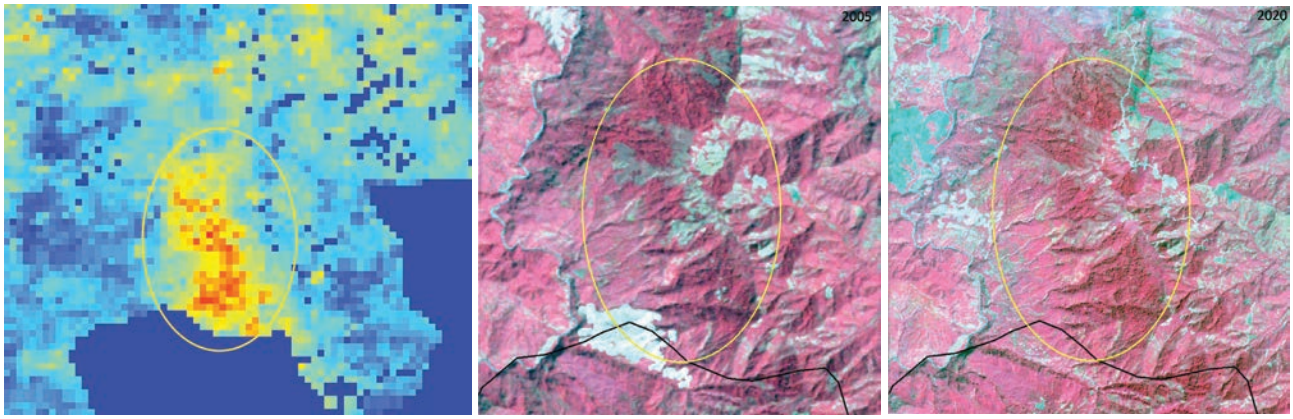
Analysis of Vegetation Phenology of NER using Time Series Satellite Data

The exercise was carried out for analysing the distribution pattern and variation in vegetation phenology for different natural vegetation types that exist in North East India using time series MODIS 16 day's composite NDVI data. Time series data for a period of the last 18 years have been analysed and the phenological parameters are computed after smoothing the data by defining the threshold for the start and end of seasons. Seasonality parameters such as the start of the season, the end of the season and seasonal amplitude have been calculated and correlated with the forest types of the region. Area with low amplitude depicts no changes in vegetation phenology during the study period, while high amplitude signifies dynamic changes in a particular region.



Amplitude map of NER except Sikkim

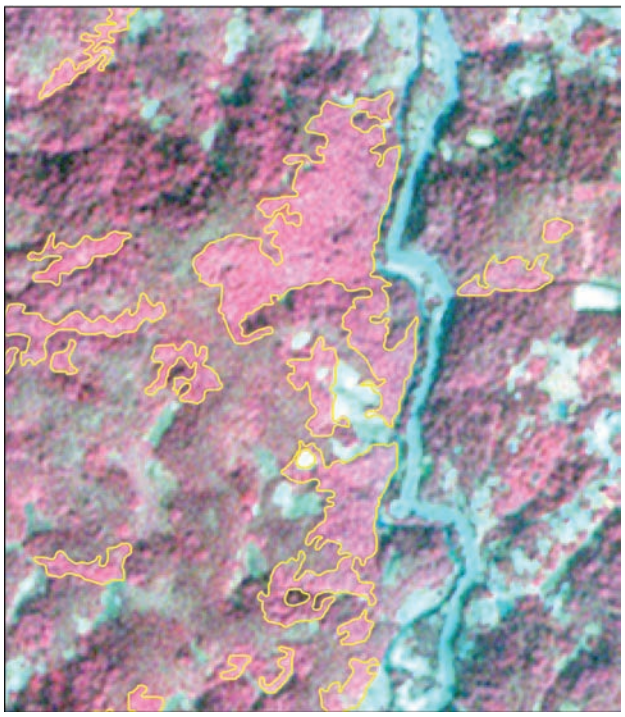
Low amplitude region in a forested area in Arunachal Pradesh



High amplitude region in southern part of Mizoram

Mapping of bamboo resources for the state of Meghalaya

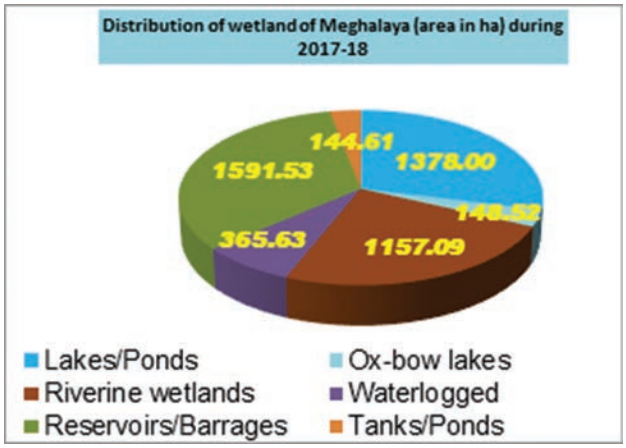
As per the requirement of the Soil and Water Conservation Department, Govt. of Meghalaya, the work on mapping the bamboo resources in the state have been initiated. ResourceSat-2 LISS IV satellite data is being used for mapping the bamboo growing areas while field data information on bamboo are being collected by the Soil and Water Conservation dept. for computing the bamboo growing stock map. Training on field data collection has been imparted to the officials of the Soil and Water Conservation dept. A preliminary interpretation of bamboo growing for Ri Bhoi district has been completed along with ground truth verification.



Bamboo growing areas in Ri Bhoi district, Meghalaya

National Wetland Inventory and Assessment (NWIA) II-Meghalaya

Wetlands are important ecosystems on the earth surface. They are regarded as the most productive ecosystems and a rich repository of biodiversity. Considering the value of the wetlands ecosystems, under the Space Applications Centre (SAC), Ahmedabad coordinated project on National Wetland Inventory and Assessment (NWIA) phase I, NESAC has mapped all the wetlands of Meghalaya using IRS LISS III data of 2005-06. Presently, under



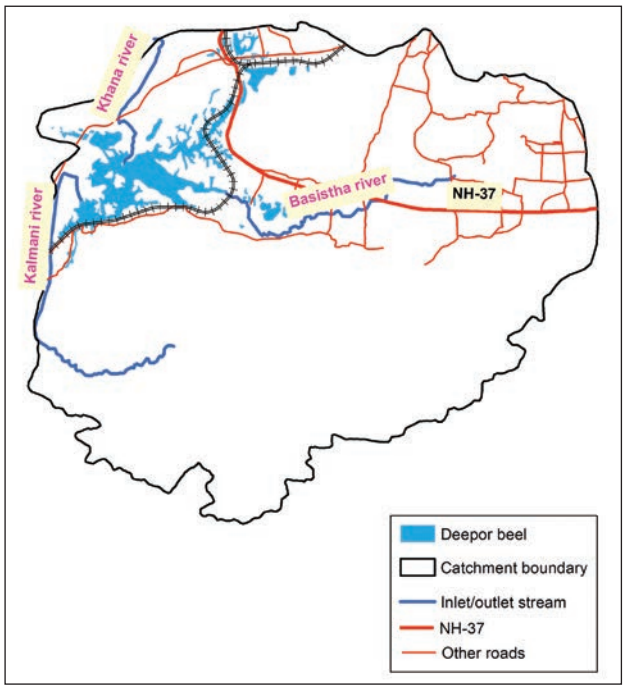
the NWIA phase II, the updation of the wetland boundaries have been carried out using IRS LISS III data of 2017-18. The prime objective of NWIA II is updation of wetlands at 1:50,000 scale and mapping of wetlands using Resourcesat LISS IV satellite data and hydrological modeling. NESAC is working for Meghalaya and coordinating for the remaining north eastern states. From the change analysis of the wetland of Meghalaya between both the periods, it is found that there are 85 wetlands that have reduced in area at the same time, three new wetlands have been identified (one of which is shown from the ground photograph).

Study on wetland change detection in Deepor Beel, Guwahati, Assam

Considering the importance of wetlands in environmental stabilisation, a study on 'Deepor Beel', a Ramsar site in Guwahati has been carried out. It is a permanent freshwater lake existing in

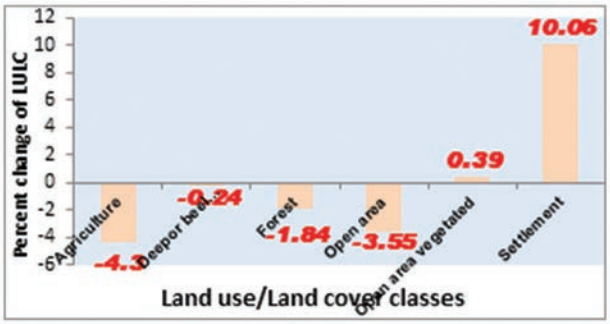
(a) A subset of image from catchment area during 2003

(b) A subset of image from catchment area during 2003



Deepor Beel and its catchment

a former channel of the Brahmaputra River on the southern bank and lies in the southwest corner of Guwahati City. The wetland serves as a major fish breeding and nursery ground. The wetland supports high diversity and concentration of indigenous freshwater fish species. A lot of transformation in the ecological and social characteristics of the lake is happening due to industrialisation, agricultural activities, and human settlement. The main threats are encroachment and over-exploitation of resources. A study using high resolution IKONOS and World view images between 2003 and 2018 have revealed the ongoing expansion of settlement area in the catchment area.



The spread of settlement areas is the main land use change taking place in the catchment area. Ground photo shows few factors affecting the wetland water and catchment quality. This work has been carried out with the funding support from North Eastern Council (NEC), Shillong, Meghalaya.

Few current landcover classes

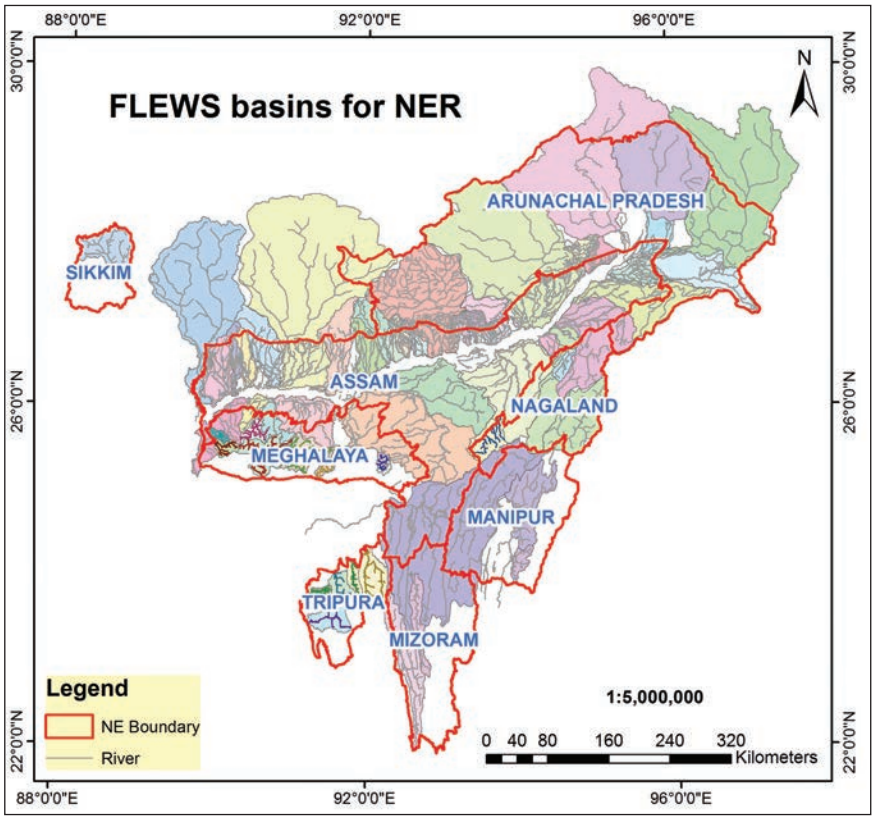
HYDROLOGY & WATER RESOURCES

Flood Early Warning Systems (FLEWS)

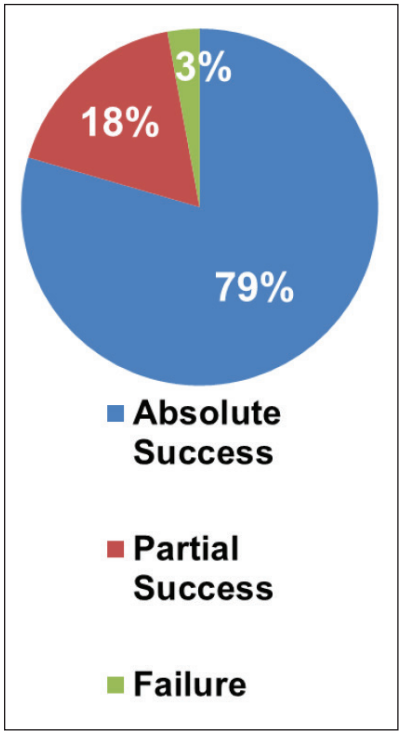
NESAC took up the Flood Early Warning System (FLEWS) for the Lakhimpur district of Assam on pilot mode during 2009. After successful completion of the pilot exercise, FLEWS became fully operational in a phased manner covering all 33 districts of Assam from 2012 to 2020. The technical component of this exercise comprises of two sub-components, namely the numerical rainfall prediction using the Weather Research & Forecasting model (WRF) and a GIS based distributed hydrological model known as Hydrologic Engineering Centre - Hydrologic Modeling System HEC-HMS. The HEC-HMS model intakes the predicted rainfall values and gives estimated values of peak discharge, which in turn is compared with established flooding threshold discharge values of the river concerned in order to generate the flood alerts and disseminated accordingly. Since the beginning, the actionable flood alerts are issued at the revenue circle level with a lead time ranging from 24 to 48 hours, having a success score of about 80%. After successful completion of the first (2012-14), second (2015-17) and third operational period (2018-20), the fourth operation period from 2021-23 has been initiated as per request from the Assam State Disaster Management Authority (ASDMA).

FLEWS in other Catchments of NER

After successful implementation of FLEWS in Assam and with the advice from the Chairman, ISRO, NESAC has taken up the expansion of FLEWS services to other flood prone rivers of North East India. Accordingly, the semi-distributed hydrological models have been built and made ready for calibration and validation. A series of stakeholder meetings have been organised with the state level disaster management authorities and State Remote Sensing Centres for the successful implementation of flood early warning



FLEWS Catchments of NER

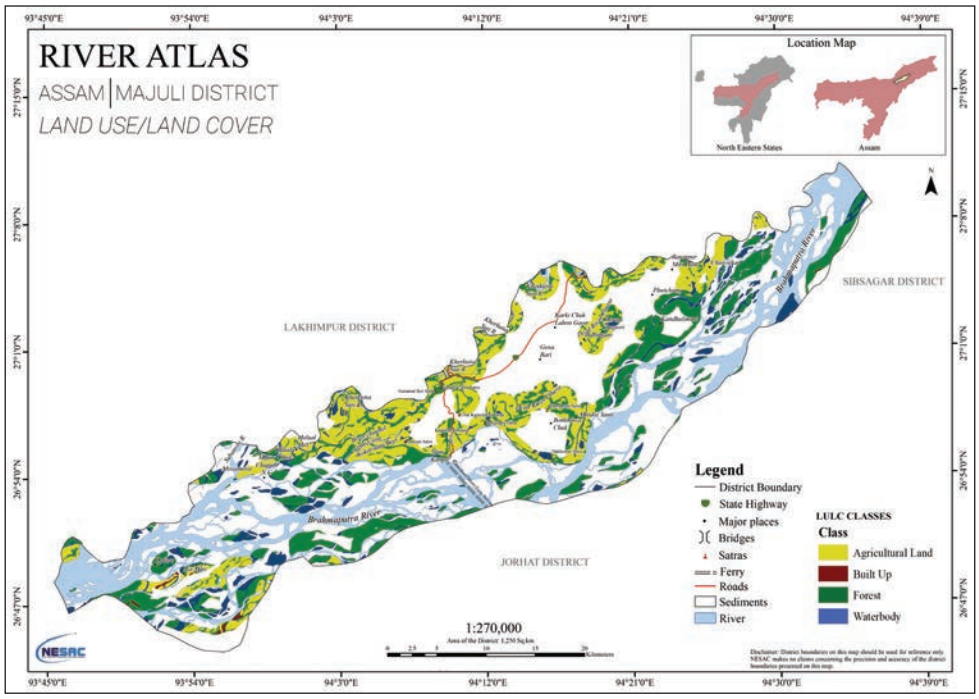


FLEWS Assam success rate in 2020

system in these states. During the monsoon period of 2020, a few experimental alerts have been issued for Meghalaya and Arunachal Pradesh.

Preparation of Assam River Atlas

NESAC has taken up the task of preparation of Assam River Atlas for Assam Water Research and Management Institute Society (AWRMIS) with funding from the Assam State Disaster Management Authority (ASDMA) during 2017. As a part of this project, the rivers of Assam have been mapped at a scale of 1:5000 along with important features such as river banks, sand deposits, embankments, hydro-meteorological observatories, sluice gates, major locations, roads, railway lines, administrative boundaries etc. A robust and user-friendly geoportal (https://riveratlas.nesdr.gov.in) has been developed and made available in the public domain comprising of all the generated layers, various functionalities and high resolution maps. As part of the Assam River Atlas, a detailed technical report comprising of district wise river maps have been prepared and were released by Shri Jishnu Barua, Hon'ble Chief Secretary, Government of Assam on 23 March 2021.



District LULC map

Release of Assam River Atlas by Hon'ble Chief Secretary, Government of Assam

Monitoring and Evaluation of IWMP watersheds for NE India

NESAC under the guidance of the National Remote Sensing Centre (NRSC) is coordinating the space based monitoring and evaluation of watersheds under IWMP (Integrated Watershed Monitoring Programme) in NER since 2017. For this purpose, NRSC has developed a geospatial tool called Sristi - a web GIS interface on Bhuvan and Drishti – a mobile based android application. State

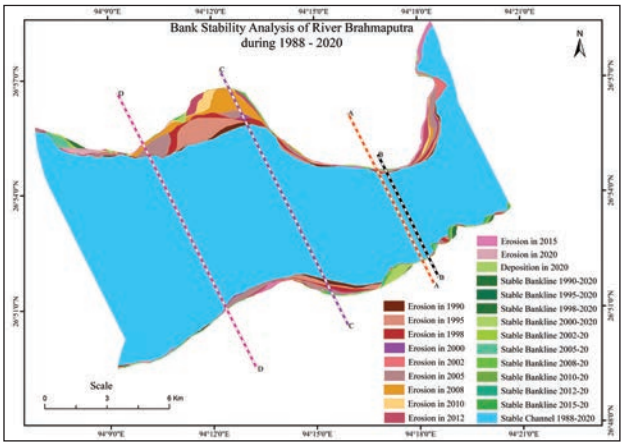
Remote Sensing Centers in NER are executing the project with the support of NESAC and NRSC. For the state of Meghalaya, NESAC is executing the project.

A summary report has been prepared for completed projects. The report contains primarily the analysis of land use land cover changes after the implementation of IWMP projects. Critical changes are shown with the help of temporal satellite data, i.e., prior and post-implementation of the IWMP projects. Major IWMP activities like construction of check dams, ponds, development of horticulture, agriculture, afforestation etc. are also shown with temporal satellite data. State wise progress achieved is shown in the table.

State	No. of Projects	Accepted Geotags	Report Prepared
Arunachal Pradesh	88	0	-
Assam	292	13950	60
Manipur	68	3149	35
Meghalaya	62	1715	23
Mizoram	103	6013	15
Nagaland	98	6586	24
Sikkim	16	1058	1
Tripura	65	5097	33

Feasibility study for the construction of roads of NH standard with major bridges over the river Brahmaputra

Public Works Department of Govt. of Assam is constructing two roads of NH standard with major bridges over river Brahmaputra connecting Jorhat - Majuli and Morigaon-Rowta, Udalguri. Considering the fact that understanding the dynamics of the river banks is a very important aspect, which needs to be taken into consideration while choosing the site for construction of bridges across the river, a study was carried out by NESAC using space technology inputs. Thirty year old temporal satellite data were analysed to identify the stable patch of the river for the construction of both bridges. The hydro-geomorphology aspect was also taken into account while carrying out the study in four probable sections in the river.



Bank stability analysis of River Brahmaputra during 1988-2020

URBAN AND REGIONAL PLANNING

Planning and development mean physical and economic growth, which effectively meets the social needs of human society. Urban and regional planning requires comprehensive large scale information for various developmental programs. Geospatial technology has catered to this requirement. The availability of very high resolution satellite data coupled with the various applications for field data collection has synthesised the capability to link the spatial and nonspatial data in a very accurate manner. The demand for geospatial data at the urban and regional levels is huge. The centre has been actively involved in urban and regional projects funded by different users. The centre has contributed to the preparation of the Master Plan / Development Plan, Transportation Plan, Urban Site Suitability Analysis, Urban Environmental Planning, etc.

Geodatabase creation of Shillong planning area, Meghalaya under AMRUT sub-scheme

Generation of GIS database layers for the Shillong Planning Area including - Base Maps, Urban Land use/land cover (LULC), Building footprints, Utilities, Hypsography, Boundaries and Hazard prone areas at 1:4000 scale is based on very high resolution satellite data CARTOSAT–2S data, field survey, data from line departments of Government of Meghalaya and other ancillary data from various sources. The project emphasized interpreting the existing features (natural and manmade) within the Shillong planning area boundary demarcated and aimed to bridge the gap between the mapping and efficient planning. The proposed master plan area has extended from 176 km^2 (as per the 1991-2011) to 312 km^2 with respect to GIS based master plan for Shillong. A major portion of the extended area is towards the north and east of the planning area. From the works carried out in the project, it is observed that the high resolution CARTOSAT 2S imagery had a clear advantage in the characterisation of existing different natural and manmade features for the study area. It ensures not only to make a quick inventory of the land use/ land cover but also in updating the road network, settlement locations & building footprints, water bodies, water supply network, power supply network, hazard prone areas, etc. The idea of the generation of digital geodatabase on such a big scale of 1:4000 followed through a national standard, would not only facilitate better urban utilities and services planning but also enable a spatial data repository for major line departments ensuring inter usability of database generated eliminating duplicity.

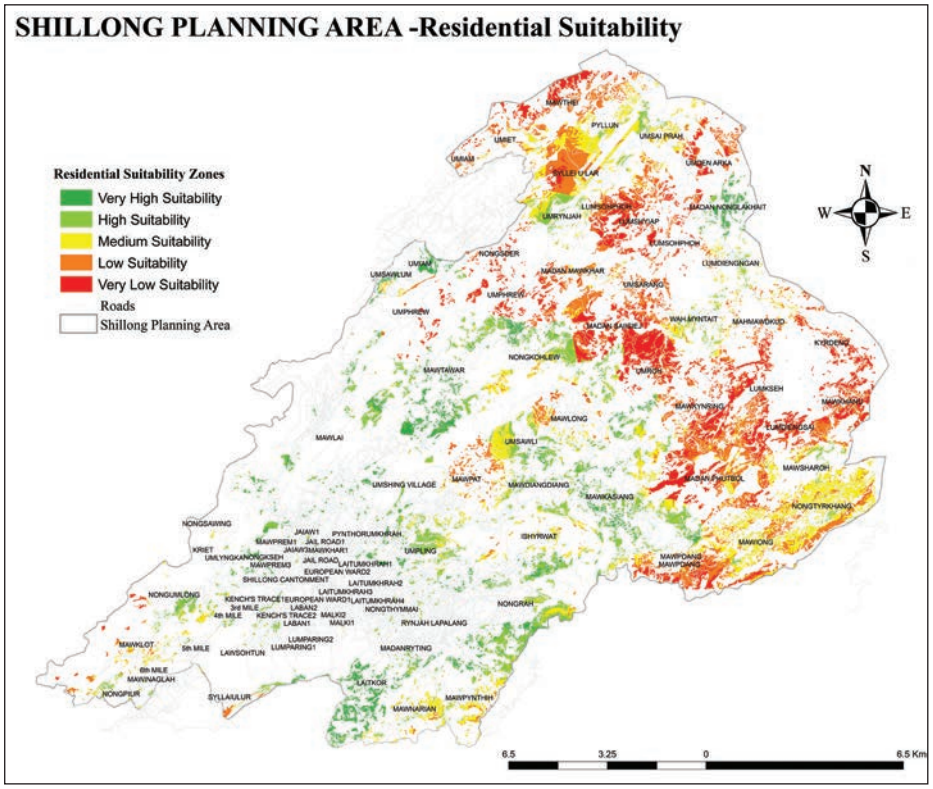
GIS based Masterplan under Atal Mission for rejuvenation and Urban Transformation (AMRUT), Shillong Planning Area, Meghalaya

The draft master plan for the Shillong Planning area was prepared for sector wise precedence by data analysis pertaining to the comprehensive primary and secondary data collected. The sectors covered include

1. Physiography & Landuse
2. Demography
3. Housing
4. Physical Infrastructure
5. Social Infrastructure
6. Mobility
7. Industry & Economy
8. Ecology & Environment
9. Governance & institutional arrangements
10. Hazard, risk, & vulnerability analysis

From the study, it is observed that development in Shillong Planning Area has been constrained by terrain suitability and forest area. While 13% of the total area is already developed (40.9 Sq km), the abundance of hills, wetlands, water bodies, eco-sensitive and forest areas has limited the

developable area to only 13.8 %. The land use distribution of Shillong indicates its administrative and educational standpoint as well as the presence of the Defence Establishment in the city. While residential areas take away nearly 41% of the total developed land, areas under Administrative, Institutional, Public & Semi-public use account for 23% of the land. 11.9% of the area comes under circulation, which is indicative of the hilly terrain of the Shillong Planning Area. The present Land Use of Shillong Planning Area has come up haphazardly. There has been no optimal use of land and the development has been organic. True to most hill stations, the development looks chaotic and no building bye-laws are followed outside the Municipal Area. Hence, any natural calamity poses a direct threat to the safety of the citizens. In the draft master plan for the Shillong Planning area, landuse for 2041 has been designed strategically. The industrial zones have been taken outside the city where connectivity is available, but development is sparse. These industrial zones will develop the less developed parts of the Shillong Urban Agglomeration Area. The residential areas have been carefully planned along with the permissible FAR (Floor Area Ratio). The dilapidated houses and rented houses have also been taken into consideration while calculating the future household requirement. Dedicated Commercial zones have been demarcated near residential areas so as to balance the activities. Green spaces and open parks have been allocated in between residential areas within walkable distances to make sure that living conditions are not devoid of open spaces. The public and the semi-public area have been allocated at a central location in the Shillong Planning Area and it is not spread throughout the city to make sure that traffic flow for administrative units moves out of the city and concentrates at one central location. This will reduce the traffic burden within the municipal area during peak hours and move it to a more desirable location.



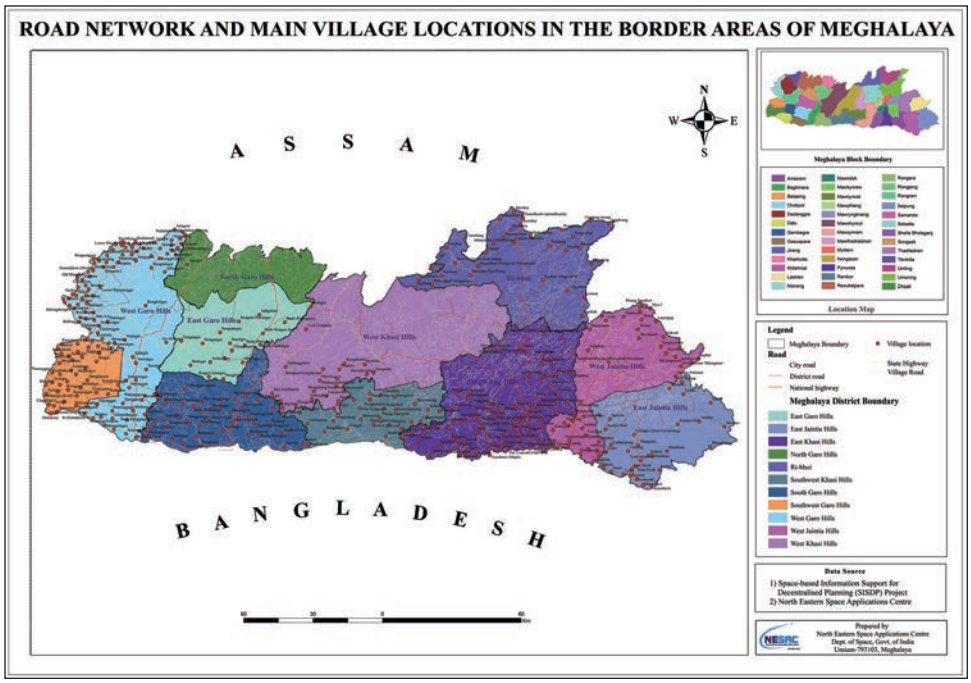
Residential Land Use Suitability Proposal for Shillong Planning Area

Border Area Development Plan, Meghalaya

Meghalaya is bounded by Bangladesh on the south side and on the western part. The Border Area Development Programme (BADP) covers 19 blocks in eleven districts that border Bangladesh. The total area of these blocks is 5136.04 km^2. The international border in the state of Meghalaya is about 423 km in length. The state of Meghalaya is bordered by the Assam on the north and east sides. The Border Area Development Programme covers 21 blocks in eleven districts that border Assam. The partition of the country in 1947 changed the economic situation of the people living there due to the strangulation of trade links that has caused trade

imbalances, population shifts to the citizens of India residing in the state of Meghalaya. In order to ameliorate the economic sufferings of the people in the Border Areas and to rejuvenate the erstwhile prosperous economy, special schemes were taken up in the notified border villages, in addition to the normal State Plan schemes.

In the area of Khasi and Jaintia Hills, there are 77 villages in the district of East Jaintia Hills, which are falling within a 10 km distance from the interstate boundary with Assam. The West Jaintia Hills district consists of 55 villages within 10 km of the boundary. Heading to the northern part of Khasi Hills, the villages in the RiBhoi district that are within 10 km of the border are 131 villages. In the Garo Hills region, as per the village locations collected, it was found out that there are 12 villages in North Garo Hills district, 410 villages in the West Garo Hills district, which are within 10 km from the border of Assam and on the district Southwest Garo Hills there are 206 villages which are falling below 10 km distance from the area bordering Assam. The area in the southern and western parts of the state of Meghalaya is bounded by Bangladesh. In the area of Khasi and Jaintia Hills, it has been identified that there are approximately 31 villages that are falling within a distance of 10 km. About 23 villages are at a distance of 10 to 20 km from the international boundary with Bangladesh in East Jaintia Hills district. The West Jaintia Hills district consists of 74 villages which are within a distance of 10 km and 20 villages that are falling at a distance of 10 - 20 km from the international boundary (IB). In East Khasi Hills district, there are 223 villages that are falling within the distance of 10 km and 136 villages which are between the distances of 10 - 20 km from the international boundary. Heading to the Western part of the Khasi Hills, in the West Khasi Hills district, it was found that the villages are falling beyond the distance of 10 km from the international boundary and there are approximately 51 villages which are beyond 10 km and within 20 km from the boundary line. Moving towards the Southern part of the West Khasi Hills district, the villages bordering the international boundary are about 143 villages which are falling within the 10 km distance and 72 villages which are between distances of 10 - 20 km are under Southwest Khasi Hills district. In the region of Garo Hills, around 170 villages in the South Garo Hills district which are within a distance of 10 km and about 163 villages are between a distance of 10 - 20 km, have been identified from the borderline. In West Garo Hills, there are 116 villages falling within 10 km and 70 villages that are lying between distances of 10 to 20 km from the international border. In the South West Garo Hills district, there are 158 villages that are within a distance of 10 km and 77 villages that are between 10 - 20 km from the international boundary line.



Road Network and village locations in the border areas (Inter-state and International) of Meghalaya

GEOSCIENCES

Surveying of the proposed Mining Lease boundary pillars over an area of 13.098 ha. of Star Cement using Differential Global Positioning System (DGPS) techniques

Indian Bureau of Mines (IBM), Ministry of Mines, Government of India has issued guidelines for the preparation of mining lease maps using DGPS techniques. Each boundary pillars shall be surveyed using DGPS (at least 2 Hours observation) for its ground position by an agency recognised by the State Government. North Eastern Space Applications Centre (NESAC) has taken up the project "Surveying of Mining Lease Boundaries of the Star Cement Limited, East Jaintia Hills, Meghalaya Using Differential Global Positioning System (DGPS) Techniques" funded by Star Cement Ltd.

DGPS survey was carried out on the existing 18 boundary pillars together with the establishment of one reference point/ benchmark inside the mining lease premises. The study area is located in the Lumshnong Village of Khliehriat Block in the East Jaintia Hills district of Meghalaya state, India. It is located about 40 km towards the south of the district headquarters Jowai, 16 km from Khliehriat, 76 km from the state capital Shillong and are connected by National Highway 35. Jowai, Karimganj, Silchar, Hailakandi are the nearby cities to Lumshnong. It is spread over an area coverage of 13.098 Hectares located at Tongseng with initial 72 Hours of continuous GPS dual frequency observations. The same BM has been utilised for surveying 18 Boundary pillars locations in DGPS mode.

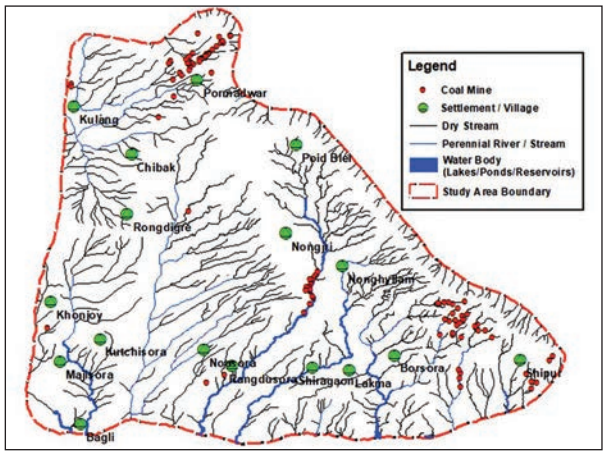
One Bench Mark (BM) reference point was established inside the Star Cement premises. All 18 boundary pillars were observed at a suitable point on top of the pillar and was marked with red colour post data collection for future reference. The boundary pillars survey was carried out in static mode placing the antenna on a tripod using dual frequency GPS receivers. The vertical height of the antenna was measured from the survey mark to the bottom surface of the antenna housing. Each point was occupied for 2 hours with 30 seconds of sampling intervals. The elevation cut off angle was assigned between 10-20 degrees depending on site pillar location. Observation data acquired at each boundary pillar was processed with respect to Bench Mark inside the mine premises. The data was processed using double difference (DGPS) techniques to eliminate common errors between Base (benchmark) and Rovers (Boundary pillar locations) observations using Leica Geo Office proprietary software. The data has been processed in the World Geodetic System 1984 Co-ordinate system in Universal Transverse Mercator (UTM) projection with Zone - 46 & Hemisphere – North to estimate final coordinates of the locations. The Mining Lease map of the site was prepared in ARC Map 10.2 showing the details of pillar locations and coordinates.

Geospatial Database inputs for Planning and Restoration of Areas affected by Coal Mining, Meghalaya

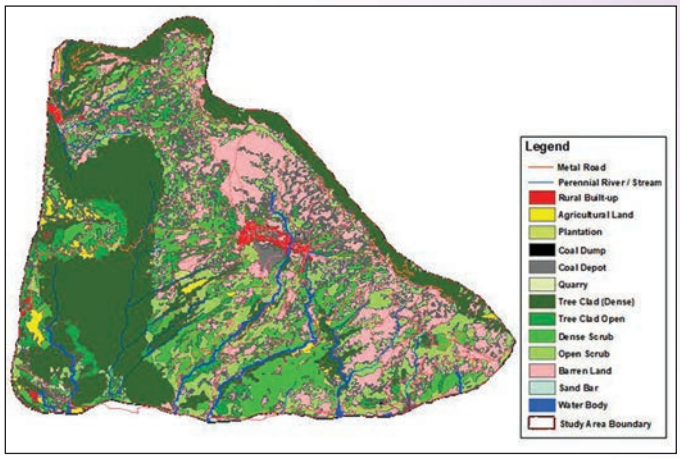
Environmental restoration is becoming an increasingly important component for sustaining an area in healthy condition and functioning the ecosystem through a variety of well planned actions identified with scientific approaches.

It is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed by various natural factors as well as man-made activities. However, the degree of degradation or damage is site-specific and may vary spatially from one place to another due to various geoenvironmental conditions prevalent in the area. Additionally, geo-genic factors also play a certain role to some extent.

Planning for restoration requires a detailed



Drainage & mine-hole map



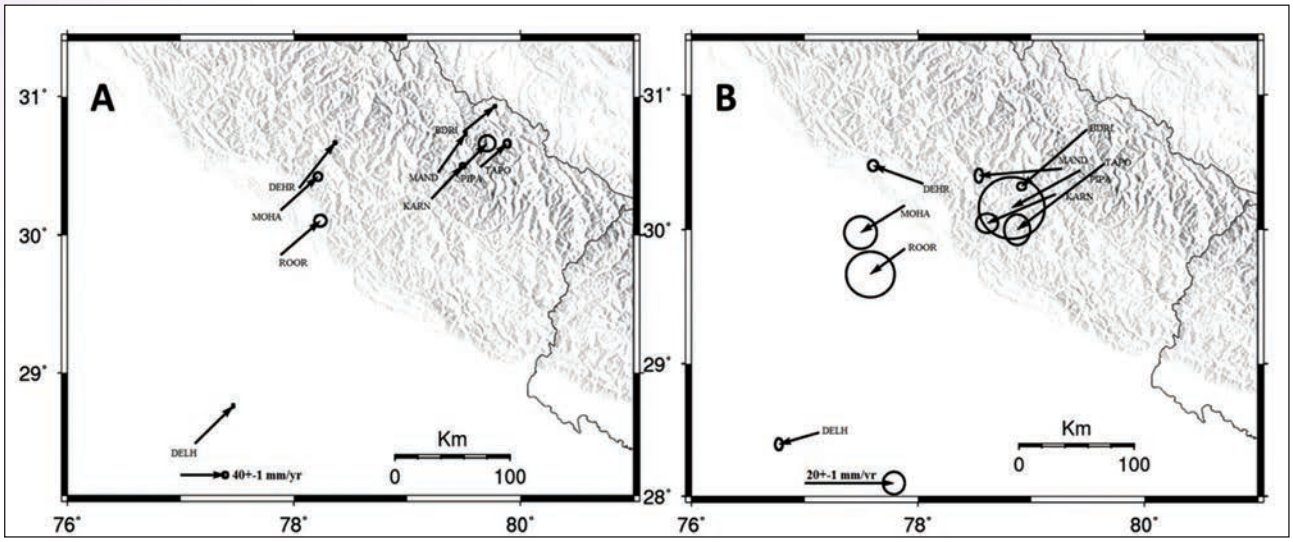
Land use / Land cover map

understanding of different aspects related to the area since each site is unique with its own set of elements in a degrading environment. A comprehensive understanding and site characteristics study includes dry and perennial streams, river configuration, surface soil and landform/physiographic conditions, geology, groundwater, land use/ land cover with their biotic and abiotic components etc. which are some of the essential inputs for planning purpose. NESAC executed mapping of coal mining areas for planning and restoration of areas affected by coal mining in Meghalaya sponsored by Meghalaya State Pollution Control Board (MSPCB) under the direction of Independent Committee constituted by Hon'ble National Green Tribunal (NGT) using geospatial technology. The aim of the project is to provide inputs for the planning and restoration of selected areas affected by coal mining in the state of Meghalaya. In this exercise, a very high resolution GF-2 satellite data having 0.8 m panchromatic and 3.2 m multispectral resolution was used. The study area (Nongjiri) covers 120 sq.km (approx.) and falling in the South West Khasi Hills district of Meghalaya. In the study area, it was observed the presence of 93 (approx.) coal mines including existing, abandoned and mine in progress for exploitation. About 28.93% of the area is occupied by dense vegetation and 23% by Barren/Grassland. The study comes under the second phase and has been completed successfully and submitted the report to the user for planning.

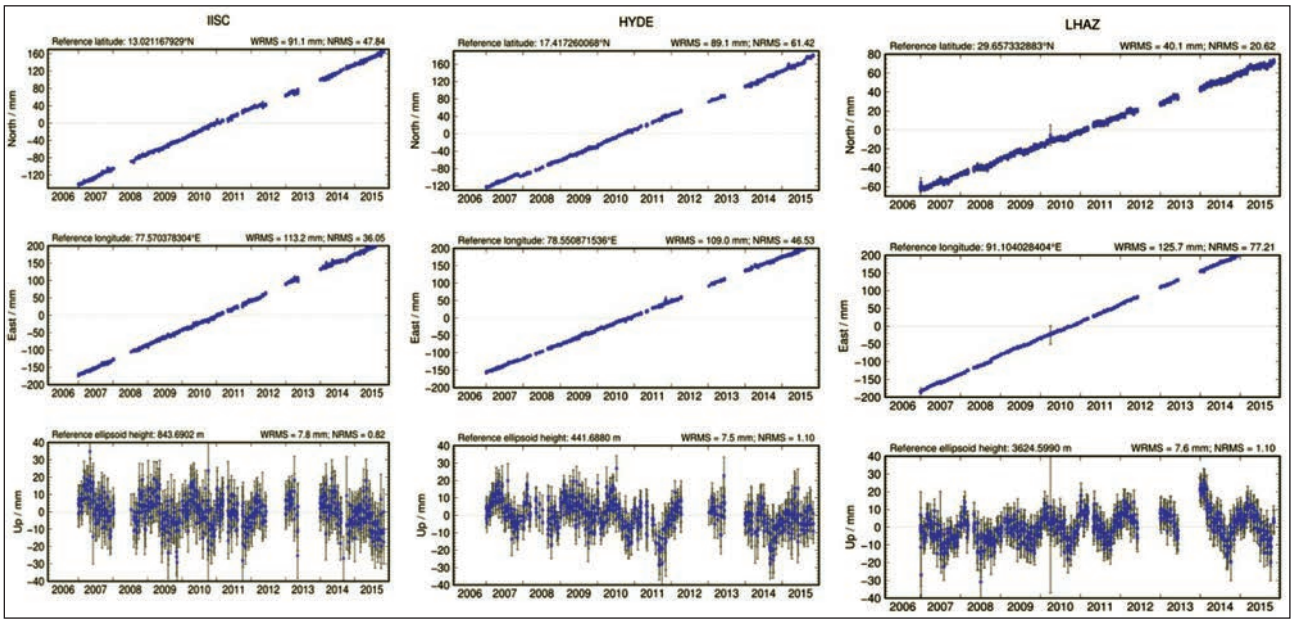
Crustal deformation analysis across Garhwal Himalaya: Part of western Himalaya using GPS observations

A team of researchers from North Eastern Space Applications Centre (NESAC), Indian Institute of Remote Sensing (IIRS), Wadia Institute of Himalayan Geology (WHIG), Indian Institute of Technology-Indian School of Mines (IIT-ISM) and Jammu University has studied the ongoing tectonic process and crustal deformation at a selected transect in a part of western Himalayas as well as of the Indian plate. The study was carried out by the analyses of GPS data processed in a GAMIT/GLOBK platform. The data were collected from four local continuous operating reference stations (CORS), six International Global Navigation Satellite System Service (IGS) stations and five surveyed based GPS campaign stations transverse to major faults system. Results show an annual crustal motion of 19.18 mm near Southern Tibetan Detachment (STD), 18.72 mm near Main Central Thrust (MCT), 11.93 mm near Main Boundary Thrust (MBT) and 11.53 mm near Himalayan Frontal Thrust (HFT) in India fixed reference. The present day Indian plate motion was estimated to be 55.33 mm/yr. In the study region at western Himalaya, the crustal convergence of 13.83 mm/yr was observed in the Dehradun-Badrinath sector in Uttarkhand. GPS sites near to north of HFT show westward movements and sites at peninsular India show eastward movements suggesting possible counterclockwise rotation of

the Indian plate. The annual motion across HFT varies between 0.1 and 2.0 mm, suggesting that HFT is locked in the Garhwal region of western Himalaya. Insignificant movement across HFT indicates greater strain accumulation and the possibility of earthquakes in the near future. The study suggests the requirement of continuous monitoring of deformation across major thrusts in the Himalayas with a dense network of GPS stations.



Map showing velocity vector in parts of Uttarakhand-Uttar Pradesh in (A) ITRF-08 reference frame and (B) with respect to the IGS station IISc, Bangalore as the fixed point. DELH: Delhi; ROOR: Roorkee; MOHA: Mohand; DEHR: Dehradun; KARN: Karnprayag; MAND: Mandal; PIPA: Pipalkoti; BDRI: Badrinath; TAPO: Tapovan.



GPS Time series observed at IGS Stations IISc, HYDE, LHAZ from 9-10 years of continuous data

IT & GEOINFORMATICS

Release of North Eastern Spatial Data Repository (NeSDR)

The North Eastern Spatial Data Repository (NeSDR), a project based on the establishment of NER Remote Sensing and GIS Resource Network was formally released on 11th November, 2020 at NESAC by Shri K Moses Chalai, IAS, Secretary, North Eastern Council. He was accompanied by six of his senior officials including Shri C.H Kharshiing, Planning Adviser, NEC. The meeting was also attended by the Directors of all State Remote Sensing Centres (SRSACs) of NER. Several senior scientists from ISRO have also participated during the official launch. The NeSDR Geoportal hosted at https://www.nesdr.gov.in is populated with 950+ datasets pertaining to land, water, administrative, terrain, action plan, infrastructure, weather and climate, utilities, etc. It provides the datasets as per OGC standards for visualisation via web services. The interface has been designed to be more responsive in all kinds of platforms and devices. It's a single window platform for seamless data accessibility across various users for data visualisation, interactive analysis, search and discovery of spatial based user's interest.

NeSDR also provides a platform for hosting Governance applications of Government Departments to empower planning and monitoring activities. A number of Governance Applications have been developed for the various Government User Departments of the region. The list of major applications is given below:

1. Meghalaya Rice Information System (MeRIS)
2. Geo-tagging and mapping of facilities and assets available at Nokrek Biosphere Reserve of Meghalaya
3. Geospatial survey of coal mining areas in the State of Meghalaya using Mobile and Dashboard Application
4. Geotagging Dashboard cum mobile application for geotagging of schemes of Bodoland Territorial Council (BTC), Assam
5. Dashboard cum mobile application for geotagging of sericulture assets for the Central Sericulture Department (CSB) etc.
6. River atlas for Assam Disaster Management Authority
7. Mobile application for collection of medical data collection for ICMR
8. Geo-tagging and geo-monitoring of NEC/ DoNER sponsored project sites
9. Dashboard application for visualisation and analysis of layers created under CHAMAN project
10. Election e-ATLAS for NE states
11. Survey of village resources for Government of Meghalaya

NeSDR Analytics for regional level Big Data Analytics

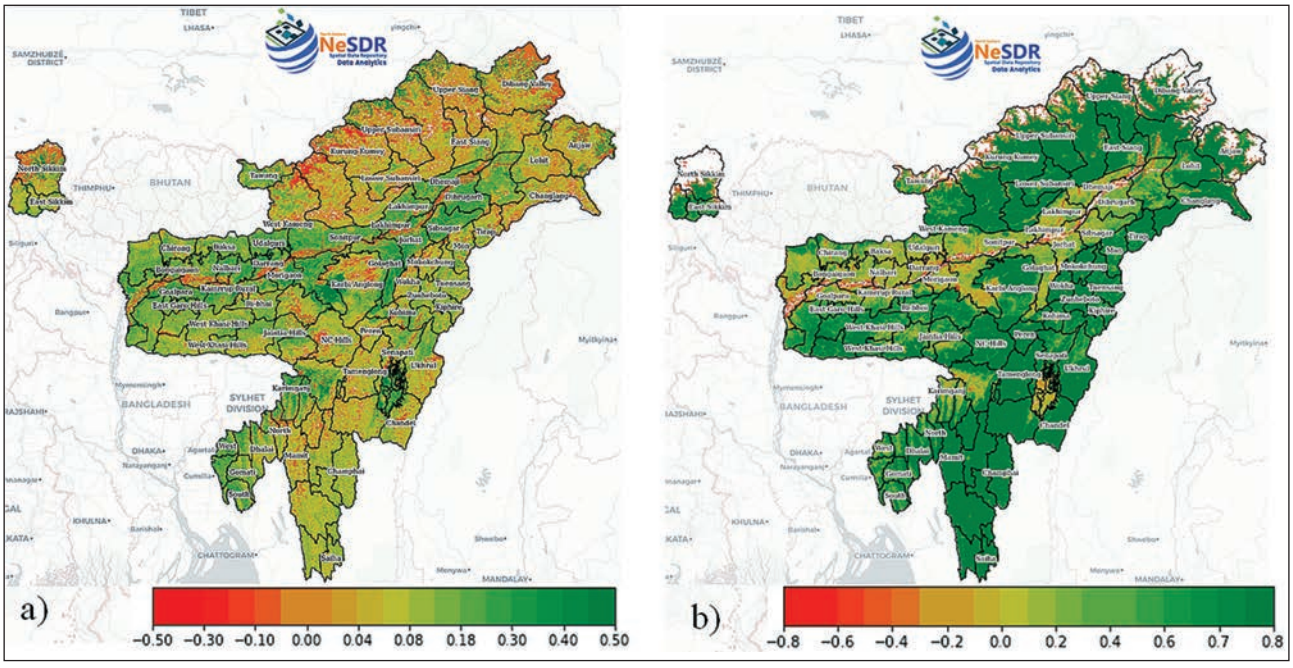
NeSDR Analytics is an indigenously developed powerful geoprocessing platform for performing on-the-fly geospatial big data analytics. The platform incorporates a range of analytical tools like long term trend analytics, point data analysis, clustering and many more on top of the catalogued data. The application is designed to analyse the satellite images on the fly and produce the result as OGC compliant Web Map Service (WMS). The platform is catalogued with a collection of widely used geospatial datasets. The bulk of the catalogue is made up of Earth-observing remote sensing imagery, including the archive of MODIS and INSAT datasets pertaining to NER along with certain cloud free scenes LANDSAT and Sentinel-2. It also includes weather forecasts, land cover data and many other environmental, geophysical and socio-economic datasets. The catalogue is continuously updated with geospatial data from active missions.

The analytics platform is built on an open-source

stack and other enabling technologies that are widely used within the geospatial domain; it is implemented using python programming language. The Geo-processing framework consists of a library of a large number of functions, ranging in complexity from simple mathematical operations to powerful geostatistical, machine learning and image processing operations. Web-based raster calculator is also implemented and made accessible via a simple and easy to use user interface to enable users to perform custom operations. The platform has various modules for disseminating output of research and applications for various thematic areas like; Web-GIS vegetation monitoring system to monitor vegetation change and disturbances using long term vegetation index datasets, Monitoring Air quality using AOD products from Satellite images, Assimilating rainfall from INSAT satellite data, Forest fire analytics using night light images, identifying the flood-affected areas using Near Real Time flood inundation rasters.

of NEC/Ministry of DoNER for geotagging and monitoring of their project sites distributed across North East states including some other parts of India. This is one of the unique geotagging and monitoring initiatives developed by the North Eastern Space Applications Centre (NESAC) using IT-enabled Geospatial Technology with a lot of innovations towards enhancing the Governance process.

The Space Technology deliverables have been effectively harmonised with the most advanced ICT tools and services in a service-oriented architecture (SOA) in the form of an interactive Web-based spatial decision support system (SDSS). There are three major technological components: a) Smart Mobile Application with analytical capability, b) Dashboard Analytics Platform with MIS capability in the spatial domain, and c) Development of Artificial Intelligence (AI)/Deep Learning (DL) based application for analysing the quantitative progress



Vegetation analysis at regional scale: a) Difference of vegetation index between 01-01-2020 and 02-02-2021 using MODIS NDVI products. b) Long vegetation stability map showing the anomaly in the vegetation over the period from 2000 to 2020. Red colour indicates the disturbance in the vegetation while green or dark green colour indicates the increase or intact of vegetation.

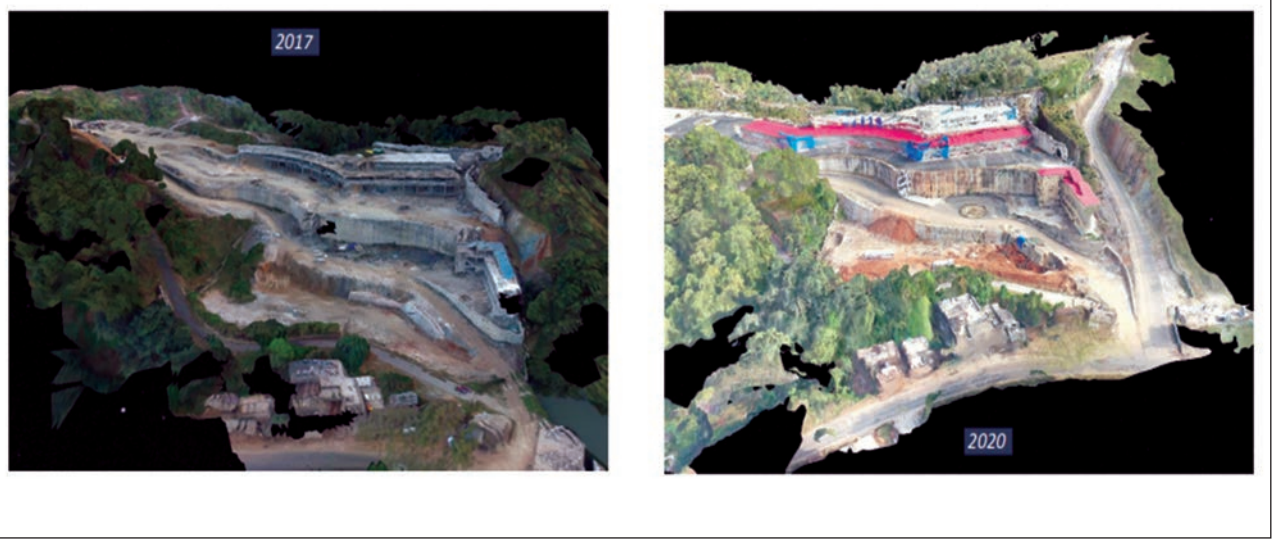
Geo-tagging and geo-monitoring of NEC/ MDoNER sponsored project sites

The project has been taken up as per the suggestion of the sites. The entire SDSS Web Application was developed purely using open-source software and standards. The analytical Mobile Application

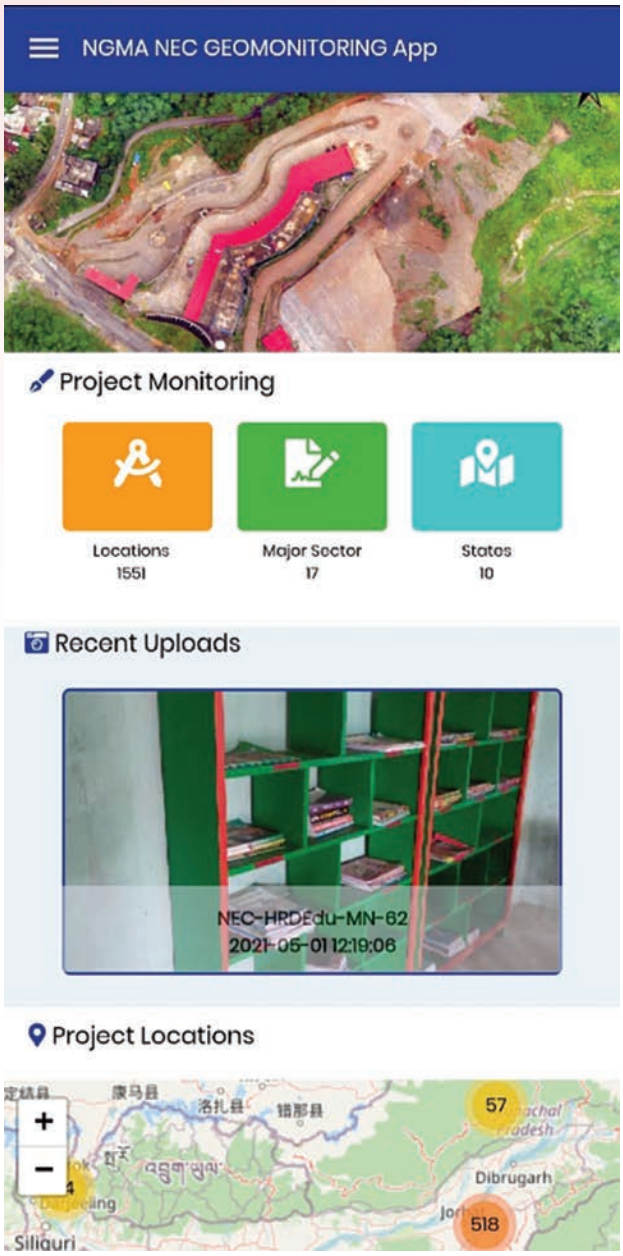
is based on the concept of a progressive web app using the Ionic and Cordova platform and is interlinked with the Monitoring Dashboard Platform for feeding live geotagged data from the project sites. The integrated framework of Geoserver for publishing the maps and PostgreSQL/PostGIS for managing the geospatial databases of Project sites are the core components for managing, publishing, and serving geospatial data as part of SDSS. Dashboard Analytics Platform which is embedded with a set of web application tools and services. A set of indigenously developed APIs is being used for linking the project location with the time-series satellite/UAV images, 3D visualisation of the project site, management of MIS, etc. The external APIs are also used to render the high-resolution base map/satellite images into the Dashboard explorer from the publicly available geospatial data source like Bhuvan, Google, etc. The 3D model of the project site was built using Open Drone map software where time-series DSMs are utilised to monitor and quantify the physical progress, in the case of large-scale infrastructure-based projects involving the construction of buildings. The IoT-based framework is developed to deploy AI/DL algorithms on Tensor Processing Unit (TPU)-based edge computing devices to monitor the quality and the extent of the roads constructed based on video feeds in real-time mode.

More than 550+ projects spreading in more than 1551+ locations are being mapped and monitored using the smart Mobile App with higher positional accuracy, which enables the visualisation of the above project sites over time-series satellite images for evaluation of the implementation process. The geotagging and monitoring analytical mechanism developed by NESAC has given a new dimension towards effective evaluation and monitoring of NEC/MDoNER sponsored projects. The entire evaluation and monitoring mechanism process has been automated with a lot of innovative tools and services to bring more transparency into the monitoring and evaluation system. With the launch of the NEC/MDoNER project monitoring application, it has been observed the speedy implementation of the projects including the remotest corner of the region, proper utilisation and funds, and timely submission of utilisation certificate (UC) for the overall growth of the region.

The NEC/MDoNER project monitoring Dashboard Application has been demonstrated to a large number of important User's Department including the Ministry of DoNER, State Innovation & Transformation Aayog (SITA), Govt of Assam, ASDMA, Assam Veterinary Department, ICMR, etc. Many of such User Departments have already tied up with NESAC for the initiation of similar activity for their Departments.



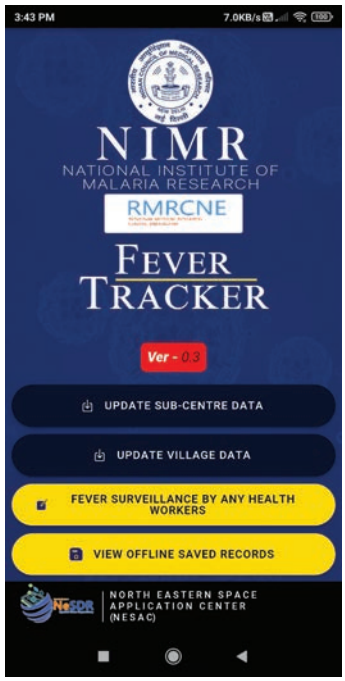
Tracking in 3D and assessment on the change quantification on high resolution multi-temporal UAV images



Geo-tagging and geo-monitoring App for NEC/MDoNER projects

Mobile based integrated surveillance system for early diagnosis & treatment of Malaria and other diseases

NESAC, in collaboration with Regional Medical Research Centre, NE, Dibrugarh has developed an integrated surveillance graphical app called 'FeverTracker' that has been designed to assist the community and the healthcare workers in digital surveillance and thereby contribute towards malaria control and elimination. FeverTracker utilises geographic information system (GIS) and is linked to a web application with automated data digitalisation, Short Message Service (SMS) and advisory instructions, thereby allowing immediate notification of individual cases to district and state health authorities in real-time. The utility of FeverTracker for malaria surveillance is apparent given the archaic paper-based surveillance tools used currently. Digital tools like FeverTracker will be critical in integrating disease surveillance and they offer instant data digitisation for downstream processing. The use of this technology in healthcare and research will strengthen the ongoing efforts at malaria elimination, and FeverTracker provides a modifiable template for deployment in other disease systems.



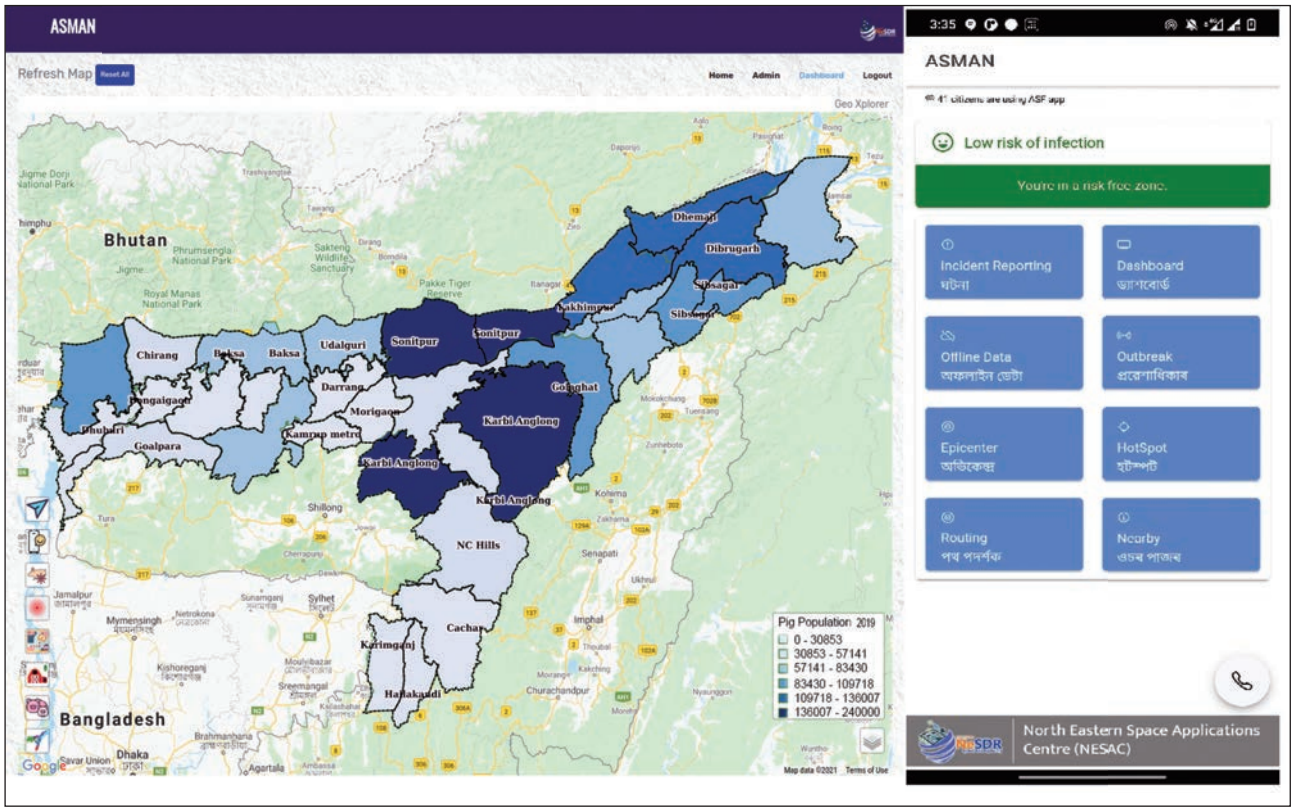
FeverTracker App (ver – 0.3)

FeverTracker is based on the concept of a progressive web application using Ionic and Cordova platforms. The app can capture ground information on malaria incidents attributed with geographic positional information, geotagged photos and other relevant data as per the prescribed format. FeverTracker supports multi-lingual data to cater to the local requirement and inclusive use. Detailed symptoms information and use cases are included in the app. Advisory regarding drug doses information based on user symptoms is also included. The app currently supports Android OS 4.4 or higher. Hypertext Preprocessor (PHP) webserver was used to deploy the app and this application works on client-server architecture where in the backend, PHP and Mysql server are used. The app also works

in an offline mode where the SQLite database is used for record management. The mobile app is interlinked with an interactive web portal for data visualisation, summaries and data downloads. The app adheres to the privacy laws and policies while seeking permission to access location, permission to use text messages, mobile data and local storage. In addition to the automated data capture, FeverTracker is linked to Short Message Service (SMS) and advisory instructions system to notify the District/State response centre as per national guidelines.

African Swine Fever decision support system (DSS)

During March-April 2020, Assam reported an outbreak of African Swine Fever – a severe viral transboundary disease affecting domestic and wild pigs. African Swine Fever caused the death of 15000+ pigs within the state, and the control of the disease is still going on. Due to inadequate capacity and resource constraints, the control of transboundary animal diseases (TADs) usually requires long drawn efforts involving various stakeholders. NESAC has developed a prototype Dashboard Application integrated with Mobile Application as per the suggestion of State innovation & Transformation Aayog (SITA), Government of Assam. Vet Helpline India Pvt Ltd has helped in the prototype development by supplying the base level data on livestocks. The application was demonstrated in virtual mode on 9th June 2020 where Joint Secretary, Livestock Health, GOI, Animal Husbandry Commissioner, GOI, Director, Department of Animal Husbandry and Veterinary, Government of Assam and Officials from important stakeholders and NGOs have attended. The prototype Dashboard Application integrated with geospatial analytics was highly appreciated by all the participants and suggested to integrate space technology inputs for controlling and monitoring the outbreak of African



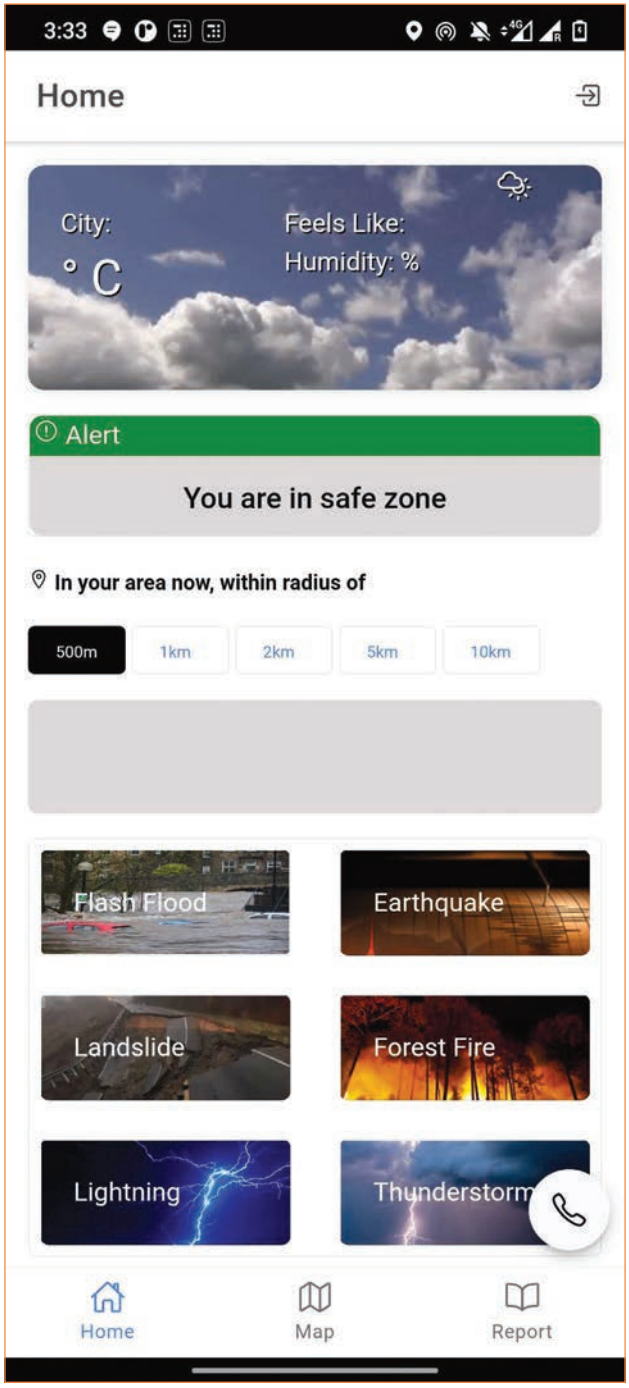
The district-wise density of pigs for the year 2019 is depicted in the visualisation panel of the prototype Dashboard Application (left). The incident reporting Mobile App is depicted on the right.

Swine Fever including other TADs. The outbreak of African Swine Fever was also reported in the states of Arunachal Pradesh, Meghalaya and Nagaland. Recently, NESAC is in the process of developing operational web-based DSS for the state of Assam and other states of NE region.

Integrated WebGIS Platform for Dissemination of Real time Early Warnings/Alerts and Enabling Analytics in Spatial Domain for Monitoring and Management of Disaster Events

With the request of ASDMA, Government of Assam, NESAC has developed a prototype application for dissemination of real-time early warnings & alerts for monitoring and management of disaster events. It facilitates the dissemination of early warnings issued by India Meteorological Department (IMD), NESAC, CWC or any other organisations responsible for providing alerts to ASDMA via Mobile Application/SMS.

The application is also integrated with time-series data on land use, climate and other relevant information from the publicly available open source web/data services to provide as reference base in a regional scale. The prototype Mobile Application on the dissemination of alerts/early warnings on floods, lightning etc. with Geofencing capability to provide real-time information while passing through any disaster risky zones. This can provide proximity to the disaster incidents or epicentres from the current location. This enables the application to facilitate the optimal or shortest route by avoiding the risky zones during any emergency situation. The application is coupled with a Dashboard management system which can send alerts to the Mobile Application including the SMS text messages. AI/DL-based analytical tools for assessment of damage/vulnerability analysis using time-series satellite images (open series) and visualised via on-the-fly analytics to provide real-time reference inputs are also added for enabling decision making.



Smart Mobile App to receive alerts and early warnings

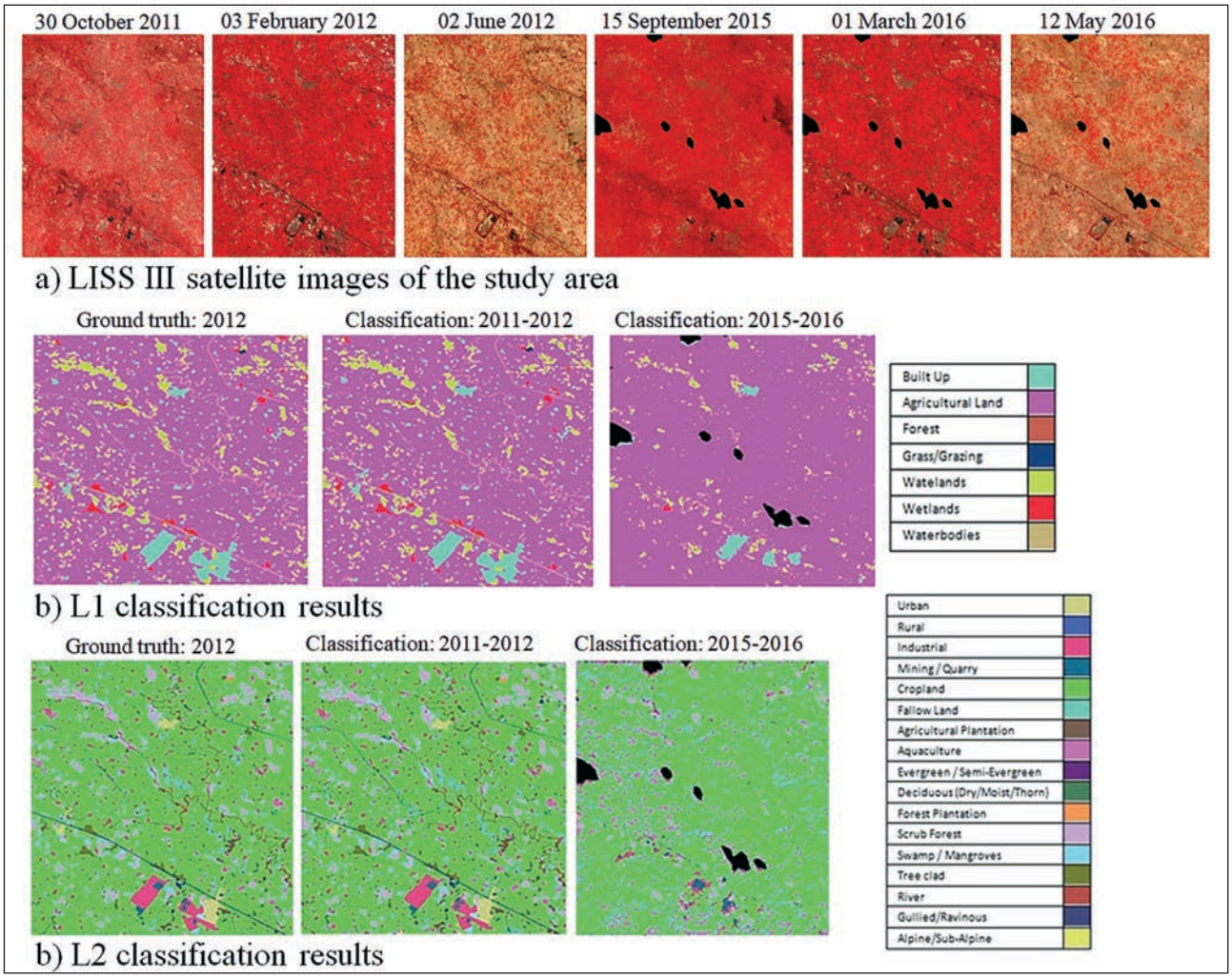
Utilisation of Artificial Intelligence/Machine Learning/Deep Learning Techniques

NESAC is utilising a number of AI/ML/DL algorithms and tools for near real-time predictive analysis, feature extraction and pattern recognition under various operational services including R & D activities. NESAC has also successfully completed three AI/DL based projects of DTDI, ISRO Hq. Some

of the application oriented techniques developed by NESAC are illustrated below:

a) Kshiti: It is an ISRO DTDI AI project to create LULC thematic maps at source and/or better resolutions using the DL technique. LISS III images of October 2011, February 2012 and June 2012 representing the pattern of three seasons have been used for classification at 1:50000 scale. The case study was conducted for a plain area of Haryana. This dataset corresponds to datasets for dynamic land cover classes covering the season of Zaid, Rabi and Kharif. Groundtruth data was generated from the land use land cover map of 2012. For validating the models, 2015-2016 LISS III datasets were used. Random 5000 patches of size 128x128 pixels have been generated and used for training the deep learning based model. Model is able to achieve accuracies of 97.5%, 95.1% and 92.1% for Level-1, Level-2 and Level-3 classification.

b) Monitoring the progress of the construction sites: The aim of the study is to monitor the progress of the construction site of Interstate bus terminus (ISBT), Shillong, Meghalaya using the multi-temporal UAV imageries of 2017, 2018 and 2019 years. The deep learning architecture proposed here for classification is a variant of CNN; comprised of 6 layers. It is comparatively a simple, effective and computationally efficient approach than any other DL approach, which demands huge computational resources as well as a large volume of the training dataset.

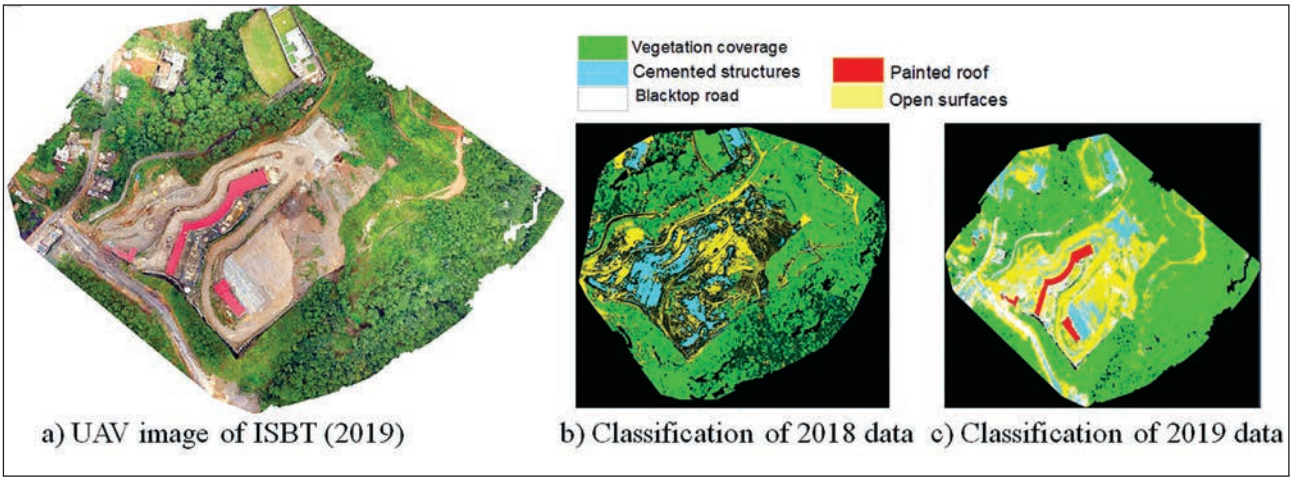


Land use land cover map (L1 & L2) generated from LISS III images using DL technique

c) Nireekshan: NESAC team was a part of the ISRO DTDI AI project initiative to use as a visual inspection Assistant (VISA) for pattern recognition/anomaly detection. Automated visual inspection in the semiconductor industry aims to automatically detect and classify manufacturing defects by utilising modern AI-based image processing techniques. The ability of such systems for early detection of defect patterns allows systematic quality control at each stage and automation of manufacturing chains leads to an increased yield and reduced manufacturing costs. This project focuses and compares different AI-based deep learning models and adopts the most suitable model for efficient autonomous detection and classification of defect categories. Further, an attempt has been made to build a scalable, user-friendly GUI framework for operationalising our output at SCL, ISRO.

e) Deep learning based automatic landslide extraction using LISS-IV imagery: Landslide detection is an important activity in disaster rescue operations. An automatic landslide detection model based on deep learning has been developed to extract landslide from LISS-IV imageries. An interactive web based interface has also been provided to use this developed model. Multiple landslide incidents in Nagaland and Sikkim region have been used for training the model. Total 3000 patches have been generated. Five layer neural networks have been designed and trained. An interactive web based interface has also been provided to use this developed model.

f) Automatic aerial road extraction using deep learning: A DL based technique was developed for automatic extraction of roads from UAV images with 5cm spatial resolution. Total 8000 annotated patches have been used for multi-scale adaptive deep model with parameters of 21.5 million. The model has achieved a total mean intersection over the union of 82.1%.

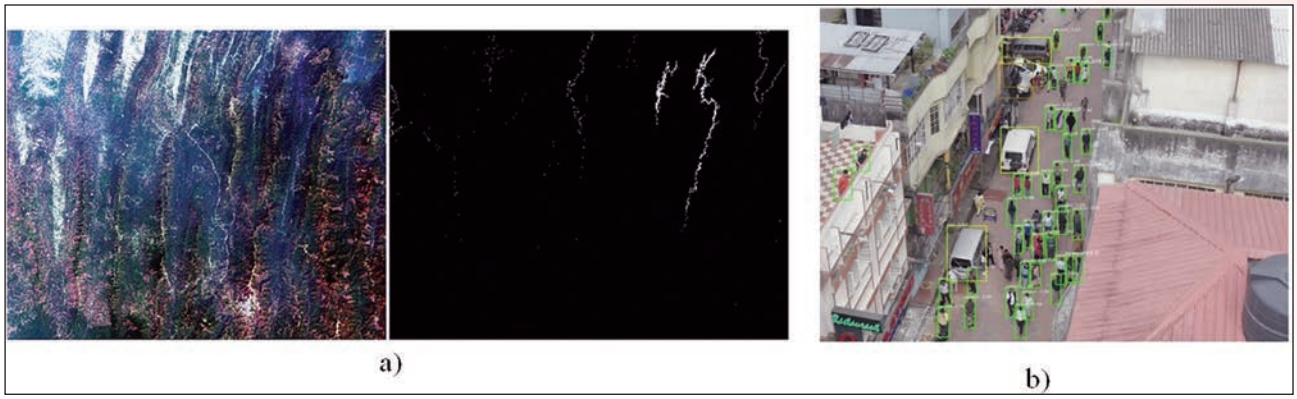


Classification of multi-temporal UAV images for assessing the progress of the construction site – a) UAV image of ISBT, Shillong acquired on 24th July 2019. b) Classification result of 2018 UAV image. c) Classification result of 2019 UAV image.

d) Waterbody extraction from Sentinel-2 images: Multi-layer DL technique was developed to extract water bodies from Sentinel-2 images. The model was trained with the ground truth images acquired during February to April of the year 2018 pertaining to NE states. The model has achieved an overall accuracy of 87.1% and was found better than any index-based water body extraction approaches.

g) Real-time multi object detection on UAV video: Under the TDP project of NESAC, a DL technique was developed to detect multi-objects from real-time UAV video feeds. The multi objective neural network has been designed to detect and track multiple objects in aerial view with

special emphasis on person and vehicle class. The model has shown a detection accuracy of 83.6% with 58 FPS.

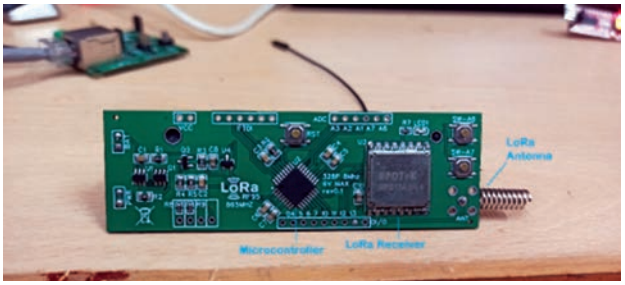


Object detection using DL technique – a) Automatic detection of landslide from Sentinel-2 image. b) Multi-object detection from UAV video feeds in real-time mode.

Development of IOT and Android Based Location Aided Flash Flood monitoring System for Anil Nagar area of Guwahati city

Every year due to heavy rainfall in Assam or its neighbouring states/countries, the state is hugely affected due to floods. NESAC has developed a framework of IoT based flood monitoring system for Guwahati city of Assam in order to support concerned Government departments towards effective monitoring and management of flood situation. The system comprises a network of water sensing nodes and base stations to monitor the rise in water levels and other weather parameters such as temperature, relative humidity and air quality. IoT based water sensing nodes are integrated LoRa Sender to communicate seamlessly with the base station. The water sensing nodes along with the base station, has been deployed in different locations of Guwahati city and the data is being continuously captured via a dashboard and mobile app based system for monitoring the water levels.

Water sensing node for measuring water level deployed at different location of Guwahati City



Base station for monitoring air quality, temperature and relative humidity

DISASTER MANAGEMENT SUPPORT ACTIVITIES – NERDRR

Flood Early Warning Systems (FLEWS)

After successful implementation of FLEWS in Assam and with the advice from the Chairman, ISRO, NESAC has extended the FLEWS project to other flood prone rivers of North East India. Accordingly, the semi-distributed hydrological models have been built and made ready for calibration and validation. A series of stakeholder meetings have been held with the state level disaster management authorities and remote sensing centres for successful implementation of the same. During monsoon 2020, few experimental alerts have been issued for Meghalaya & Arunachal Pradesh.

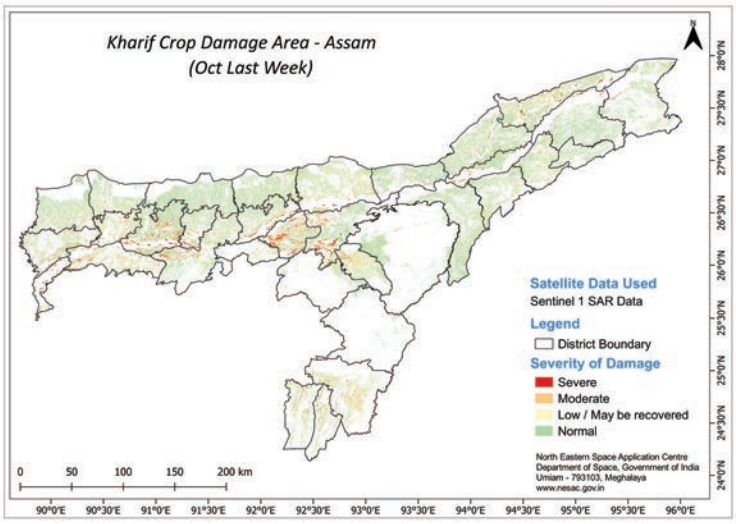
Assessment and monitoring of embankment breach locations under FLEWS in Assam (2020-2021)

River embankments are also known under various nomenclatures as Levees, Dykes, etc. They are essentially structural control measures constructed along the river banks to mitigate flood. As a part of the FLEWS programme, NESAC has taken up an exercise of mapping the existing embankments in major flood prone districts of Assam and also to identify breach points using temporal satellite data in various locations of river embankments covering all districts of Assam, prior to the occurrence of monsoon on an operational basis. Post-flood Sentinel-1 data were acquired during August 2020 to identify the embankment breaches due to the floods. Using Sentinel-1 SAR data, 17 breach locations were identified in 9 districts of Assam.

An attempt has also been made to evaluate the embankment breaches using Planet Lab archive data acquired during the month of January to April 2021 and the status of plugged or unplugged breaches have been evaluated. 17 numbers of breach locations that were identified using sentinel-1 data were relooked for monitoring its status. Out of 17 breaches, 9 were plugged, 1 was unplugged and the remaining 7 were unidentified.

CropDAMS: Crop Damage Assessment and Monitoring Service

The main objective of CropDAMS is to provide near real-time information on the crops damages due to floods, bankline erosion, drought, disease and pest and other factors. Floods have been recognized as one of the significant natural hazards encountered almost every year in several parts of the North-Eastern states, most often around the monsoon season which results in huge crop losses. During the year 2020, in Assam, 27 districts have been affected by the overflow of rainwater. It was observed that Barpeta, Morigaon, Nagaon, Dhemaji, Cachar, Goalpara, Lakhimpur, Kamrup rural, Kokrajhar, Sonitpur and Dhubri were the most affected districts in Assam by floodwater in 2020. Barpeta district was the worst hit with 7.35 lakh people affected, followed by Morigaon where 3.50 lakh people were suffered due to flood. Monitoring of crop growth stages has been done in a scheduled manner for the entire state of Assam. Crop phenological changes and damages has been observed using Sentinel 1A data at 12 days interval from the middle of June to first fortnight of December (Kharif season). In Assam, crop transplanting starts from 15th June to 15th July every year. In 2020, the transplanting started in mid of July (most of the districts) and harvested in November/December but, in the district like Barpeta, we have observed that transplanting started late, and crops were continuously affected by flood water even at 48 Days After Planting (DAP). Crop damage areas were categorized as severe, moderate, and low based on areas inundated as of October last week. Non affected crop area due to flood was categorized as normal. The total damage area is **91945** ha (**4.56**% of total Kharifcrop area) considering only the Severe category and where moderate and low severity areas (**698990** ha) may recover later.



Kharif Crop Area Damage Assessment due to flood in Assam

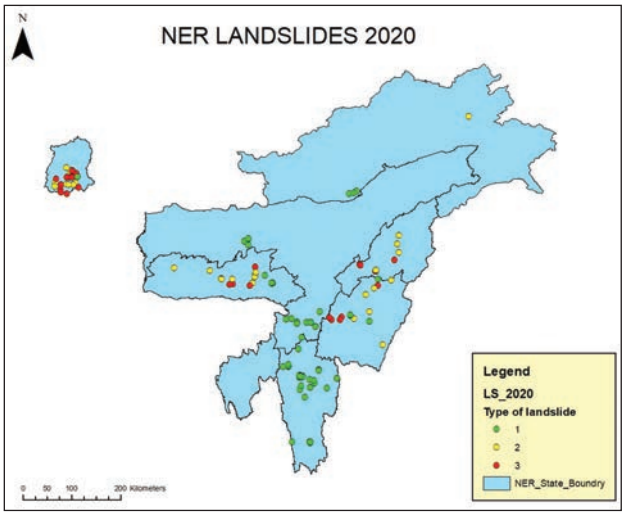
Landslide susceptibility mapping in NER

Recognizing landslides as a chronic problem for the North-Eastern Region, a need was felt for a long-term, exhaustive and detailed study of landslide occurrences in the NER over the past several years. Accordingly, a Multi-temporal Landslide Inventory is being carried out for the different states of NER using data from a variety of sources spanning several decades including satellite data, newspapers, toposheets, etc. In 2020, there were 141 landslides recorded during post-monsoon season in NER. The landslide sources for the inventory include Newspapers, online media, SDMA reports from certain states, as well as field visits. The satellite data used for identifying and verifying landslides is the open-source SENTINEL-2 Multispectral Instrument (MSI) Level 1C and 2A data which have a Ground Sampling Distance of about 10m. The verification of landslide incidents in the inventory was carried out via field visits and inquiries to local personnel and state administration.

NESAC also carried out the Rainfall-Threshold Studies for the landslide incidents in 2020 to examine the role of rainfall as a Triggering Mechanism for landslides in NER. NASA's Global Precipitation Model (GPM) IMERG Final Run (v06) Gridded Rainfall product which has a spatial resolution of about 0.1 degrees (approximately 10 km) was selected for this purpose. The parameters Critical Intensity and Critical Duration were identified from graphs using cumulative rainfall for the preceding 14 days of a landslide occurrence. The graphs also demonstrate that at first, rainfall gets percolated and stored in the soil but persistent rainfall ultimately breaches the threshold and triggers landslides. This study has been carried out for the Barak Valley Landslide incident of 2020.

This exercise is very important as once I-D (Intensity-Duration) Thresholds are realized for the entire North-Eastern Region, then strategic deployment of sensors in areas with active landslides will be carried out by NESAC.

Thangshalai Landslide, Meghalaya (3d view on left; Orthomosaic on right)



NER 2020 Post Monsoon Seasonal Landslide Inventory

AI based landslides detection

A study to identify landslides on satellite imagery using AI based landslides detection model which may help in rescue process if landslide occurs as a secondary event for a natural disaster like an earthquake or any other natural hazards. This AI based landslides detection model will help to identify all the landslides areas once satellite imagery is available after any disaster.

The current AI based landslides model is trained with 8 scenes of LISS-4 MX images of the northeast region and tested in 3 scenes. One preliminary sample result is shown below:

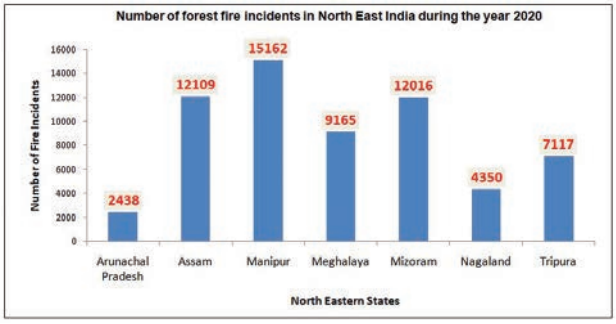
Scene-1:

Persistent Scatterers continuous streaming for landslide monitoring and mapping

The main objective of this activity is systematic tracking and monitoring of ground deformation in active slide areas at regional scale as well as for the slow and very slow landslides using PSInsar technique. This work currently is in progress.

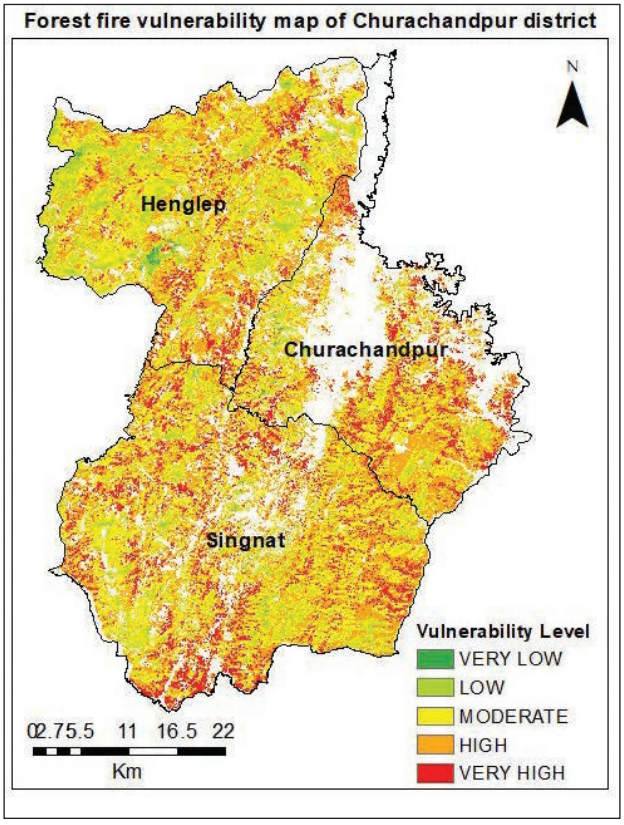
Forest fire assessment in NER

NESAC is actively involved in monitoring and assessment of forest fire through space-based technology and field surveys. Forest fire hazard alerts based on fire occurrence for each state were given from the month of February to April every year. The forest fire locations are obtained from NRSC Bhuvan. Additional information on site characteristics like forest type, forest density, elevation, slope, road connectivity, etc., are added for evaluation of the fire spread. During the 2020 time period, the entire NE region of India has witnessed around 62352 numbers of fire incidents.



Overview of Forest fire in Churachandpur district, Manipur

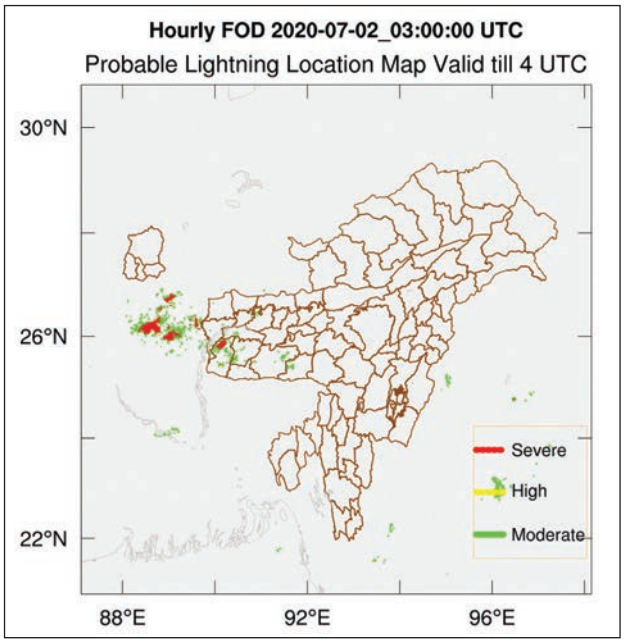
Forest fire occurs regularly in Churachandpur district, Manipur leading to forest loss. The district witnessed the total number of fire occurrences in the year 2017, 2018, 2019 and 2020 was 256, 381, 1255 and 2252, respectively (Source: FSI). NESAC sends value added forest fire location information to the forest department for assistance in forest fire mitigation. The forest fire vulnerability map has been generated by multiple-criteria decision analysis to know the spatial distribution of the forest fire vulnerable areas. The vulnerable areas as shown in the map are categorized into very low, low, moderate, high and very high. The respective areas under each category are 5 sq.km, 166.8 sq.km, 645.9 sq.km, 801.9 sq.km, and 206.9 sq.km. The forest fire burned area information has been provided on request from Churachandpur forest division, Manipur. The estimated total annual burned area in Churachandpur is 50.6 sq.km in 2017, 82.0 sq.km in 2018, 81.1 sqkm in 2019 and 140.1 sq.km in 2020 (map shows burned



area during 2017 and 2020). The burned area has been estimated by Normalized Burn Ratio (NBR) for pre- and post-event using Sentinel-2 MultiSpectral Instrument (MSI), and Landsat-8 Operational Land Imager (OLI) sensors from the year 2017 to 2020 and verified by field visits.

Severe Thunderstorm and Lightning Nowcasting (Operational Services)

In 2019, an attempt was made to provide location-specific lightning strike warnings with a lead time of up to 6 hours using the Numerical Weather prediction model (WRF-ELEC). The model was run in 3 km spatial resolution during the 1st April to 15th June 2020 period as well as from 15th March 2021. The NER-DRR team also provides maps identifying the region where there was potential for the development of thunderstorms occurrence using data from numerical models, satellites, and weather radars. The nowcasting services are uploaded in the NER-DRR portal and also communicated directly with all concerned people. The lightning nowcasting services are provided on an hourly basis, while the thunderstorm potential maps are generated three times a day with three hours lead time for each nowcasting. The whole

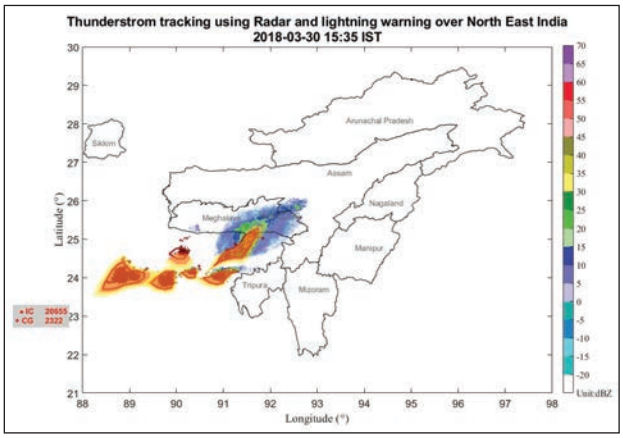


Forecasted lightning flash density on 2nd July 2020.

processes have been fully automated in 2021 and displayed on the NER-DRR website.

Development of Thunderstorm tracking system (R&D initiative)

As lightning is associated with thunderstorms and due to stochastic changes in speed and direction of thunderstorm cells, the pathway of a convective thunderstorm cell is very difficult to be predicted perfectly. Nevertheless, the use of total lightning [all the intra-cloud (IC) and cloud to ground (CG) lightning] and Radar data (radar reflectivity and windspeed) can play a vital role in the thunderstorm tracking and lightning warning. NER-DRR team took up an experimental study for tracking severe storm and lightning using data from a lightning location network combined with radar or satellite-based observations. The initial developments of the thunderstorm tracking system have been completed using the DWR, Sohra data which has the potential to be used for operational nowcasting services once the study is completed. Performances of the tracking system using archive data have also been taken up and initial results are encouraging. To validate this tracking system in real-time, data provision is under process with NRSC, Hyderabad and IITM, Pune.



Thunderstorm tracking with a combined total lightning and DWR data

Automatic Rainfall Data Pre-Processing

According to different studies, it is found that rainfall is one of the major contributors to landslides

in the hilly region. In this year, it is initiated to work on estimating rainfall threshold (empirical model) triggering landslide in different terrain (especially lithology, soil and overburden) conditions of NER. As part of this task, a python based tool developed to download and compute hourly /monthly rainfall precipitation to reduce the time taken to pre-process data manually otherwise.

IT Support and Services under NER-DRR

The NER-DRR has a state-of-the-art facility for necessary IT support, services and dissemination of information for disaster support and mitigation through its secured network infrastructure. The infrastructure provides efficient storing, processing and retrieval for a large number of geospatial datasets for the region. Further, it also has a web hosting infrastructure for secure web hosting and dissemination of these datasets in the form of user-friendly and responsive web applications. In this regard, the Centre has also created a number of decision support systems for various disaster scenarios based on the database generated under different disaster domains and their dissemination via the NER-DRR website for the user departments and general public.

Some of the web applications developed and operationalized for web dissemination of various information pertaining to disaster management under the NER-DRR programme of NESAC are highlighted below:

Spatial Decision Support System (SDSS) for Earthquakes

A spatial decision support system was developed for monitoring earthquakes that occur in the north eastern region of India and surrounding areas. The latest information for the Earthquakes are acquired from USGS and are presented through a geo-web portal that includes NESDR (NESAC) base maps and layers along with certain seism tectonic layers sourced from Bhukosh – GSI's portal. There are two main views in the web portal – the first shows all the earthquake points that have occurred in the last 24 hours with the ability to display relevant information on click; the second is the one concerned with the display of historical earthquake data with enhanced visualization options that include heatmaps and spatio-temporal filters for date/magnitude/depth. Additionally, the portal also scrapes text news items from national e-news feeds (RSS and ATOM) which are related to earthquakes happening in the NER region. The entire processing chain is completely automated with PHP scripts that run at regular intervals for pulling information.

SDSS for Forest Fires

A spatial decision support system was developed for monitoring forest fires that occur in the north eastern region of India during the forest fire season (the months ranging from January to April each year). There are two views – one that shows fire locations that have happened in the past day and another which shows fire data on a yearly basis (last 20 years). While reporting for forest fires was happening even prior to this through the NERDRR web portal in the form of reports, there were two marked differences from the information being disseminated now. First, the reports previously generated were in the form of static PDF files. Secondly, they were in the form of fire point locations. The data was being gathered from the Bhuvan portal and used SNPP/VIIRS and MODIS to provide the fire point information. However in the new portal that is developed, the data is displayed in a spatially queryable form and is dynamic in nature. Additionally, the information uses FSI data (the portal automatically pulls data from a WFS exposed by FSI in a periodic manner) which makes the fire locations available in the form of polygons instead of points giving a better understanding of the clusters of fires happening. The portal also displays NESAC provided information like several base layers for roads, water bodies, settlements etc. along with some weather parameters for the fire locations like wind speed, wind direction and

relative humidity which come from the WRF model outputs at NESAC. The entire system is almost fully automated and requires minimal human intervention. As of now, additional changes are being made so that even the email alerting process (fire alerts sent to district and block level authorities and concerned departments) is automated.

SDSS for Landslides

A spatial decision support system was also newly developed for landslides happening in the NE region of India. Near real time, verified information about landslides are hard to come by as the entire process from the landslide event happening, being reported, being investigated and being verified is long and there are as of now no operational alert systems for landslides happening in India. As of now, the information disseminated through the portal is sourced from multiple sources, namely the SDMA, field visits, GSI reports and newspaper clippings. This is essentially the catalogue of landslides that have happened in the year 2020. In addition, the portal also provides relevant NESAC provided base layers and also the details about the rainfall precipitations happening in the 24 hours preceding the landslide in the form of a graph. The portal also displays the text news items from national e-news feeds (RSS and ATOM) relevant to landslides in the NER. As of now, work is going on automating the landslide information capture which is currently being done manually.

SATCOM Activities under NER-DRR during 2019-2020

The ISRO DMS VPN Node at NESAC was kept active all the time, communicated to NDMA, Delhi and other SDMAs regularly as part of keeping the system working on a 24x7 basis. Demonstration of the system was done to many dignitaries/agencies in relation to emergency communication during a disaster.

INMARSAT satellite terminals are being introduced for emergency communication during a disaster scenario in the region. These satellite phones are easy to maintain and operate. Necessary hands on training imparted to stakeholders on how to operate the terminal in the field during an emergency.

Satellite Mobile Radio and other MSS Terminals developed by ISRO were also kept at NESAC for the demonstration to the regional nodal agencies. These were demonstrated to many agencies like NDMA and NDRF Officials during various workshops and training, Police dept. of various state, state disaster management authority, etc. such that they can adopt these systems/technologies.

Video Wall and other audio-visual systems used for NER-DRR operation were always kept working and also operated on a regular basis.

Capacity building on 'Applications of Geographic Information System in Disaster Risk Management' under NER-DRR programme

NESAC conducted four training programs on 'Applications of Geographic Information System in Disaster Risk Management' sponsored by the National Disaster Management Authority (NDMA), Ministry of Home Affairs to the officials from various state and central government organizations like DoT, SDMA, DDMA, IMD, etc. The first training was held during 18th-19th August 2020, the second training was held during 28th-29th October 2020, the third one was held during 25th-26th November 2020 and the last training was held during 25th–26th February 2021. A total of 157 participants have been trained during these four training programs.

The training was mainly focused on different aspects of geospatial technology and their applications to various disasters like flood, forest fire, landslide, earthquake, thunderstorm, cyclone, lightning, weather forecasting, Web-GIS, satellite communication, and UAV technology.

PHOTOGRAMMETRY & UAV APPLICATIONS

New UAV Systems/sensors at NESAC

During the year, NESAC has increased the surveying capacity manyfold by including Trinity F90+ VTOL UAV into its fleet. The UAV is equipped with a PPK module for providing accuracy in cm level. It is having a 42 Mp very high resolution Sony Rx1 RGB camera along with Micasesne Red Edge Dual (10 Bands) Multispectral sensor. The system can map up to 10 sq km area in a day. NESAC has also developed three UAVs under the Swarm UAV TDP project with KJSCE, Mumbai for demonstrating the SWARM of UAVs.

Trinity F90+ VTOL Fixed wing UAV

Sony Rx1 42 Mp RGB camera

Dual band (10 bands) Multispectral sensor

UAV developed under SWARM UAV TDP project

UAV pilot training for NESAC Officials

NESAC has also sent three of its officials for UAV pilot training certification by DGCA approved training centre. All three of the officials have completed the training successfully and got the RPAS pilot certificate for small category UAVs.

Aerial Survey using UAV Platforms

NESAC has been effectively providing operational UAV services in the NER region. NESAC has conducted 28 UAV surveys in the year 2020-21 for different users departments in NER.

List of UAV Surveys conducted in the year 2020-21

Sl. No	Survey Area/ Location	User
1.	Landslide mapping (Umiam, Shillong viewpoint, NEPA, Sumer) Meghalaya	In-house
2.	Landslide mapping (Umiam viewpoint)	In-house
3.	Large Scale Mapping of Bara Bazar and Police Bazar, Shillong, Meghalaya	In-house
4.	Survey for mapping of Maize crops under SSS program of DES in Bhoirymbong block, Meghalaya	Directorate of Economics & Statistics, Meghalaya
5.	Mapping of winter crops in Umling block, Meghalaya	Directorate of Economics & Statistics, Meghalaya
6.	Landslide mapping on NH6 at Jowai, Meghalaya	In-house
7.	UAV Surveys for mapping of winter ricein 5 districts of Meghalaya	Directorate of Economics & Statistics, Meghalaya
8.	Survey of Sericulture plantations in RiBhoi district, Meghalaya	CSB & NESAC
9.	UAV survey at ISBT Shillong for project monitoring, Meghalaya	NEC & NESAC
10.	UAV survey at Central Agricultural University, Barapani campus	College of Agriculture University, Umiam
11.	UAV survey of wetland site ChakmalBeel, ChatolaBeel, Nongmahir Reserve, Phadkyla Bora Beel, Pham Pallanja in Meghalaya	Forest Dept., Govt. of Meghalaya

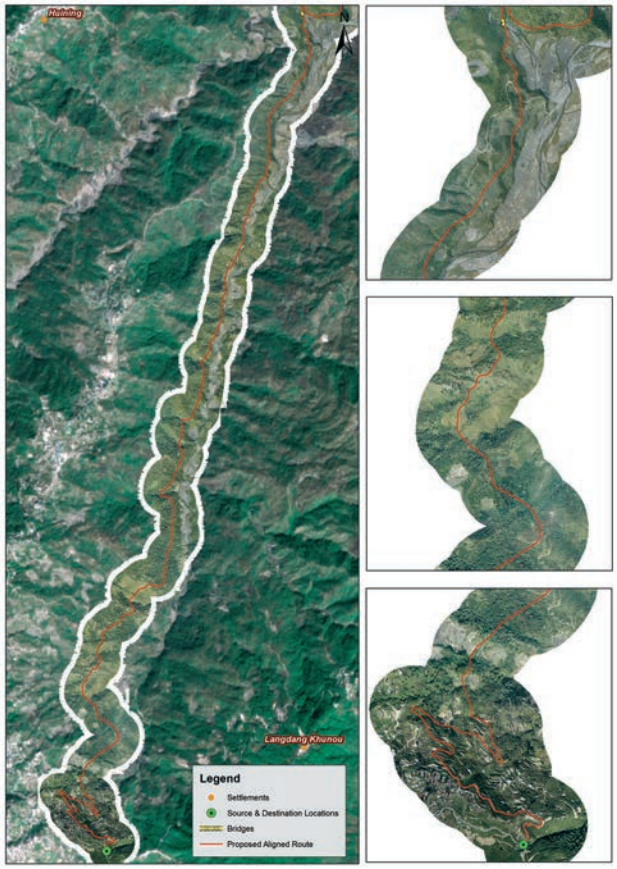
12.	Crop mapping using UAV in Myllium Village, East Khasi Hills District, Meghalaya	IIDS Project
13.	Wetland site at Wards Lake, Shillong	Forest Dept., Govt. of Meghalaya
14.	Wetland site at Syndai park and Nongmahir, Meghalaya	Forest Dept., Govt. of Meghalaya
15.	Embankment mapping on Brahmaputra river in Pasighat and Majuli in Arunachal Pradesh and Assam	Brahmaputra Board and NESAC
16.	Village resource mapping in Garo Hills district, Meghalaya	GHADC
17.	Crop mapping using UAV in Thynroit Village, East Khasi Hills District, Meghalaya	IIDS Project
18.	Mapping of Dalmia Cement factory, Jowai, Meghalaya	Dalmia Cement Pvt. Ltd., Meghalaya
19.	Mapping of SyndaiPark, Meghalaya	DFO office, Shillong
20.	Forest mapping in Rongsahep (Nongpoh), Meghalaya	DFO office, Shillong
21.	Survey for maize acreage estimation in Darrang (Assam) under SUFALAM project	SAC, Ahmedabad & NESAC
22.	Mapping of Dalmia cement factory in West Jaintia Hills, Meghalaya	Dalmia Cement Pvt. Ltd., Meghalaya
23.	Mapping of Tea plantation near umsning, Meghalaya	Tea Board sub regional office, Umsning
24.	Wheat affected by RUST UAV survey at Gurudaspur in Punjab	In-house
25.	UAV survey at Bhoirymbong Block, RiBhoi District, Meghalaya under IIDS using VTOL	IIDS Project
26.	UAV survey at Kemragre, Wadagre and Asigre in Tura, Meghalaya using VTOL	GHADC and NESAC
27.	UAV demonstration for disaster relief and monitoring at Guwahati Secretariat	ASDMA
28.	Growth and damage assessment of Maize crop in Darrang District, Assam under SUFALAM program	SAC, Ahmedabad & NESAC

RS & GIS based inputs for suitable route Alignment Planning for Construction of Mahadev-Toloi-Pfutsero road

This work has been carried out based on the request made by North Eastern Council (NEC), Shillong considering the poor connectivity between the two towns, Dungrei and Pfutsero of Manipur and Nagaland States of NER, respectively. Generation of landslides susceptibility map on 1:50000 scale and the generation and suggestion of new route alignment based on the landslide susceptibility map and ruling gradient as specified by the user were completed and also reported earlier. The proposed aligned route connecting Dungrei, Manipur and Pfutsero, Nagaland is approximately 122.74 km in length.

Along the proposed route, an aerial survey using UAV and DGPS survey has been conducted. The UAV based aerial imageries were processed and generated seamless ortho-mosaic image with 5 cm/ pixel or Ground Sampling Distance (GSD), digital surface model (DSM) and digital terrain model (DTM) of 0.2 m posting.

Due to the difference in the scale of mapping, it is observed that there is a certain shift of 3 – 10 m of the proposed aligned route with respect to UAV based ortho-mosaic image. The proposed aligned route has been refined by overlaying the proposed aligned route over the ortho-mosaic image. It has been observed that the length of the proposed aligned route has decreased by approximately 5.06 km. The total length of the proposed aligned route is 117.50 km inclusive of six bridges of total length of 278.93 m long (5 proposed and 1 existing).



A part of proposed aligned route overlaid with UAV data

The volumetric analysis of earthwork estimation has been done using UAV based digital terrain model (DTM) of 0.2 m posting. The longitudinal profiles are also extracted along the proposed aligned routes.

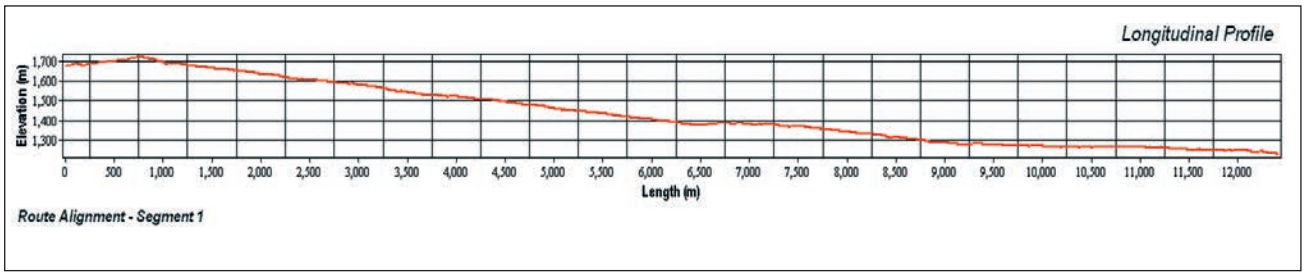
Availability of natural construction material is another important component for mega engineering projects/structures such as roads, buildings, dams, etc. which may have a direct or indirect effect on the estimated cost/budget. So, it is important to identify the availability of building material near the site of construction as far as possible for roads and dams especially in the hilly areas.

Remotely sensed data in combination with published maps and literature and during the field survey, some observations were made and few locations of probable source of material that can be utilized in the construction of the road were identified. The survey carried out from Pfutsero to Tsupfume and Tsupfume to Thetsume and few locations of rock outcrop were identified along the corridor.

This work has been completed successfully and submitted the project report to the user department for the preparation for the detailed project report (DPR).

Large Scale Survey and Mapping using UAV

With the development of UAV based surveying approach, time and manpower requirement has reduced drastically for any kind of land surveys. The aerial data collected using the UAV platform are processed to generate the ortho-products using the Photogrammetry technique. The generated ortho-products are 3D point clouds, 3D texture models, Digital Surface Models (DSM),

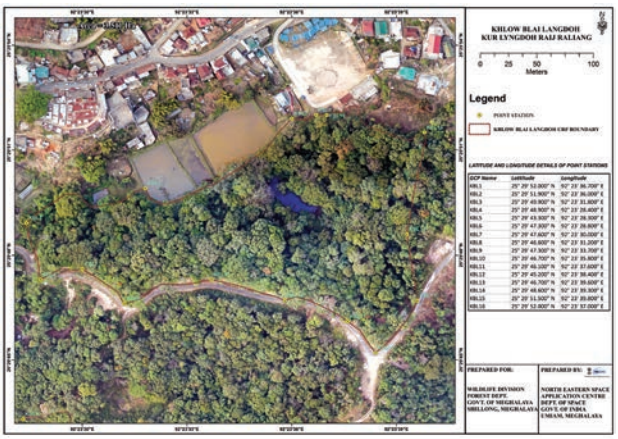


Longitudinal profile of a part of proposed aligned route

Digital Terrain Models (DTM) and ortho-mosaic images of very high spatial resolution at the range of 2 – 10 cm. For various user/ line departments from the north eastern region as well as outside the region, large scale survey and mapping works were carried out. These UAV based data are used by the user/ line departments as inputs for the preparation for their planning and developmental activities. Some of the works carried out using UAVs are given below:

a) Survey and Mapping of Community Reserve Forest (CRF) using DGPS and UAV

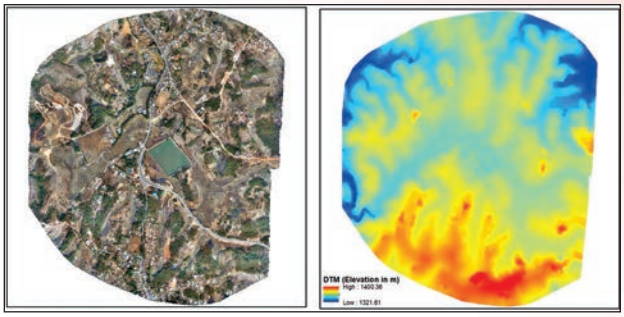
This work has been carried out for Chief Wildlife Warden, Forest Dept., Govt. of Meghalaya. DGPS surveys were conducted to GCP establishments within the study areas. These GCPs were integrated during the UAV data processing to improve the accuracy in centimetres (0.002 m) of the resultant outputs. Using these field surveyed data (DGPS/ UAV) and also as per the inputs from the user department, boundaries of 4 nos. of community reserve forests are delineated and the maps are prepared defining areas in the GIS platform.



CRF boundary of Khlow Blai Langdoh Kur Lyngdoh Raij Raliang

b) Wetland Survey and Mapping using UAV in Jaintia Hills & EKH Districts, Meghalaya

This work has been carried out for State Forest and Environment Department, Govt. of Meghalaya. The work has been carried out to generate land use land cover along with other existing utilities/ assets at a very large scale using UAV based very high resolution orthoimage for an area of 500m buffer. A total of 14 no. wetlands across Meghalaya has been surveyed and mapped. The user department will use the information as input for effective planning in the conservation of wetland.



(a) *(b)*

(a) Ortho-mosaic Image; (b) DTM of 500m buffer of Thadlaskein Lake, Jowai

Enlarged orthomosaic image part of Thadlaskein Lake, Jowai

Additionally, many other works were also carried out for state line departments and private sectors. In the area of agriculture and allied sector, an aerial survey using UAV platforms were also conducted in collaboration with SAC, Ahmadabad. The aerial surveys were conducted using multispectral and thermal sensors for the generation of very high spatial resolutions multispectral and thermal orthomosaic images.

False colour composite (FCC) of a part of paddy field in Sanand, Gujarat

SATELLITE COMMUNICATION (SATCOM)

NESAC is implementing ISRO's societal development programs like Tele-Education, Tele-Medicine and Emergency Communication System through the utilization of Satellite Communication Technology. As one of the mandates of NESAC is to work towards the development of the people in NER, the centre has established an extensive network for distance education and remote healthcare in the region as the region lacks quality educational infrastructure and healthcare services. SATCOM division has facilities like SATCOM studio for content generation, primary node under ISRO-DMS VPN network, emergency communication devices, Spacenet connectivity for secure communication among other ISRO centres, Ka-Band propagation experiment facility etc.

Tele-Education project in North Eastern States during 2020-21

All the seven HUBs cum Teaching end and 330 Satellite Interactive Terminal (SIT) are operational in all the NE states. The statewise break up of SITs is as follows: Arunachal Pradesh-51, Assam-32, Manipur-25, Meghalaya-47, Mizoram-50, Nagaland-25, Sikkim-50 and Tripura-50.

A live & interactive Tele-Education class going on in Assam Network

Hundreds of live and recorded programs were telecasted by these networks in 2020-21 during the Covid 19 pandemic time.

Communication support for disaster management

NESAC is equipped with a number of Satellite Mobile Radio (SMR) and SatSleeve terminals under GSAT-6 satellite for emergency communication. NESAC has a transportable VSAT system and a node under the ISRO DMS network to communicate with NDMA, New Delhi and SDMAs of all NER states at the time of emergency. A satellite phone also procured to provide support in an emergency situation. These systems were always kept in operational condition and used as per need.

ISRO-ONERA-CNES joint Ka-Band Radio Wave propagation experiment at NESAC

ISRO-ONERA-CNES joint Ka-Band propagation experiment is operational at NESAC to assess atmospheric effects (attenuation) on the propagation of the Ka-Band signal for use in satellite to earth communication. The equipment includes two high gain parabolic receiving antennas to receive the beacon signals, a Tipping Bucket Rain Gauge, a Laser Precipitation Monitor and a Humidity Profiling Radiometer to get atmospheric humidity profile for validating satellite data.

Survey for setting of internet based network for online classes in Arunachal Pradesh

A survey has been conducted jointly by IIT Chennai, ERNET representatives and NESAC along with the Department of Secondary Education, Govt. of Arunachal Pradesh for the setting of an internet based network for online classes for secondary education in Arunachal Pradesh. The report has been submitted to the competent authority for the needful.

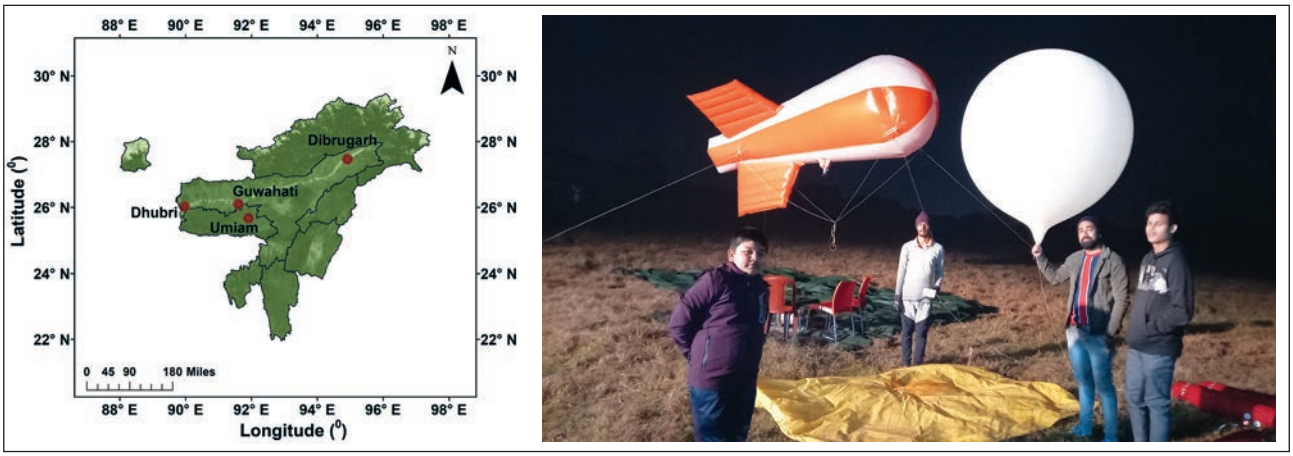
SPACE AND ATMOSPHERIC SCIENCE AREA

Space and Atmospheric Science group at NESAC is one of the major groups working with a focus on understanding and characterizing the major drivers of climate change like aerosols and greenhouse gases, through the collection and analysis of in-situ data, satellite based data and products, and numerical modeling. Research to improve short and medium range weather forecasts for the NE region of India with a focus on improving the severe weather forecast, including lightning forecast, is another major activity of the group. In addition, the group provides support and critical input in the management of major disasters like floods, severe storms, lightning, etc. using data from the S-band polarimetric radar, automatic weather stations, satellites, numerical models, etc. The major activities and achievements of this group are described below:

1. Vertical profiling of Black Carbon along Brahmaputra Valley of NER

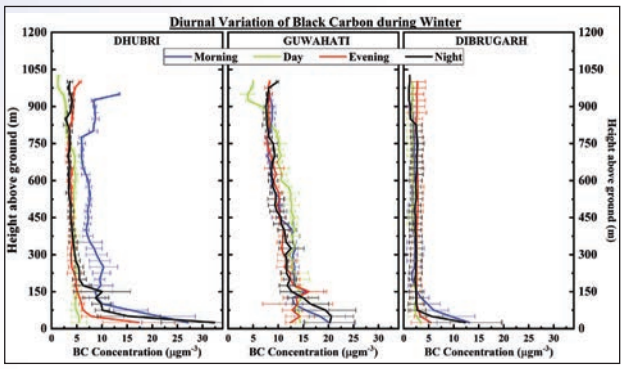
A campaign was conducted along the Brahmaputra river valley in Assam covering three places viz. Dhubri (26.02° N, 89.97° E, 31 metres), Guwahati (26.10° N, 91.60° E, 55 metres), and Dibrugarh (27.47° N, 94.91° E, 108 metres) for vertical profiling of Black Carbon (BC) aerosol concentration, Particulate Matter (PM), and weather parameters during winter and pre-monsoon seasons. Vertical profiling of aerosol parameters is important to understand Aerosol-Atmospheric Boundary Layer (ABL) interaction which is further essential for mesoscale and general circulation models. In this campaign experiment, Micro-aethalometer, Particle Spectrometer, and Dr Pisharoty Radiosonde were used as a payload on Hydrogen gas filled tethered balloon (volume 9.9 cum) platform. The launches were carried out 4 times per day at 6 hourly intervals for 4-5 days in each station under clear weather condition. Meteorological balloon along with Dr Pisharoty Radiosonde was also launched simultaneously at all the stations.

Near surface BC concentration was found to be high during morning and night time over all the stations. During winter, mean BC concentration was as high as 30 μgm^{-3} during the night and early morning hours over Dhubri. However an exponential decrease (5-10 μgm^{-3} at >300m altitude) in concentration was observed in the vertical profiles. The rate of decrease is more prominent near surface areas (below 100 m) in all seasons and over all sample sites. During day time and evening time, the BC concentration was seen to remain almost unchanged over the entire measurement range of upto 1000 m. Near surface BC over Guwahati and Dibrugarh are approximately 20 μgm^{-3} and



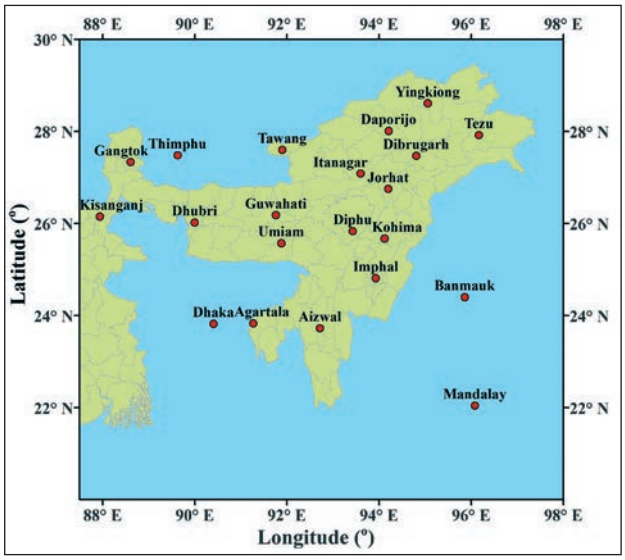
The red dots on the NER image shows the locations of experiment (left) and field photograph with tethered balloon and meteorological balloon.

12 μgm^{-3} respectively during winter and approximately 15 μgm^{-3} and 7.5 μgm^{-3} respectively during pre-monsoon season. While the near surface BC concentration is maximum over Dhubri during morning and night hours, the BC concentration in the entire measurement column is maximum over Guwahati at all times.



Diurnal variation of BC concentration over Dhubri, Guwahati and Dibrugarh during Winter

2. Characterizing planetary boundary layer heights over NER using satellite data

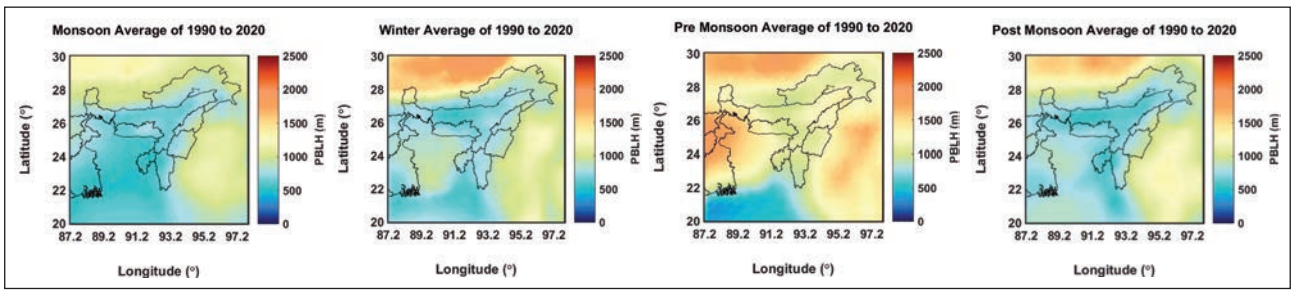


Study sites over NER

Planetary Boundary Layer Height (PBLH) is one of the fundamental parameters that characterizes the extent of vertical mixing of pollutants in the atmosphere. The Modern-Era Retrospective analysis for Research and Applications-2 (MERRA-2) PBL height product has been used to understand the PBLH characteristics over NER of India (20˚N-30˚N, 87˚E-98˚E). Long term (31 years from 1990 to 2020) PBLH has been investigated over 21 selected sites for different seasons. Maximum PBLH (2300 m) has been recorded over Dhubri and minimum (1200 m) over Tawang during winter. The seasonal mean of 31 years data shows maximum PBLH during the pre-monsoon and minimum during the monsoon season. Most of the parts of Assam, Meghalaya, Mizoram shows lower PBLH than the rest of NER. Neighbouring areas of NER is observed to have higher PBLH. Distinct seasonal variation was also observed in all stations. The highest PBLH is observed during the pre-monsoon season and the lowest during the monsoon season. PBLH in Guwahati was observed to vary from ~380 m to 1870 m. Dibrugarh being the easternmost station among the study sites, showed PBLH varying from 500 m to 1900 m. Tawang having the highest altitude among all the stations have PBLH ranging from ~690 m to 1250 m. This information on PBLH could be used for pollution dispersion and other studies.

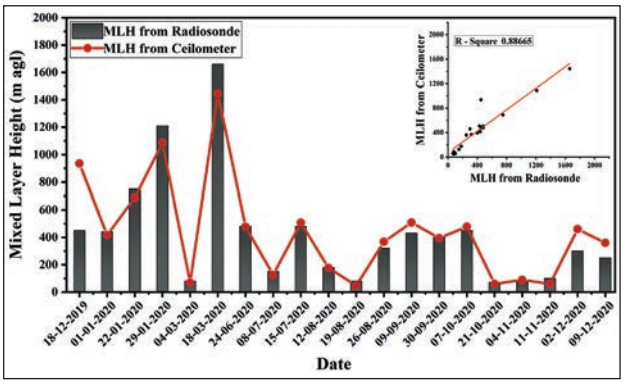
3. Study on seasonal variation of mixing layer height over Umiam using Vaisala Ceilometer data

Meteorological balloons, along with Dr. Pisharoty Radiosonde are launched at NESAC, Umiam every Wednesday during 1230-1330 hrs (IST). A Vaisala Ceilometer was also installed at NESAC on 27th



Seasonal variation of PBLH over NER

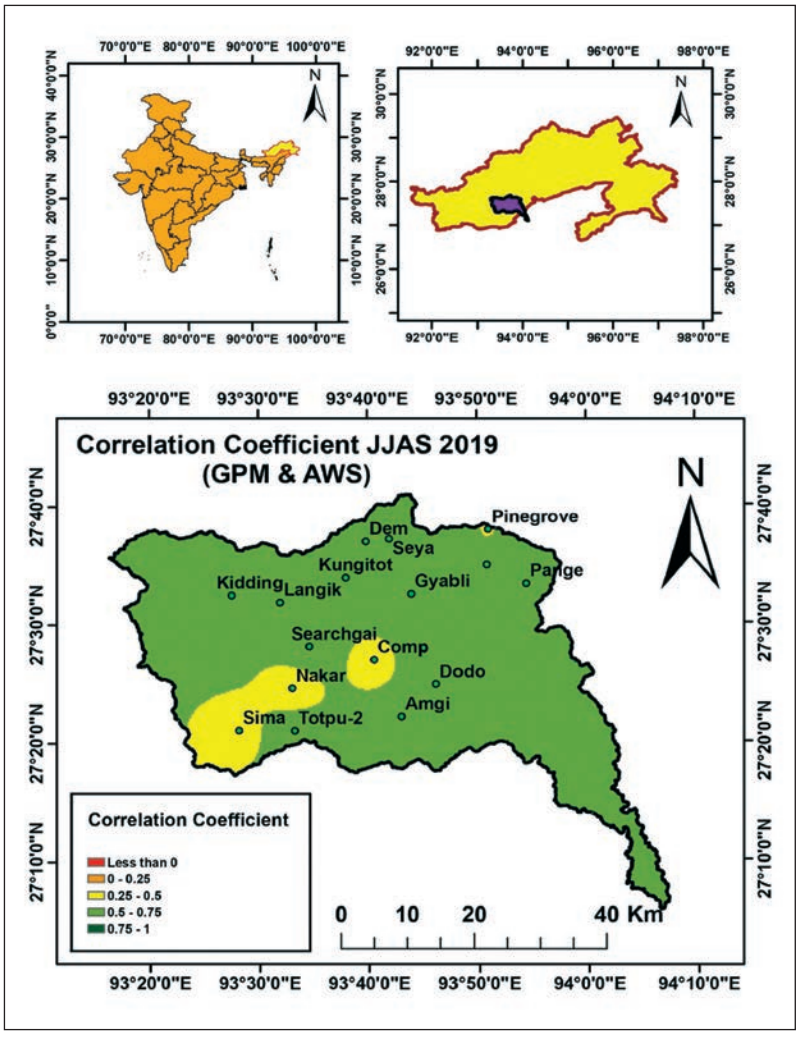
November 2019 under PRL and NESAC collaboration. A total of 35 balloon launches were conducted on clear weather conditions during 2019-2020, out of which 20 meteorological balloon launches coincided with Ceilometer observations. Mixing Layer Height (MLH) was derived from Dr Pisharoty Radiosonde and Vaisala Ceilometer data over NESAC, Umiam for the days when we had simultaneous observations. Comparative analysis for the Mixing Layer Height (MLH) obtained from both datasets have been done. Seasonal variation of MLH shows highest during pre-monsoon followed by winter, monsoon and minimum during post-monsoon season. Both the MLH obtained from Radiosonde and Ceilometer show a correlation coefficient of 0.94. For almost all the 20 cases, both the measurement show one-to-one matching except for four minor mismatch and one large mismatch. The mismatch was mostly observed on the days when the local weather had hazy conditions. In the presence of low layer clouds, MLH is typically situated at the top of the clouds and in these conditions, The ceilometer is unable to provide the true MLH. The disagreements between the ceilometer and radiosonde derived MLH might also be caused by the drifting radiosonde, as the fixed active sensor might not be observing the same vertical extent as that of the radiosonde. Diurnal variations from both the instruments are also being studied and further, comparison analysis will be made with satellite data. A detailed study will be carried to understand MLH as derived from Vaisala Ceilometer and Dr. Pisharoty Radiosonde.



Comparison of MLH obtained from Dr. Pisharoty Radiosonde and Vaisala Ceilometer over NESAC, Umiam

4. Validation GPM precipitation estimates over eastern Sub-Himalayan river basin

A study has been carried out for the validation of precipitation estimated from GPM (Global Precipitation Mission) with in-situ measurement over a hilly river basin in the eastern sub-Himalayan region of Arunachal Pradesh. The study region

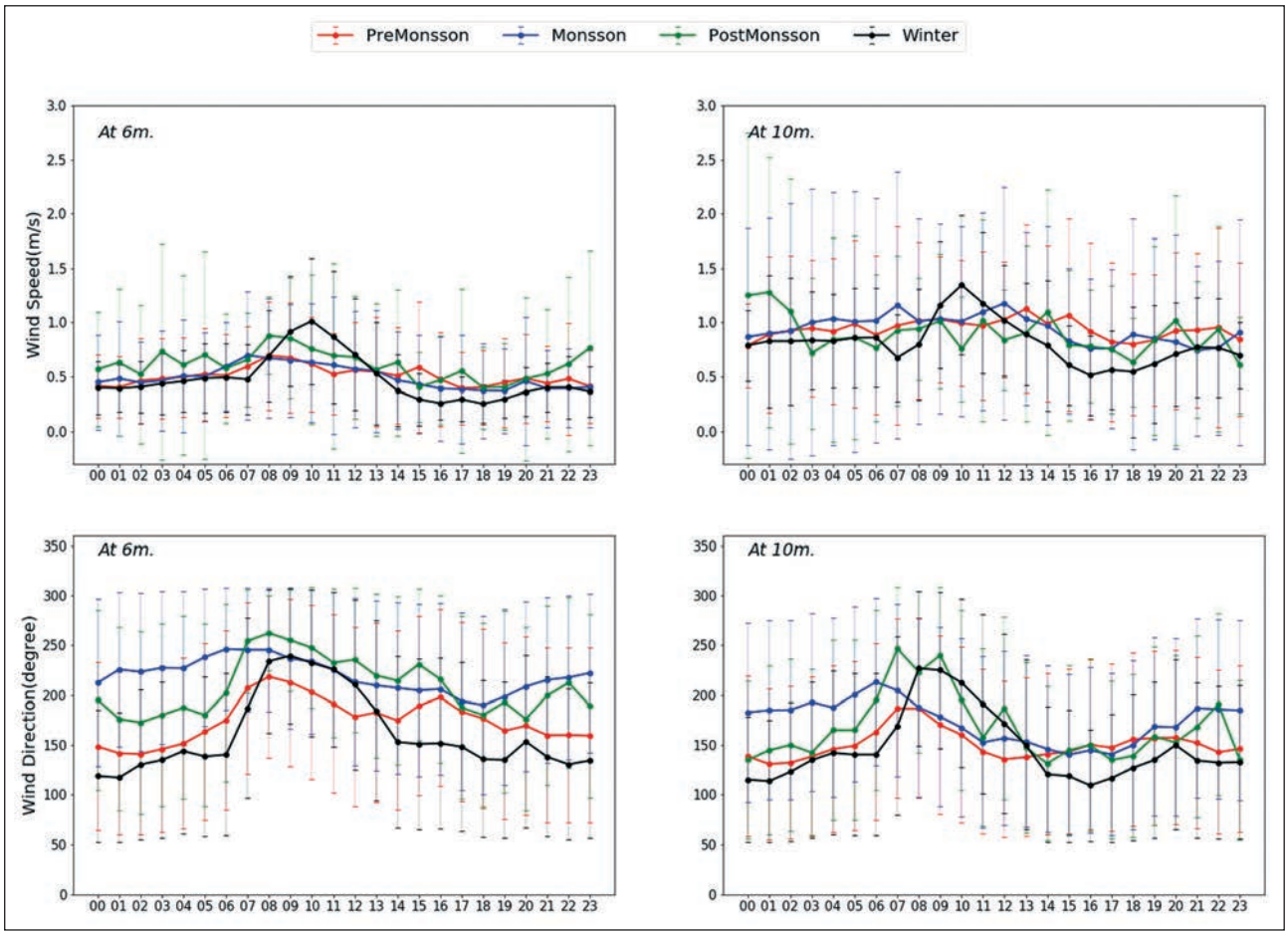


Correlation Coefficient for JJAS 2019 & KGE for different Rainfall Class

covers the Ranganadi river basin (extending from 93°25′ to 93°96′ E & 27°26′ to 27°68′ N) in Arunachal Pradesh. Ranganadi River is the northern tributary of Subansiri River which finally combined with the Brahmaputra River near Lakhimpur, Assam. GPM final run products (GPM_3IMERGHH v06) over the study region has been compared with AWS (Automatic Weather Station) precipitation data. Total 17 no. of AWSs have been installed over the basin. Data obtained from the same has been compared with GPM data for each station for the monsoon (June, July, August and September) season of 2019 in different rainfall classes viz. <10, 10-55 and >55mm. The statistical parameters viz. Pearson's correlation coefficient, root mean square error (RMSE), relative bias, and Kling-Gupta efficiency (KGE) has been calculated for each station. Preliminary results show GPM precipitation products have a significant correlation (>0.5) and KGE value close to 1 over a larger area of the basin with low positive bias. It is observed that GPM outputs have significant performance for low to moderate rainfall over the study area than higher rainfall. A detailed study is being carried out for different terrain and seasons.

5. Intra annual variation of wind circulation & surface layer parameters over hilly station, NESAC, Umiam

Wind circulation and energy exchange i.e. surface parameters, are significantly influenced by the hilly terrain or mountain topography. In this study, the seasonal variation of wind circulation and lower surface parameters have been depicted over a hilly station at Umiam (25°40'32"N, 91°54'06"E, altitude 1040 m amsl), Meghalaya. For this study, high-speed response sonic anemometer data is used at level 6m and 10m. The mean diurnal variations of wind speed (WS) and wind direction (WD) are



Seasonal mean diurnal variation (line) and standard deviation (bar) of Wind Speed and Direction at the 6 m & 10 m for all seasons

shown in the figure. The diurnal prevailing wind direction varies between 100°-230°, 130°-200°, 170°-240° and 140°-270° at both the heights 6 & 10 meters for winter, pre-monsoon, monsoon and post-monsoon respectively.

WD direction varies between 200°-250° (South Easterly) during 0600-1030 hours (IST) for all season except monsoon. Similarly, seasonal averaged WS varies from 0.8 m/s to 1.5 m/s with a maximum during 0600-1030 hours (IST). This may be due to the Solar Elevation Angle has an immense impact on wind circulation i.e. the temperature variation during the day creates a temperature difference gradient between the valley and nearby hilly regions. In monsoon, the wind direction is confined between 200°-230 due to the influence of synoptic flow over the station over mountain wind circulation.

The seasonal variation of Momentum Flux (MF), Turbulent Kinetic Energy (TKE) and Sensible Heat Flux (SHF) is shown. The momentum flux values at 10 meters are higher than their corresponding values at 6 meters during daytime. The maximum momentum flux is obtained during the winter season and minimum momentum flux is observed during post-monsoon period for both the heights mentioned above, but the time period of minimum momentum flux is arbitrary and most probably happens during the nighttime. The variation of momentum flux is maximum during the daytime between 08.00-16.00 hours for both the heights for all seasons. The values of turbulence kinetic energy at 10 meters height are higher than the values of turbulence kinetic energy at height 6 meters for all the season mentioned. TKE is higher in the winter season than pre-monsoon. Similarly, SHF is higher during daytime than nighttime for all the seasons due to the solar evaluation angle variation between daytime & nighttime. The peak of SHF occurred during the winter season (during daytime) for both the height mentioned above and is observed at the same time interval as TKE and MF. At nighttime, there was no large variation in SHF for all seasons. The variation is maximum during the period 08.00 – 16.00 hours due to the maximum solar elevation angle in the daytime.

6. Impact of COVID-19 lockdown on the air quality over North-East India

Lockdown announced by the Indian government to mitigate the spread of COVID-19 has significantly reduced all anthropogenic activities, including industrial activities and vehicular movements. So, it gave us a unique opportunity to look for the impact of changing the environment under less pollution loading. Data obtained from both the satellite and in-situ platform have been used for this study to find out changes in the concentrations of parameters that are critical for air quality as well as human respiratory health. The study region which encloses the north eastern part of India, encompassing from 20° to 30° N and 88° to 98° E, has been divided into four equal quadrants. Mean concentration of Aerosol Optical Depth (obtained from MODIS onboard Aqua/Terra platform) and Black Carbon (obtained from MERRA 2 model) for each quadrant are compared during pre-lockdown and lockdown times of 2020 from its decadal mean. The study period consists of a total of 45 days and sub-divided into three periods of 15 days as per the stringency of the containment guidelines such as Period 1: Pre-lockdown (10th Mar - 24th Mar), Period 2: Lockdown 1.0 (25th Mar - 8th Apr) and Period 3: Lockdown 2.0 (9th Apr - 23rd Apr).

The result showed that the mean concentration of AOD over the whole NEI decreased by 34.8% and increased by 4.3% during Period 2 and 3 with respect to Period 1. Whereas the mean concentration of BC over NEI is found to increase by 19.6% during Period 2 and decreased by 27.6% during Period 3 from Period 1. It is noted that AOD and BC have dropped substantially over almost all the quadrants as compared to pre-lockdown times, but the amount is inside the standard deviation of the decadal mean. The only exception is the southwest quadrant, where AOD has reduced drastically. This can be attributed to the fact that this quadrant gets its aerosol loading primarily

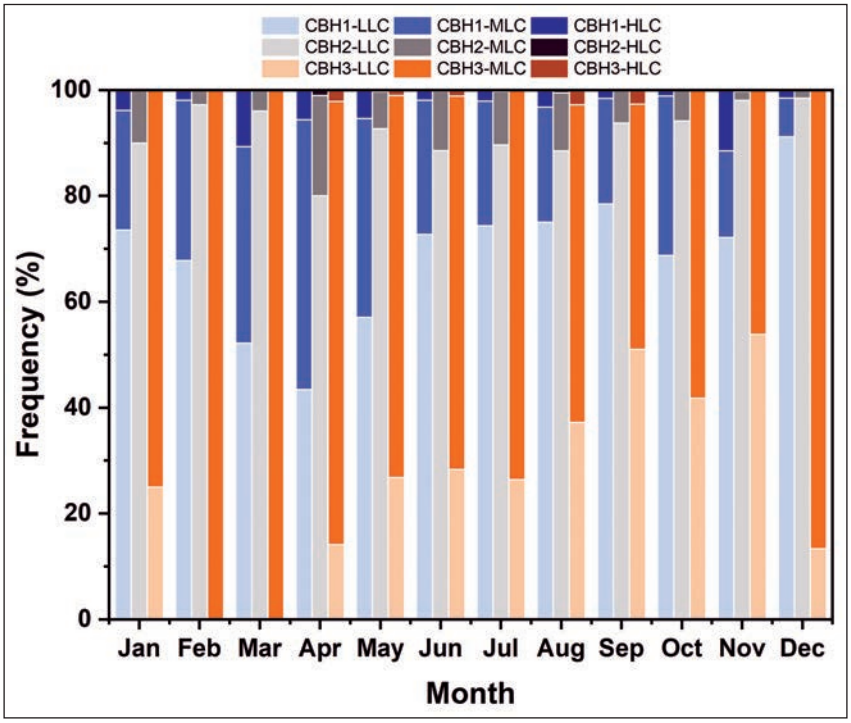
from the long range transport from the North West part of India. Several studies already reported a huge drop of aerosol loading there and in the Indo-Gangetic Plain owing to strict lockdown. In the other parts of NEI, the analysis implies that the local pollution is predominant and most of which is coming from natural events such as forest fires, etc.

In-situ observations were made over Umiam (25.65° N, 91.88° E, 1040 m ASL), Meghalaya and Lachung (27.41° N, 88.42° E; 2650 m ASL), Sikkim, both are high altitude stations under ARFINET. Data were collected using a seven channel Aethalometer (AE33, Magee Scientific operating at 370, 470, 520, 590, 660, 880 and 950 nm) for measurement of black carbon (BC) aerosol and using a Microtops II Sunphotometer (Model 540, Solar Light Co, operating at 380, 440, 500, 675, and 870 nm) for measurement of AOD. Besides that, to understand the dominant aerosol size mode, Absorption Ångström exponent (AAE) and Ångström exponent (AE) are calculated using Ångström's empirical formula.

It was observed that the BC concentration continuously decreased over both locations after the imposition of lockdown. Umiam, being close to a national highway and Industrial area is more influenced by anthropogenic activity and experienced more reduction in concentration than Lachung. Although Lachung is a remote place, the pollution did not drop as expected because of the movements and inhabitation of the defence personnel which did not stop during the lockdown. The high value of Absorption Ångström exponent (AAE) indicates that the pollution is mostly coming from vehicular combustion that is of man-made origin. The AOD properties over Umiam, however, show a contrasting behaviour with respect to the BC variations and actually increased post implementation of the lockdown. The AOD was seen to be influenced more by the rainfall, however the same increased quickly within a couple of days. Post lockdown, the Ångström exponent slowly reduced, indicating the dominance of coarser aerosols, probably of local origin.

7. A statistical study of cloud base height over a complex topography of North East India

Cloud Base Height (CBH) is an important parameter that plays a key role in global radiation balance as well as aviation meteorology. CBH observations are obtained using Ceilometer measurements and studied over Umiam, situated in the complex terrain of North East India. Here, in this study, we present a comprehensive analysis of CBH from January 2020 to December 2020. Clouds are found to be present throughout the year with a frequency of about 56.76% out of approximately 84.95% of Ceilometer observations during the year 2020.



Stacked column representing frequency of occurrences of monthly mean distribution of Low Level Cloud (LLC), Mid Level Cloud (MLC) and High level Cloud (HLC) when detected by Ceilometer as the first Cloud Base (CBH1), second Cloud Base (CBH2) and third Cloud Base (CBH3) from January 2020 to December 2020

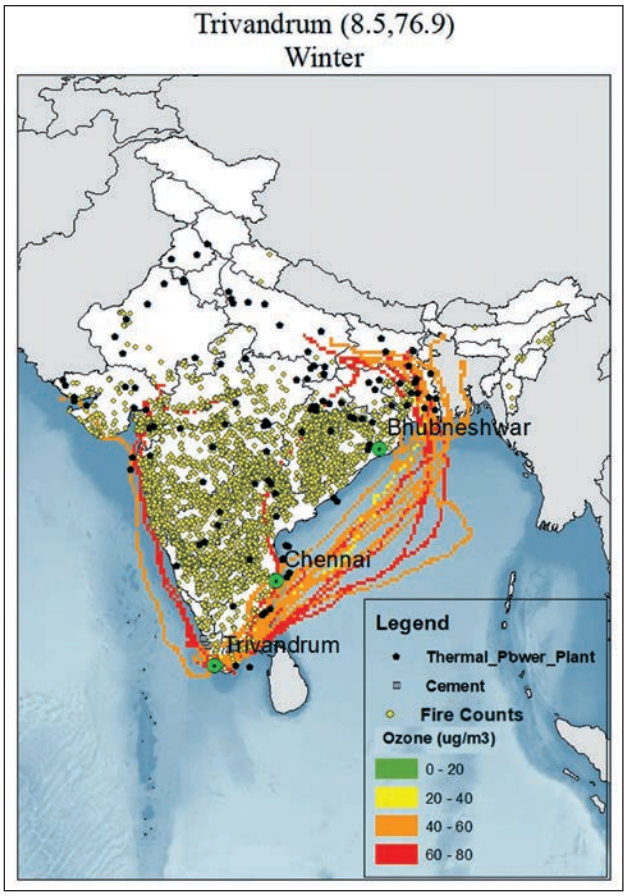
Noticeable seasonality can be observed in cloud occurrence frequency which peaks in July with a frequency of 87.02% with respect to observation and falls thereafter. November experiences minimum cloudiness with a frequency of 24.9 % and increases afterwards.

Although the cloud structures are multilayered over Umiam, most of the clouds observed are of a single layer and closely follows the pattern of monthly occurrence frequency of cloudiness. All the months showed the presence of double layer clouds which is maximum in September (22%) and minimum in January (5.64%). Triple layer clouds are rare to be seen and can only be found in the months from July to September with a frequency of 0.03%. Umiam, being a high altitude site, experiences clouds near the ground very often, most of which is observed during November (26.81%). Near ground cloud occurrences are very less during February and March which could be due to the local origin of cloud systems (mostly convective) at that time.

The presence of CBH at different altitudes is identified and it was found that the detection of first and second CBH are in the lower atmosphere (< 2 km) in most of the cases. During the pre-monsoon months of March, April and May, the first CBH is in the middle atmosphere (2 - 6 km) for a considerable amount of time. This could be because of the common occurrences of thunderstorms over this region, where the top of a neighbouring convective cloud can form an anvil or outflow region. The high level (> 6 km) CBH is mostly the first CBH detected by Ceilometer and can be seen throughout the year, although the frequency of occurrences are very less. The third cloud bases detected are mostly in the middle level.

8. Source apportionment of surface level trace gases and particulate matter at three tropical coastal sites in India

Quantifying the source contribution (regional emission due to various anthropogenic activities such as city traffic density vs. long range transport due to meteorological influence) of trace gases and PM over different temporal and spatial scales has been receiving significant attention. In view of this, measurement of trace gases and PM in concurrence with meteorological variables (wind speed and direction) is of paramount importance. We present three-year surface measurements of TGs (O_3, CO, NOx, SO_2 and NH3) and PMs (PM2.5 and PM10) at three coastal sites Trivandrum (TVM, 8.5°N, 76.9°E, 5m AMSL), Chennai (CHN, 13.7°N, 80.2°E, 6.7m AMSL) and Bhubaneswar (BHB, 20.2°N, 85.8°E, 45m AMSL) in India. Three years' data from the year 2016 to 2018 at TVM and CHN and from the year 2012 to 2014 at BHB were analyzed. In addition to that OMI's surface mass concentration data for SO_2 and MODIS fire counts data were also used to identify potential sources.



Concentrated Weighted trajectories analysis of surface Ozone measured at Trivandrum (8.5N, 76.9E), for Winter Season

The principal component analysis (PCA) and concentrated weighted trajectories (CWT) were applied to the dataset. The TGs and PM showed high values during winter and lower values in monsoon at these sites. Both TGs and PM values were higher at BHB compared to those at TVM and CHN. Surface O_3 at BHB was about 3 times higher than that at TVM and 2.2 times higher than that at CHN. Interestingly, PCA suggests that the major concentrations of O_3, PM10 and SO_2 at TVM and CHN were transported from different locations and not produced locally except for pre-monsoon season at CHN and pre-monsoon and monsoon season at BHB, which was of local origin. CWT analysis and OMI's surface mass concentration data also suggests that the air quality at TVM could be influenced by heavy emissions transported from the Indo-Gangetic plain. The Merra-2 reanalysis well captured seasonal variations of TGs and PMs. However, it overestimated surface O_3 by a factor of about 2 to the in situ measurement at the study sites.

9. Indirect assimilation of DWR reflectivity for simulation of thunderstorm over NER India using WRF model

This study is one of its first kinds where retrieved moisture field from radar data is used to simulate thunderstorm events over the NER of India using deterministic and flow-dependent DA (Data Assimilation) systems. The radar observations can be assimilated into the numerical weather prediction (NWP) model either directly or indirectly. In the direct method, the radar observations are straightforwardly ingested into the numerical model using the DA techniques. In contrast, in the indirect method, the model compatible variables such as rainwater, water vapour are derived from the radar reflectivity before the assimilation. The indirect method is used in this study.

This study uses one of the most well-known limited area models, the Weather Research Forecast (WRF) system version 3.8.1 and its two data assimilation (DA) methodologies, namely, three-dimensional variational (3DVAR) and hybrid ensemble transform Kalman filter-3DVAR (ETKF-3DVAR) system for conducting the experiments. In order to analyze the impact of radar data assimilation in a convective scale, four experiments are designed. Two experiments where only conventional observations and satellite data from Global Telecommunication System (GTS) are assimilated are named 3DVAR and HYBRID based on the type of DA technique. On the other hand, where the experiments use both GTS and radar data from Cherrapunji Doppler Weather Radar (DWR) are named 3DVAR-RQ and HYBRID-RQ. RQ represents the derived rainwater and water vapour from reflectivity before assimilation. The initial and boundary conditions are interpolated from the National Center for Environmental Prediction (NCEP) Global forecast system (GFS) analysis at $0.25^0 \times 0.25^0$ gridded resolution. In each case, model initialization is done at 18 UTC of the previous day of the thunderstorm event and the 6-hour forecast from the initial model condition is used as the initial file for the first assimilation cycle at 00 UTC. The next assimilation cycle is performed at 12 UTC using a 12-hour forecast from the previous assimilation cycle. Finally, the model is given a free forecast for the next 12 hours. For the HYBRID simulations, 30 ensemble members are used for the estimation of flow-dependent BEC. The ensemble members are generated using WRF-3DVAR CV3 BEC by adding 30 random perturbations.

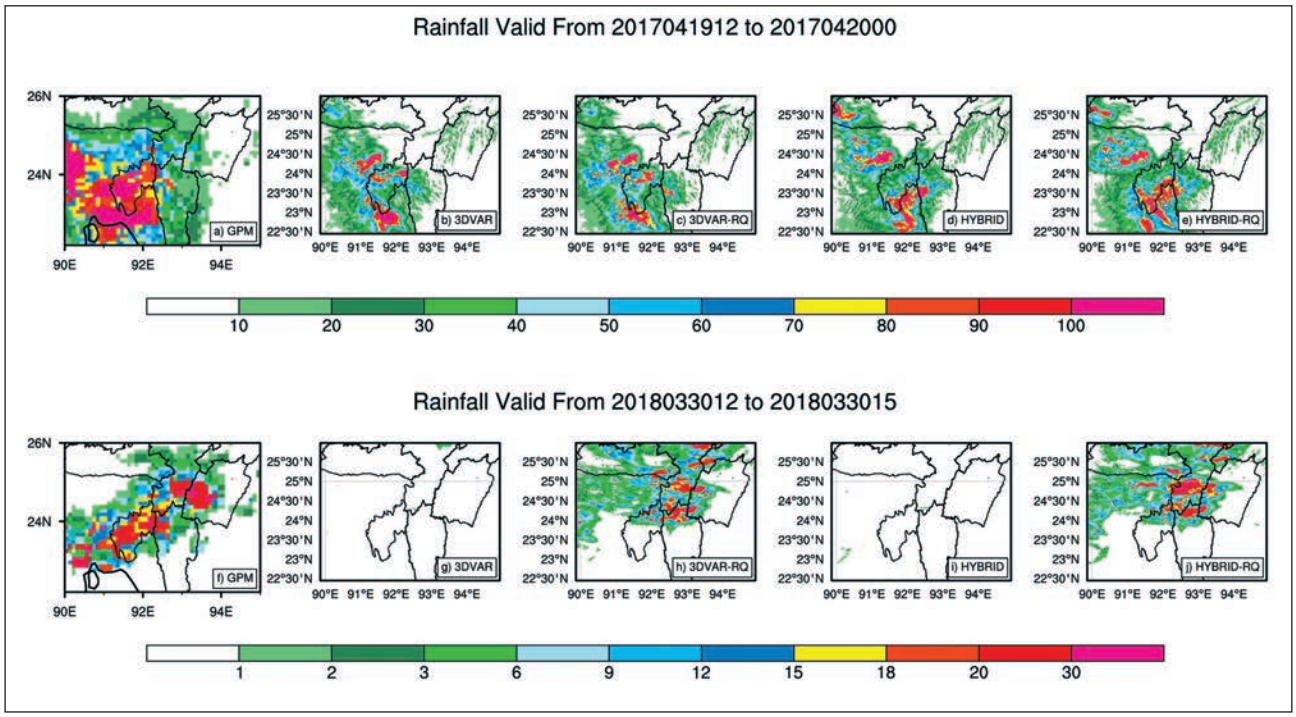
Two thunderstorm cases are considered, one is a synoptic scale long duration TS system (19th UTC 2017 valid from 12 UTC to 21 UTC) and referred to as Case 1. The other is a locally developed short duration TS (30th March 2018 valid from 12 UTC to 15 UTC) and referred to as Case 2. This study assesses the influence of radar reflectivity in the model simulated moisture analysis fields, namely water vapour mixing ratio (Qv) and relative humidity (Rh). Model simulated rainfall over the thunderstorm affected areas is compared with Global Precipitation Measurement (GPM) mission data.

The vertical structure of the analysis fields (Qv, Rh) show that for a locally developed TS event, the impact of retrieved radar DA is more where the first guess model state variables depict a dry environment (Figure 1e), in comparison to the synoptic system in which the background moisture fields are already wet (Figure 1a). The radar DA elevates the surface level moisture fields that support the formation of a convective system (Figure 1f) for Case 2. For Case 1, no significant impact of radar DA is observed in any DA experiments. However, the improvement due to HYBRID DA is evident in simulating the thunderstorm structure by improving the relative humidity field from low to mid-tropospheric level. HYBRID experiments show a much stronger TS system for Case 2 (Figure 2 c, d).

The positive impact of radar DA in the HYBRID DA system in simulating thunderstorm structure is also observed in the rainfall forecast during the TS period. Overall performance of HYBRID DA system with radar DA in rainfall forecast is superior compared to the rest of the experiments for both the TS cases. The improvement is more significant for Case 2, where the background model fields depict a dry environment compared to the actual scenario (Figure 3 h, j).

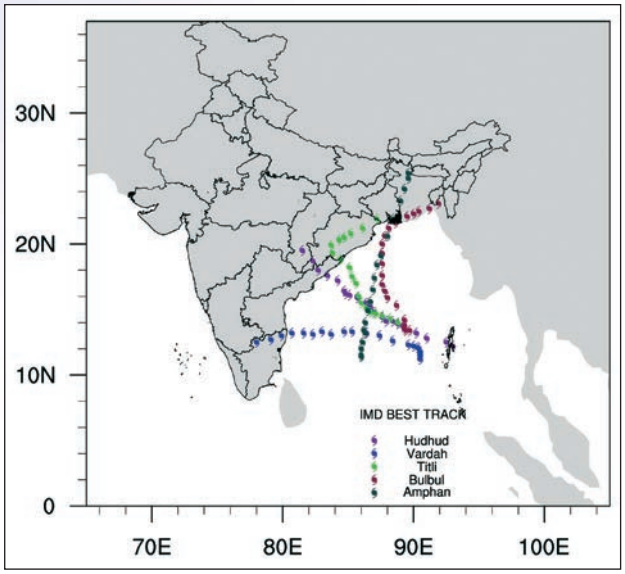
10. Impact analysis of INSAT-3D wind data assimilation for the simulation of Tropical Cyclones over the Bay of Bengal

This study examines the impact of assimilation of atmospheric motion vectors (AMVs) from the INSAT-3D satellite in the Weather Research and Forecast (WRF) model for track and intensity forecast of tropical cyclones (TC) formed over the Bay of Bengal. In addition to satellite wind, conventional observations from the GTS are also used for assimilation. The observation system experiments are conducted using the three-dimensional variational (3DVAR) and Ensemble Transform Kalman filter (ETKF)–3DVAR (HYBRID)data assimilation (DA) techniques. Depending on the availability of INSAT-3D data, five tropical cyclones with intensity ranging from very severe cyclonic storm to super cyclone centred over the BoB over a



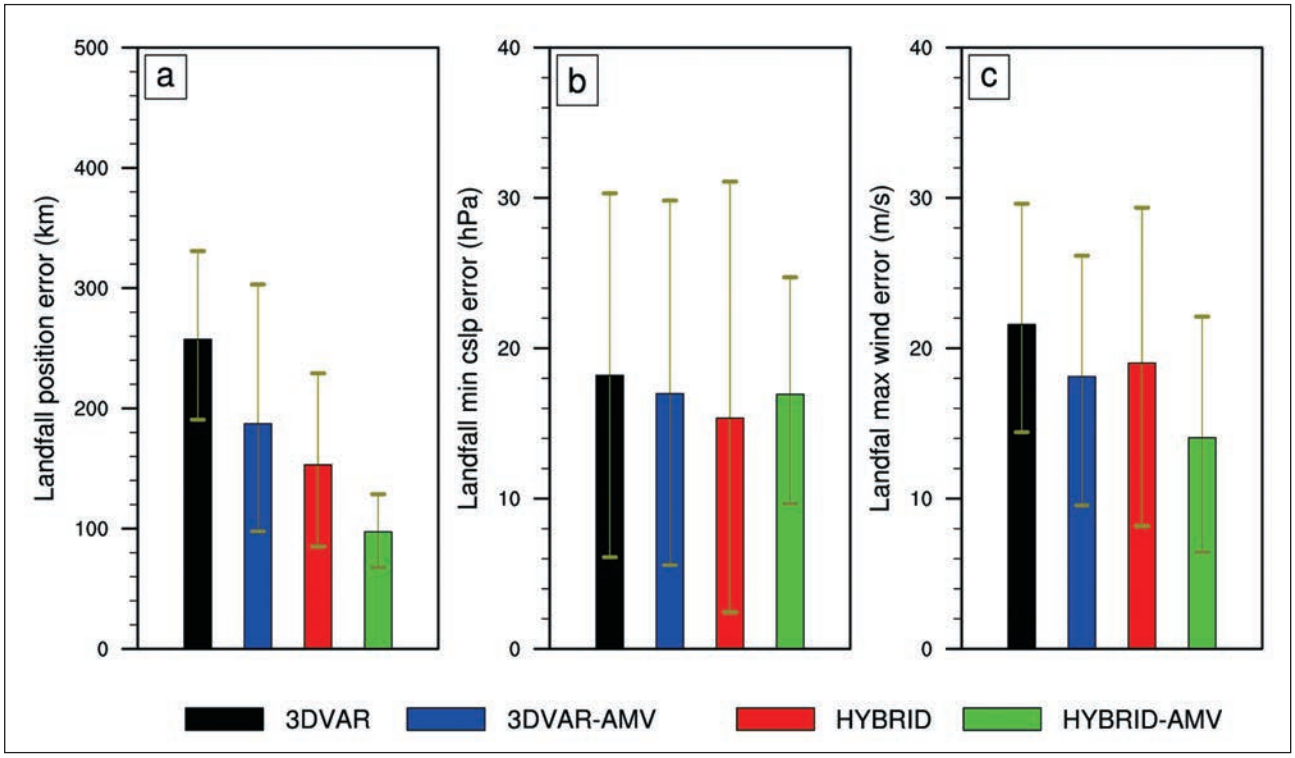
Accumulated rainfall calculated from GPM data; Model simulated rainfall forecast from b) 3DVAR, c) 3DVAR-RQ, d) HYBRID and e) HYBRID-RQ valid from 20170419 12 UTC to 20170420 00 UTC for Case-1. f) Accumulated rainfall calculated from GPM data; Model simulated rainfall forecast from g) 3DVAR, h)3DVAR-RQ, i) HYBRID and j) HYBRID-RQ valid from 20180330 12 UTC to 20180330 15 UTC for Case-2

period of 2014 to 2020 is considered. The impact of INSAT-3D AMV in 3DVAR and HYBRID DA systems is evaluated by conducting four experiments, namely 3DVAR, 3DVAR-AMV, HYBRID, and HYBRID-AMV. While the 3DVAR-AMV experiment assimilates INSAT-3D AMV and GTS observations, the 3DVAR run includes GTS observations alone using the 3DVAR DA approach. Similarly, HYBRID-AMV and HYBRID experiments are conducted with and without INSAT-3D AMV observations in the HYBRID DA system, respectively. The ensembles required for HYBRID DA systems are generated by adding random perturbations drawn from the static BEC of the WRF DA system. An ensemble of 75 initial conditions thus generated is then integrated for the next 24 hours before the first DA cycling experiment. Assimilation is performed only in the parent domain with 27 km resolution, and the free forecasts are performed until the TC made landfall.



The IMD best track of five tropical cyclones considered in the study

The track and intensity of TCs are evaluated with respect to IMD best track data and the quantitative precipitation forecasts during the landfall are validated with respect to GPM rainfall data. Assimilation of INSAT-3D AMV observations has improved the forecast of TC landfall locations in both the DA systems and more significant improvement is observed in the HYBRID-AMV



The average forecast error in the time of landfall in the (a) Initial position (b) Minimum Sea level pressure (c) Maximum sustained wind speed. The error bars represent 5th and 95th percentiles determined from bootstrap resampling.

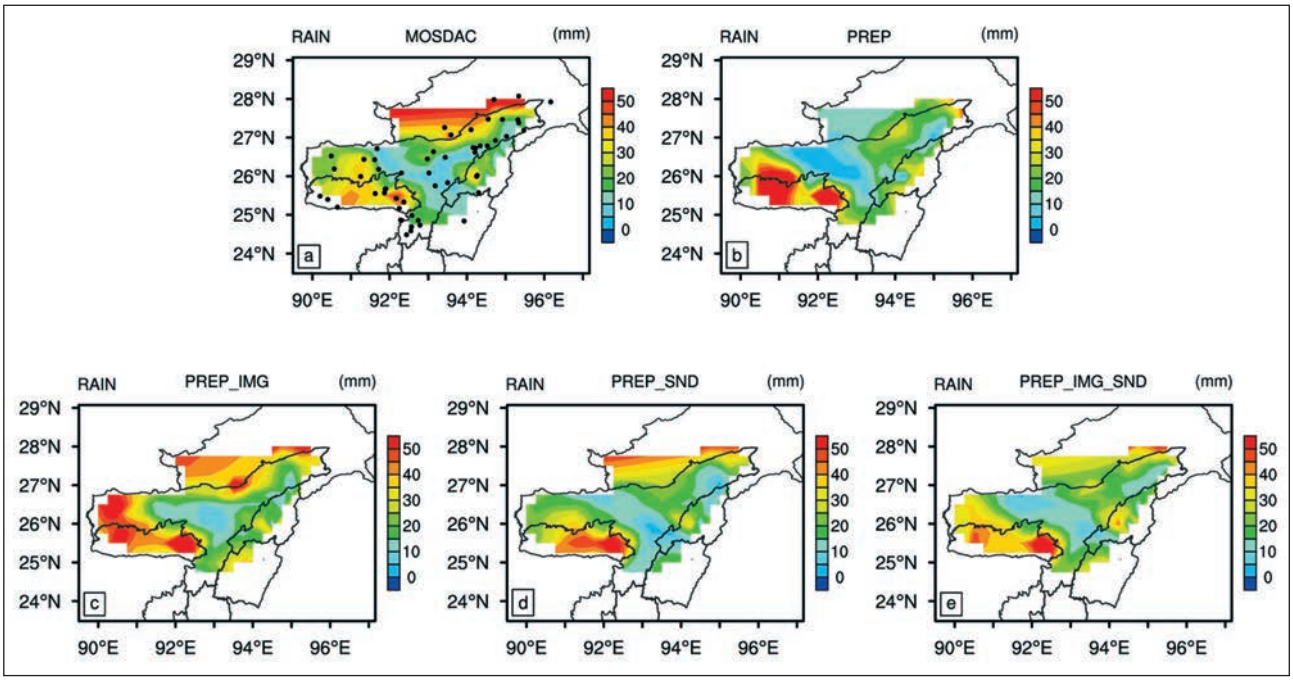
experiment (Figure 2). The average position error at the time of landfall is 260, 180, 160, and 93km for 3DVAR, 3DVAR-AMV, HYBRID, and HYBRID-AMV experiments. The relative improvements in intensity in terms of maximum sustainable wind speed compared to 3DVAR for TC are 18%, 13%, and 36%, respectively, for 3DVAR-AMV, HYBRID, and HYBRID-AMV.

Rainfall forecast is improved significantly in both HYBRID and 3DVAR by incorporating the INSAT-3D AMV data. The HYBRID-AMV experiment show improved skill scores for precipitation over all the other experiments, in general. Overall, assimilation of INSAT-3D AMV observations in the HYBRID DA system reduces the relative errors in landfall position significantly and with minor improvement in the intensity.

11. Impact of INSAT-3D radiance data assimilation using WRF 3DVAR on simulation of heavy rainfall forecast over hilly terrain

In this study, the effect of the assimilation of INSAT-3D radiance data from imager and sounder on the heavy rainfall forecast over the northeastern region (NER) of India is evaluated using the Weather Research and Forecast (WRF) model and three-dimensional variational (3DVAR) data assimilation technique. The model is configured for three nested domains at 27, 9, and 3 km, respectively, with 36 vertical levels. The parent domain covers India's monsoon prevailing region, the D02 domain covers India's eastern region, and the innermost domain D03 covers India's northeastern region (NER). The meteorological input data are the Global Forecast System (GFS) Model data of half-degree grid resolution distributed by the National Oceanic and Atmospheric Administration (NOAA). Except for the land use land cover data over the Indian domain, all other static information is taken from USGS available with the WRF model. Over the Indian domain, the land use land cover (LULC) data is obtained from ISRO at 30sec resolution. Data used for assimilation are: 1) Global Telecommunication System (GTS) conventional surface and upper air observations; 2) INSAT-3D IMAGER and SOUNDER radiances.

A heavy rainfall case from 1st July 2016 to 5th

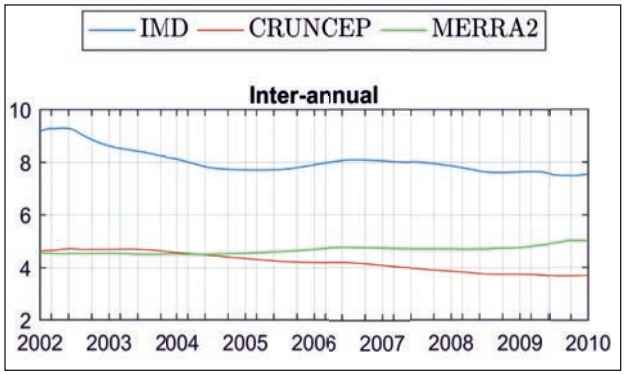


Spatial distribution of four days average observed rainfall (mm) from (a) AWS stations and simulated rainfall from (b) PREP, (c) PREP_IMG, (d) PREP_SND, (e) PREP_IMG_SND experiments; rainfall valid from 2nd July 2016 to 5th July 2016 over the D03 domain. Black dots on (a) represents locations of 66 AWS stations

July 2016 over the D03 domain is evaluated by comparing the rainfall forecast with 66 AWS stations obtained from www.mosdac.gov.in. It is observed that the rainfall event is better simulated by the radiance experiments compared to only conventional data assimilation experiments, mainly towards the north and central portion of NER. The northern part of NER consists of very complex hilly terrain and is also one of the most data-sparse regions of India. The improvement over such regions reflects the significant importance of satellite data for assigning accurate early warnings using NWP models. The ETS scores reveal better forecast skill of PREP_IMG compared to the rest of the experiments throughout the rainfall threshold.

12. Analysis of inter-annual behaviour of spatial variance of rainfall over Indo-gangetic and Brahmaputra basin

The spatial distribution of rainfall is influenced by various factors and this interaction between the different factors and rainfall is non-linear in nature. Hence, an evaluation of the inter-annual behaviour of rainfall or trend using linear approaches might miss out on some key features. In this study, a new non-linear trend estimation method is used for estimating the long-term trend of rainfall from different sources. This study uses the Singular Spectrum Analysis (SSA) for estimation of the long-term non-linear trend of rainfall. The notion of SSA can be easily understood as the principal component analysis for a time series, the leading principal component represents the long-term trend of a time series. The datasets used here are IMD gridded rainfall, CRUNCEP, and MERRA2 gauge corrected reanalysis rainfall. The analysis is performed over the Indo-gangetic and Brahmaputra basin, which is dominated by a warm temperate climate with dry winters and hot summers. The analysis shows a decreasing trend of the spatial variance of rainfall over the Indo-gangetic and Brahmaputra basin by IMD and CRUNCEP rainfalls. On the contrary, MERRA2 rainfall shows an increasing trend of spatial variance over this region.



The inter-annual behaviour of spatial variance is shown. The vertical axis is the spatial variance of rainfall.

13. Implementation of the Gaussian Process Regression (GPR) for estimation of heavy rainfall days

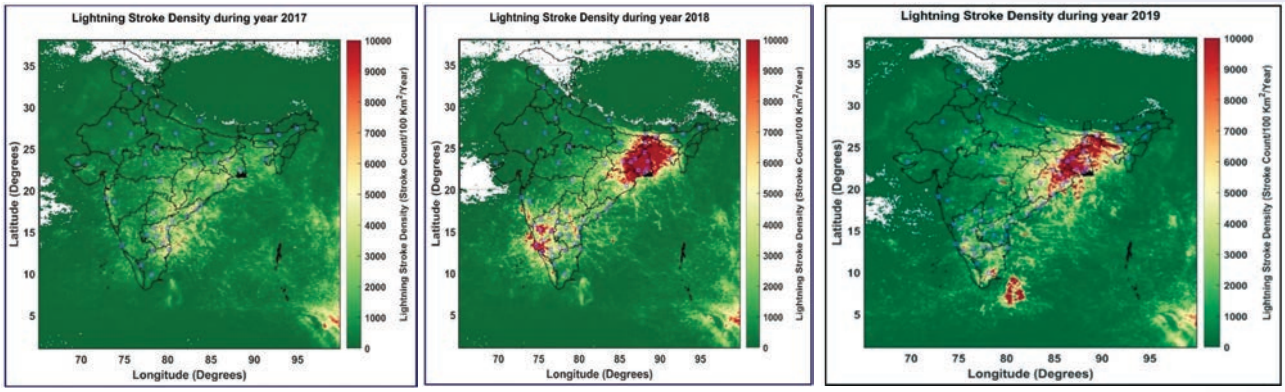
In the present study, the Gaussian Process Regression (GPR) approach, one of the machine learning methods, is implemented on long time-series rainfall data for the determination of heavy and light rainfall days. Climatological data of daily rainfall for a period of 116 years between 1901 to 2016 over Sriharikota is used for training the GPR model for the identification of the heavy and light category of rainy days. The GPR results indicated that the performance of the proposed model is satisfying, especially for the heavy rainfall days. This is a collaborative work with Kandula V Subrahmanyam (SPL), C. Ramsenthil (SHAR), A. Girach Imran (SPL), R. Sreedhar (SHAR), E. Ezhilrajan (IPRC), D. BalaSubrahamanyam (SPL), Radhika Ramachandran (SPL), M. Rajasekhar (SHAR), and C. S. Jha (NRSC).

14. Lightning climatology over India using in-situ lightning data

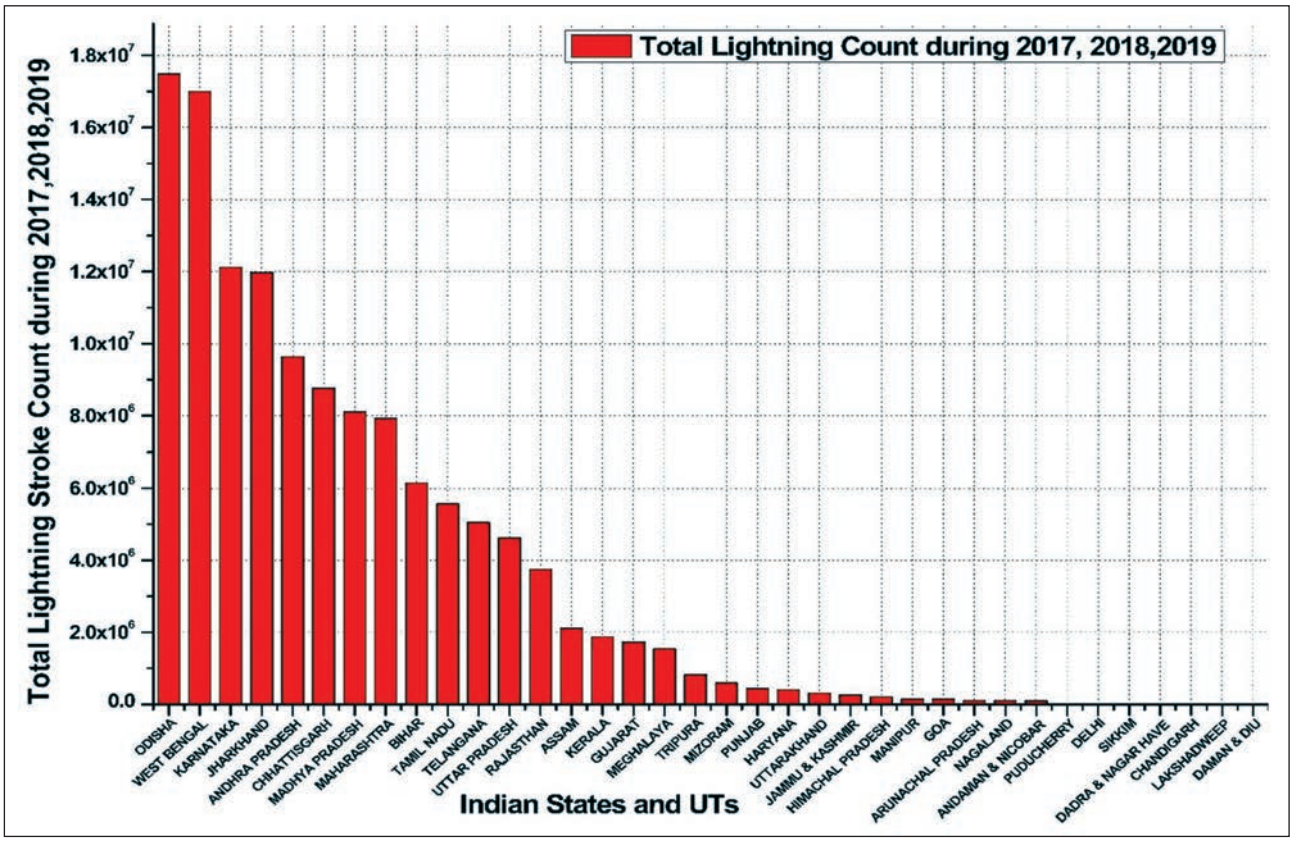
Lightning strikes were the worst killer in India among all the natural disasters in India as per the data of the National crime records bureau of India (ncrb.gov.in). Lightning strokes major impacts was human deaths and many people who survived after lightning strokes showed symptoms of "memory loss, dizziness, weakness, numbness, and other life-

altering elements". Lightning strokes impact trees by vaporize water present in the tree into steam and may blow the tree apart. (nationalgeographic.com). The present study aimed to analyze lightning strokes for the three consecutive years i.e., 2017, 2018 and 2019 respectively, across the Indian subcontinent utilizing Earth Networks datasets. Major parameters like lightning strokes density (LSD) and total lightning events recorded in each state and union territories of India from 2017 to 2019 were reported here.

The phenomena of lightning have analyzed using the parameter Lightning Strokes Density (LSD) is measured the number of stroke count per 100 kilometer2 area/year across the Indian region and data observed for three consecutive years from 2017 to 2019. Significant LSD was seen in states like Andhra Pradesh, Telangana, Odisha, West Bengal, Meghalaya, Assam, Maharashtra, Karnataka, Chhattisgarh, Kerala, Bihar and Tamilnadu, respectively in 2017, 2018 & 2019. This is very important to note that even a single lightning



Lightning stroke density for the years 2017, 2018 & 2019 using Earth Networks Lightning Datasets.



Indian State & Union Territory wise Total Lightning Stroke Counts combining the analyses years 2017, 2018 & 2019 using Earth Networks datasets.

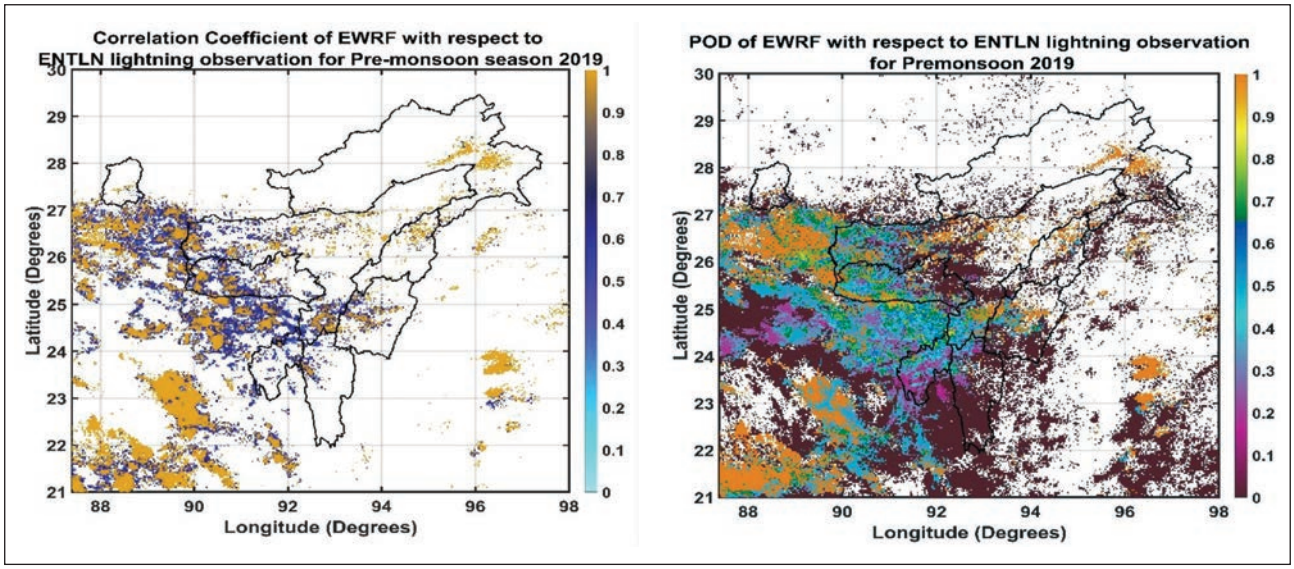
incident can be deadly to anyone out there during a storm. Therefore, even if some states have low LSD, it does not mean those states are free from lightning hazards.

The population density also plays a vital role in such a situation. The states like Uttar Pradesh, Bihar, Andhra Pradesh, Assam, Odisha and Maharashtra belongs to high population density and high LSD. Therefore, in terms of human life threat and property damages, those states are highly vulnerable. One incident during 25th June 2020 over Uttar Pradesh & Bihar proved that. A thunderstorm with a high amount of CG lightning killed more than 100 people in Uttar Pradesh and Bihar. NESAC is working for the last four years, generating lightning-related information, running lightning forecast and disseminating the same with the various concerned department of North Eastern states.

The total numbers of lightning counts for all three years showed that Odisha, West Bengal and Karnataka states recorded the highest numbers of lightning strokes counts while among union territories, Andaman and Nicobar Islands, Puducherry and Delhi recorded the highest number of lightning strokes. Across the Northeastern states of India, Assam, Meghalaya and Mizoram were recorded the highest number of lightning strokes. Deaths and significant impact due to lightning strokes were observed mainly in the Uttar Pradesh and Bihar region of India, although these states were not among the maximum lightning counts in the country as we observed data year-wise.

15. Forecast of lightning activity over the NER of India using Numerical Weather Forecasting Model with Ground based lightning data assimilation

A comparison between EWRF simulated lightning flash density and ENTLN observed lightning flash density for the pre-monsoon 2019 was studied. All the forecasts during the pre-monsoon season have been circulated to all north eastern states for their preparedness. The comparison has been made for the time period of 1 UTC to 9 UTC. We noticed model captures the observed density very well. In addition, we have assimilated the ground based lightning data into the EWRF model to improve the forecast capability and evidence a significant improvement in the simulated lightning density.



Probability of Detection (POD) and Correlation Coefficient (CC) for Earth Networks detected Lightning flash density and EWRF simulated Flash density for the Premonsoon 2019.

The grid-wise distribution of POD and CC are represented in fig. 1.5 we noticed high POD & CC values over Lower Assam, Eastern Part of Arunachal

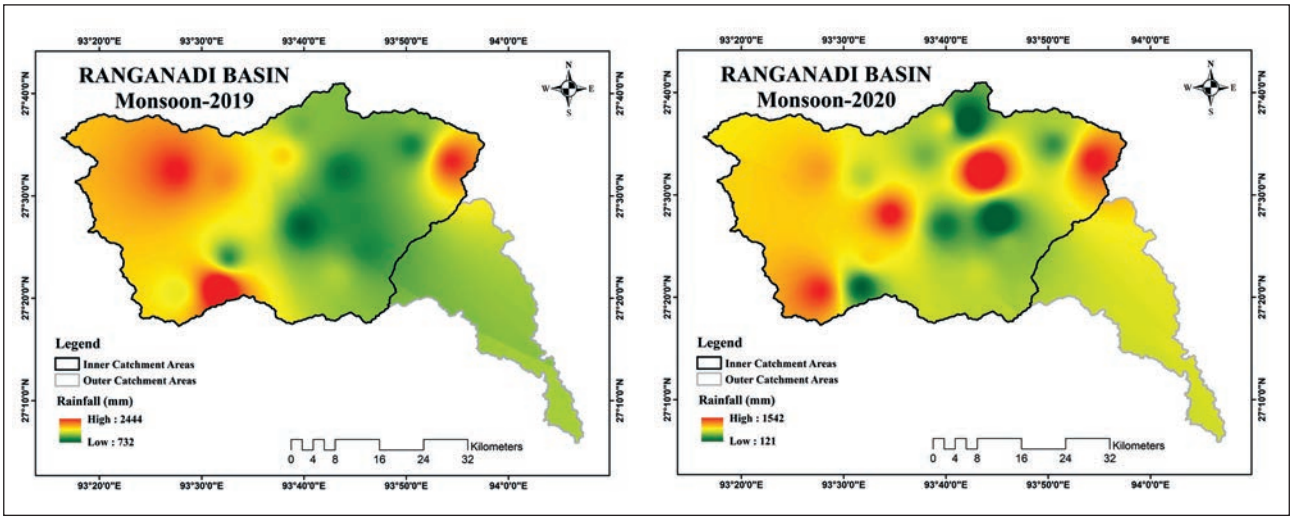
Pradesh, Middle Assam, Meghalaya and also over Barak Valley. The high POD is also observed over Bangladesh. We also noticed moderate to low POD values over different places of the north east region (NER) of India and also distributed randomly over the whole NER of India.

16. Setting up a Hydro-Meteorological network in RHEP, Arunachal Pradesh

The network of 17 Automatic Weather Stations (AWS) installed within the Ranganadi river basin under the North Eastern Electric Power Corporation (NEEPCO) funded project on "Setting up a Hydro-Meteorological Network for Ranganadi Hydro Electric Power Project" was kept fully operational with all the AWS providing data during the critical monsoon season. The major objective of setting up the network is to provide near real-time rainfall information to NEEPCO to support their dam operations to control the flood events in the downstream areas of the Ranganadi basin. Based on the data received from the AWSs, rainfall contour maps were generated on a daily basis and the same was shared with NEEPCO. The data was also shared with the NESAC Hydrology team, who used that data to generate a forecast of river discharge at the dam location. In the year 2019, total monsoon rainfall over the basin shows significant spatial variability with high rainfall over the south-western region of the basin, whereas the eastern part of the basin received less rainfall. In the year 2020, total monsoon rainfall over the basin shows significant spatial variability with high rainfall over the middle region of the basin, quite similar to the western region, whereas the south-eastern part of the basin received less rainfall.

All the AWS in the network was serviced and maintenance activity was carried out and the AWSs were calibrated during the January-March 2021 time period to ensure the smooth operation of the AWS during the monsoon season in 2021. A web-based dashboard is also developed for real-time visualization of AWS data, AWS health, rainfall pattern, heavy rainfall warning, and a host of several other advisories. The dashboard will be web-hosted with limited access for real-time monitoring of the network and proposed management of the RHEP dam.

In terms of the monitoring year 2019, the AWSs installed at Badletam, Pinegrove, Seya, Dem, Kungitot, Sima, Totpu-2, Nakar, Searchgai, Kidding Langik performed moderately (75-85%). The AWSs installed at Hari Village, Gyabli, Dodo, Amgi, Comp, Pange performed average (60-75%) in 2019. In terms



Map showing location of AWSs in Ranganadi basin (upper) and spatial distribution of rainfall (mm, left-right) during Monsoon season 2019 and 2020

of the monitoring year 2020, the AWSs installed at Pinegrove, Sima, Nakar, Comp, Kidding, Pange performed moderately (75-85%). The installed AWS at Dem, Kungitot, Dodo, Amgi, Searchgai, Langik performed average (60-75%). The installed AWSs at Hari Village, Gyabli, Totpu-2 performed below average (50-60%). The installed AWSs at Badletam, Seya performed poorly (0-50%) in 2020. Totpu-2 received the heaviest and Comp received the least rainfall during the monsoon-2019, while Gyabli received the heaviest rainfall and Seya received the least rainfall during the monsoon 2020.

17. Study of depolarization phenomenon using polarimetric DWR to differentiate among different hydrometeors

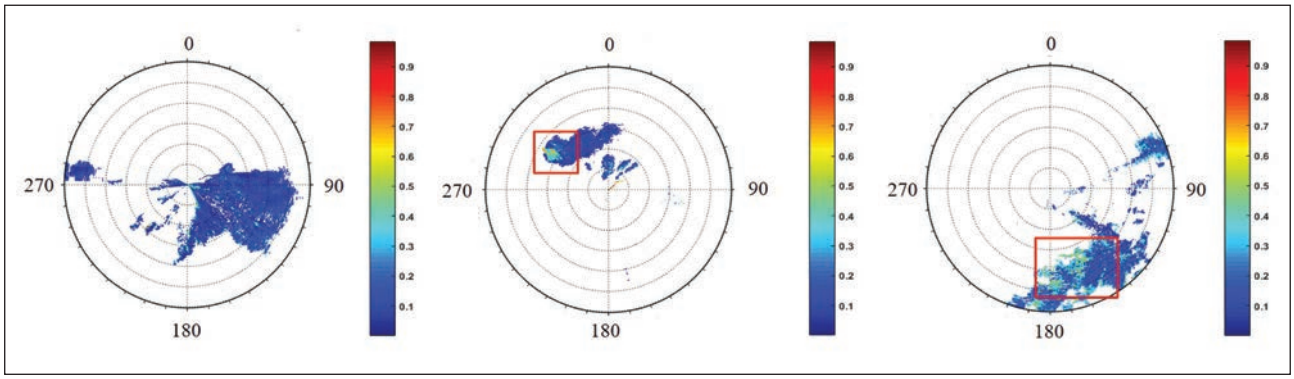
Depolarization is a stochastic process where energy is coupled from deterministic to random modes of fields. It is a common phenomenon with radar that occurs when the scatterers possess asymmetry. Even the phenomenon describes the randomness in determining the types of scatterers, it can be used to analyze the anisotropic behaviour of the scatterers as well as the media in weather observations. The study of depolarization processes can be used to differentiate among different types of hydrometeors present in the clouds. Study of variations of depolarization ratio (DR) for different types of hydrometeors is done using Doppler weather radar, Sohra.

18. Study of melting layer characteristics using polarimetric DWR products

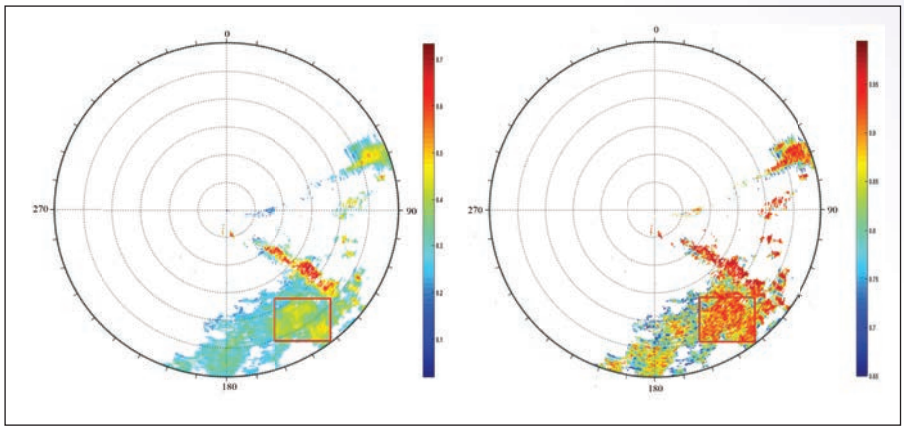
The melting layer has its own crucial role in weather forecasting and nowcasting systems since it describes the phase transition of hydrometeors. Interpretation of the microphysical characteristics of the precipitation is important for numerical weather prediction models. A weather radar is an important tool to study the microphysical characteristics of precipitation events. In the melting layer, the radar signal interacts with both the solid and liquid phase of hydrometeors, thus, samples both types of precipitations.

The variations of different polarimetric weather radar products in the melting layer have been presented using S-band Polarimetric Doppler Weather Radar, Sohra. The behaviour of different combinations of polarimetric features has also been analyzed using gradient based method to estimate the location of the melting layer correctly. The polarimetric products reflectivity Z, differential reflectivity Z_{dr} and correlation coefficient ρ are sensitive to the precipitation type and represent the melting layer characteristics. Therefore, we used the products to detect the layer. The melting layer contains heterogeneous hydrometeors with various axis ratios of melting ice particles, raindrops, and wetted particles.

The increase in dielectric constant due to melting of the ice has been observed as the high reflectivity in radar. The mixture of solid and liquid precipitations response differently to horizontal and vertical



Depolarization ratio PPI plots for rain data (left), hailstorm data (centre) & melting layer (right)



Normalized Z values [0 60] to [0 1] (left) and ρ values [0.65 1]

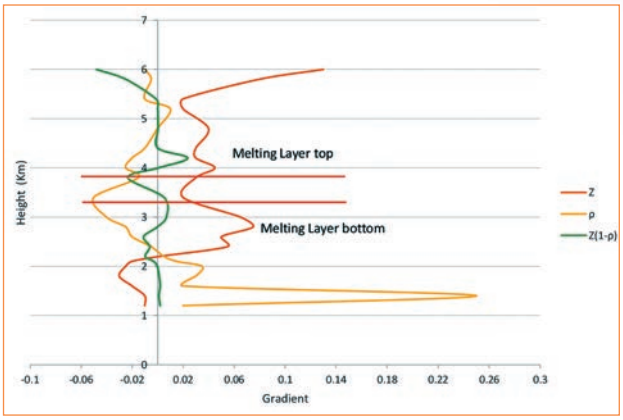
polarizations. This results in low correlation values. Using the hydrometeor classification, the melting layer is analyzed, which was consistent with the boundary between dry snow and rain regions.

The implementation of the methodology has been carried out over the region near Aizawl, the capital of Mizoram, India. The Latitude of the study area is 24°17'48.48"N and the longitude is 92°25'33.96"E. The red rectangular box is the indication of the presence of a melting layer. The normalized Z values over the study area are near about 0.5 (30db) and ρ values fall within 0.88 to 0.94.

A gradient based method for melting layer detection based on Z and ρ is proposed. In this method, the values of Z and ρ are initially normalised by the maximum value in the respective profiles, and their gradients were then estimated. Since the melting layer is characterised by high values of reflectivity Z and small values of correlation coefficient ρ, the complement of ρ is used in the product.

The steps followed in studying of melting layer using the polarimetric products Z & ρ. Computation of normalised values of Z, ρ and Z(1- ρ) is done and then the gradients of Z, ρ and Z (1- ρ) are taken. The Positive peak in the gradient of Z(1- ρ) is associated with the bottom of the melting layer. And, the negative peak in the gradient of Z(1-ρ) along with the positive peak in the ρ gradient is associated with the upper edge of the melting layer.

The top and bottom of the melting layer can be estimated



Detection of melting layer through peaks of gradients of Z, ρ and Z(1-ρ)

at the heights of 3.8 kilometres and 3.25 kilometres, respectively using the gradient based method.

This type of study is particularly important to identify the particle types in the precipitation events for aviation forecasting. The study here done is preliminary, which can be further optimised for better interpretation of the melting layer through the combinations of various polarimetric weather radar products, e.g. differential reflectivity Z_{dr} and differential phase shift K_{dp}.

NEWS & EVENTS

Training & Workshops

NESAC conducted two days online training course on Applications of Geographic Information System in Disaster Risk Management

NESAC organised two days online training course on Applications of Geographic Information System in Disaster Risk Management, sponsored by the National Disaster Management Authority (NDMA), Ministry of Home Affairs, Government of India through online mode on 18th–19th August 2020. The program was inaugurated by Shri P.L.N. Raju, Director, NESAC. Shri Brijendra Mishra, Advisor, NDMA addressed the participants during the inaugural program. A total of 60 officers from various state and central government organisations were nominated and participated in the training program.

Inauguration of the NDMA training at NESAC

The training course was planned and conducted under the overall guidance of Shri P.L.N. Raju, Director, NESAC. Dr. K.K. Sarma, Sci/Engr. 'SG' was the Course Coordinator and Dr. Arjun B.M., Sci/Engr. 'SD' and Dr. Gopal Sharma. Sci/Engr. 'SD' was the Course Officers for the two-day training program. The course was conducted through the E-Learning platform of IIRS, Dehradun and also through the GoToMeeting platform. The course focused on how Remote Sensing and GIS can be efficiently used for effective management and monitoring of various disasters. Shri B. Chandrasheker, Chief General Manager, BSNL, NE-1 Circle graced the concluding session as the Chief Guest and highlighted the role of BSNL during disaster situations.

A lecture being delivered online to the participants by Dr. K.K. Sarma from NESAC

NESAC conducted one week virtual training programme on Satellite Meteorology and its Applications in Numerical Weather Prediction during 5th–9th October 2020

One week virtual training programme on Satellite Meteorology and its Applications in Numerical Weather Prediction was jointly conducted by the North Eastern Space Applications Centre and Indian Meteorological Society–Shillong Chapter at NESAC during 5th–9th October 2020. Dr. Mrutyunjay Mohapatra, DGM, IMD, New Delhi graced as the Chief Guest during the inaugural programme held on 5th October 2020. The course was a compact five days experience on the basic concept of satellite meteorology, numerical weather prediction using the Weather Research and Forecasting model and Geographic Information System (GIS) in meteorological applications. The course consisted of theory lectures and online practical demonstrations. Apart from the lectures by NESAC scientists, a few lectures were delivered by prominent Scientists from ISRO, IMD, and Professor from Cotton University. A total of 35 participants from all around India have attended this training programme on virtual mode. The valedictory program was graced by

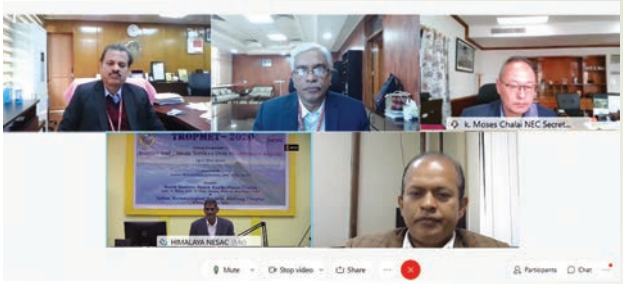
Dr D.R. Pattanaik, Secretary, IMS. The participants expressed satisfaction during the valedictory program and desired NESAC to conduct more such program with a longer duration. This was the first course conducted by Space and Atmospheric Science group at NESAC.

NESAC jointly organised TROPMET-2020 Virtual Conference

The annual national symposium of the Indian Meteorological Society, TROPMET-2020 was organised virtually with the theme "Weather and Climate Services over Mountainous Regions" during 14th-17th December 2020 by North Eastern Space Applications Centre (NESAC) and Indian Meteorological Society – Shillong Chapter.

For the first time, this symposium was conducted virtually and controlled from NESAC, Shillong. Efforts were made to provide uninterrupted, user friendly, real 3D feel with a nicely designed lobby, three separate halls, namely Himalaya, Brahmaputra, and Ganga hall for three parallel technical sessions, e-poster area, e-exhibition areas, etc.

The symposium received overwhelmed response with more than 450 registrations and 315 abstracts. In addition, 12 plenary lectures, 13 invited talks, 2 memorial lecture, 1 popular lecture, and one special talk by Dy Secretary General of World Meteorological Organisation was planned during the four days. The inauguration program of the symposium was conducted from 10 AM to 11:15 AM on 14th December 2020. The Secretary of the Ministry of Earth Sciences, Dr M.N. Rajeevan was the Chief Guest while Shri Moses K. Chalai, Secretary of North Eastern Council, Shillong was the guest of honour. The inauguration program was also attended by Dr. M. Mohapatra, Director General of Meteorology, IMD; Shri P.L.N. Raju, Director, NESAC; and Dr. D.R. Pattanaik, Secretary, IMS.



Inaugural Program of the TROPMET Virtual Symposium

The importance of weather and climate services for the mountainous regions including the complex NE region of India was discussed. Secretary, NE Council stressed on the importance of improved services and enhancement of observatories to address the challenge posed by severe weather and climate change that can derail the livelihood options for the indigenous population living over the mountainous regions. Secretary, MoES stressed on the utilisation of advanced technology and the greater involvement of the younger generation to develop solutions for the problems faced by the population living in mountainous regions.

There was a consensus that different departments need to join hands to address the complex problems of weather and climate services over the mountainous regions.

Two eminent Scientists, Dr. S. Raghavan and Dr. G.B. Pant, who contributed immensely in the fields of Atmospheric Science, left for heavenly abode during 2020. IMS paid tribute to these great scientists and organised two memorial lectures during the TROPMET-2020.

A special talk was organised on 17th December 2020 before the valedictory session. This talk was delivered by Dr Elena Manaenkova, Deputy Secretary-General, WMO. She delivered her talk on "WMO - International Cooperation for Improved Weather and Climate Services for Mountain Regions". She briefed about the WMO's initiatives on mountain meteorology and discussed about the outcome of the High Mountain Summit organized

by WMO in 2019. She congratulated IMS and NESAC for the successful conduct of TROPMET-2020.

NESAC conducted first Basic Course on Satellite Communication & Satellite Navigation: Technologies & Applications in online mode

NESAC conducted the inaugural "*Basic Course in Satellite Communication (SATCOM) & Satellite Navigation (SATNAV): Technologies & Applications*" during 7th-18th December 2020 in Online Mode. The two-week course was targeted towards Engineering students and working professionals of the NE Region. The course was planned to provide a basic understanding of the Satellite Communication & Navigation Technologies and apprising about the diverse applications of SATCOM & SATNAV with special emphasis on such applications for the NE region.

Shri D.K. Das, Distinguished Scientist & Director, SAC, Ahmedabad graced the inaugural session on 7th December 2020 as the Chief Guest and Shri K. Ratnakara, Director, Satellite Communication Program Office (SCPO), ISRO HQ, Bengaluru as the Guest of Honour. 40 participants from various backgrounds registered for the course. A total of 10 lectures were scheduled and a lecture was designed to be of one hour duration keeping in mind the normal duration of a conventional class. Faculties were a mix from various ISRO Centers including Space Applications Centre (SAC), Ahmedabad, ISRO Telemetry, Tracking & Command Network (ISTRAC), ISRO HQ, Bengaluru, Indian Institute of Remote Sensing (IIRS), Dehradun, Developmental Education & Communication Unit (DECU), Ahmedabad as well as from NESAC. The topics covered in the course are Introduction to Satellite Communication, Ground Segment & Payload structure, Channel Characteristics, Link Design, Modulation, Coding, Multiple Access, Applications of Satellite Communication in NER as well as Disaster Management, Introduction to Satellite Navigation, Satellite Navigation Technologies, Concepts of GNSS performance, Concepts about IRNSS & GAGAN, Applications of Satellite Navigation & Location Based Services, etc. The valedictory program cum concluding session was hosted on 18th December 2020. Shri Virender Kumar, Director, Developmental Education & Communication Unit (DECU), Ahmedabad graced the occasion as the Chief Guest. He appreciated NESAC for the initiatives in NER and also encouraged to take up more such courses in future as well. Shri Ramani Kumar Das and Shri Anjan Debnath from NESAC acted as the Course Coordinator and Course Officer respectively for the course.

NESAC participated in Brahmaputra Aamantran Abhiyaan Program

The Hon'ble Chief Minister of Assam, Shri Sarbananda Sonowal inaugurating the Brahmaputra Aamantran Abhiyan

The Brahmaputra Aamantran Abhiyaan programme sponsored by the Ministry of Jal Shakti, Govt. of India was organised by Brahmaputra Board. The theme of the Brahmaputra Aanabtran Abhiyaan was "Live with the River". Brahmaputra, one of the mighty rivers in the world has enormous water resources potential. But due to excessive pressure on its catchment areas coupled with the effect of climate changes, the river is causing problems like floods and bank erosion. The Abhiyaan aimed at understanding different aspects of the river Brahmaputra and creation of awareness among people to live with river with sustainable development. A team of NESAC staff led by

Shri P.L.N. Raju, Director, NESAC participated in the Abhiyaan and acquired UAV images for selected locations to understand river configurations and the status of embankments. NESAC scientists also made presentations on flood early warning system developed for different rivers and tributaries in Assam.

NESAC conducted one week online course on 'Remote Sensing and GIS applications in Forestry & Ecology'

An online one week course on 'Remote Sensing and GIS applications in Forestry & Ecology' was conducted at NESAC during 1st - 5th February 2021. The course covered geospatial technology with introductory concepts of remote sensing, GIS and GPS, visual and digital satellite data interpretation techniques, accuracy assessment, forest type and density mapping along with growing stock assessment. The course also covered important theoretical concepts on wildlife habitat evaluation, forest change detection, hyperspectral, microwave and forest fire monitoring. Familiarisation with QGIS software and demonstration of basics of information extraction from satellite data for information extraction was also arranged. A special lecture on 'Indian space Program' was presented by Shri P.L.N. Raju, Director, NESAC. A total of 56 participants joined the course from different parts of India, with a maximum number of participants from North East India. Resource persons for the course were Dr. K.K. Sarma, Smt. H Suchitra Devi, Dr. Kasturi Chakraborty, Dr. B.K. Handique, Dr. Pebam Rocky, Sri Victor Saikom, Dr. Arjun BM, Sri Nilay Nishant and Ms Ritu Anil Kumar. The course coordinator and course officer for this course were Dr. Kasturi Chakraborty and Dr. Pebam Rocky respectively.

NESAC conducts one week online training course on Applications of RS and GIS in Geosciences

NESAC organized a one week online training course on 'Applications of Remote Sensing & Geographic Information System in Geosciences' during 8th–12th February 2021. The program was inaugurated by Shri P.L.N. Raju, Director, NESAC. A total of 19 participants from various academic organisations and industries participated in the training program. Shri M. Somorjit Singh, Sci/Engr. 'SF' was the Course Coordinator and Dr. Gopal Sharma, Sci/Engr. 'SD' was the Course Officer of the training program. The course is conducted through Google Meet platform. The course consisted of a series of lectures followed by hands-on/practicals on the relevant topics. The course was designed with a view to provide participants with an understanding of the scientific concepts associated with remote sensing and its applications to various areas of Geoscience. During the concluding session, a number of good feedbacks were received. Most of the participants suggested to have more number of hands-on using different software, orientation to live dashboards, geoportals, and modeling exercises etc.

NESAC conducted training program for scientists from ICAR

The training programme was organised as a part of 6 days training on "Application of information technology in agriculture: geo-spatial mapping, sensor based drip irrigation, GHGs emission and statistical computing tools" during 22nd to 27th March 2021 at ICAR Research Complex for NEH Region, Umiam.

Dr. B.K. Handique with ICAR Staff at NESAC Outreach Complex academic Block

One day training was organised at the NESAC Outreach Facility on 1. Recent Advances in Space Science: India and North East Perspective. 2. Potential Applications of Geo-spatial tools in Agriculture - North-eastern Perspective and Exposure to GIS (Arc Info, QGIS) and Image processing software (ERDAS Imagine and TNTmips).

NESAC celebrated National Science Day-2021

NESAC celebrated National Science Day on 1st

Students at NESAC Outreach Conference Hall for the National Science Day program

March 2021 (28th February, being Sunday). The programme was organised under the aegis of the Indian Society of Geomatics (ISG)-Shillong Chapter. As part of the programme, essay writing and painting competitions among school students were conducted. Shri Paritosh Choudhary from Christ School (International), Nongsder bagged the First prize in Essay Writing Competition, while Ms Laalla, Kendriya Vidyalaya, North Eastern Police Academy bagged the Second prize and Ms Bithika Baruah from Army Public School, Umroi bagged the Third prize. In Painting Competition, first prize went to Ms Anamika Kharkang from Kendriya Vidyalaya, North Eastern Police Academy. The second prize was shared by Shri Aditya Paul from Army Public School, Umroi and Ms Brenila Marak from Kendriya Vidyalaya, North Eastern Police Academy while the third prize was bagged by Ms N. Pragati, Army Public School, Umroi. Around 60 students from 9th to 12th standard attended the popular science talk on "Glory of Indian Science: From Zero to Quantum Computing" delivered by Prof. Arup Kumar Misra from Assam Engineering College & former Director of Assam Science, Technology & Environment

Students at the exhibition organized by NESAC

Council (ASTEC), Guwahati during the National Science Day Celebration. An exhibition on different aspects of Space technology and its applications was also organised to mark the occasion.

Training program on emotional Intelligence at NESAC Outreach Conference Hall

Training Program on Emotional Intelligence held at NESAC

One day online training programme on Emotional Intelligence for achieving better work life balance was organised at NESAC by the HRD committee on 19th March 2021. The training programme was organised for Scientists and Researchers of NESAC and all other permanent staff. The training aimed at providing the employees with higher emotional intelligence so as to have a higher work life balance. The programme was inaugurated by

lighting of the lamp and followed by welcome address by Director, NESAC and introduction about the Centre for Organization Development (COD) by Dr. B.K. Handique, Chairman, NESAC HRD Committee. Faculties from COD, Hyderabad have conducted the training on the following topics,

- Developing Emotional Intelligence
- Achieving Balance through Self Management
- Achieving Balance through Relationship Management

The day long training program was ended with the concluding remarks of the Director, NESAC followed by a Vote of thanks offered by Dr. Kuntala Bhusan, Scientist-SE, NESAC.

NESAC conducted two weeks joint program on RS & GIS with ASSTC

Partcipants of the training at NESAC Outreach Conference Hall

NESAC in collaboration with Assam Survey and Settlement Centre (ASSTC), Government of Assam had successfully conducted the two-week training course on "Basics of Remote Sensing and Geographic Information System" during 15th-26th March 2021. The course was carried out both at ASSTC and NESAC in offline mode. There were total 28 participants from different parts of Assam attended the course. Experts from IIT, Guwahati, IRRI, Mangaldoi College, Climate Change Cell, Assam including NESAC and SSTC were invited as resource persons. This is the first course as part of the MoU signed between NESAC and ASSTC.

VARIOUS OFFICE EVENTS & CELEBRATIONS

Celebration of 74th Independence Day at NESAC

74th Independence Day of the Nation was celebrated at NESAC on 15th August 2020. Due to the ongoing COVID-19 pandemic, the gathering of NESAC Staff

Smt. R.M. Kurbah, IAS, DC, Ri Bhoi District at NESAC during Independence Day program

was restricted and only senior NESAC Scientists were present during the program. Director NESAC hoisted the National Flag at 9 AM amidst singing of National Anthem. He gave a brief speech on the prevailing challenging situation and summed up the activities and achievements of NESAC in the present year. The CISF Unit, NESAC gave a Guard of Honor to Director NESAC as per norms. The newly built Squash Court at NESAC Residential Campus was inaugurated by Director NESAC as a part of the Independence Day celebration. Deputy Commissioner of Ri Bhoi district, Smt. R.M. Kurbah, IAS graced the occasion as the Guest of Honour and inaugurated the newly commissioned 100 feet high Flagpost at NESAC and inaugurated the augmented NER-DRR facility at the Centre. Various NESAC Dashboard Services were demonstrated to her by NESAC Scientists at the NER-DRR room. She appreciated the efforts of NESAC in spearheading the advanced scientific research and support rendered in development planning in the region. The program was live-streamed to NESAC Staff who could not physically present in the office due to restrictions.

20th Foundation Day of NESAC was celebrated virtually

NESAC celebrated its 20th foundation day on 7th September 2020, commemorating twenty years of its dedicated services in space technology applications benefiting NER. To mark the occasion, NESAC organised a virtual meet on "20 years of NESAC-the journey towards excellence" inviting Chairman, ISRO/Secretary, Dept. of Space (DoS), former Chairmen of ISRO, Directors of major ISRO/ DoS centres and Heads of other State Remote Sensing Centres and User organisations.

The Foundation Day Celebration started with the welcome address by Shri P.L.N. Raju, Director, NESAC. He welcomed the Hon'ble Chief Minister of Meghalaya, former Chairmen of ISRO, Directors of major ISRO/DoS centres and Heads of State Remote Sensing Centres and Heads of Academic institutions and User organisations in NER. He also appraised the invited dignitaries about the activities of NESAC and the milestones achieved during the past twenty years. He sought suggestions and guidance from all the participants for making NESAC a centre of excellence.

The Chief Guest of the Foundation Day Celebration, Shri Conrad Sangma, the Hon'ble Chief Minister of Meghalaya congratulated NESAC on behalf of the Meghalaya government on the completion of 20 years. He pointed out that NESAC has really contributed a lot to the state of Meghalaya and the north east as a whole addressing many challenges. He mentioned that many departments of the state are taking benefit of space technology applications in the areas of disaster management, weather prediction, agriculture, health etc. and stressed on the use of satellite technology and ICT tools for developmental support. He suggested that it is time for NESAC to really go in-depth in addressing problems of the region and prepare a road map for the next 5 years addressing the challenges in the area of disaster management, defence, health, agriculture etc. He said that NESAC should share its platform to bring the younger generation to the domain of science and scientific research.

Hon'ble Chief Minister of Meghalaya Shri Conrad K. Sangma addressing the NESAC staff via online mode

The Virtual Meet started with the welcome address by Shri P.L.N. Raju, Director, NESAC followed by an address from Chairman, NESAC GC/ ISRO & Secretary, Department of Space. He appreciated the role of NESAC in providing operational space application services in various domains. He pointed out that the strength of the Centre lies with the young and dynamic staff carrying out space applications, capacity building and research. He appreciated the establishment of the North Eastern Spatial data Repository (NESDR) by NESAC for providing easy access to space based data and value added products for development planning by stakeholders. He also mentioned about the National level recognition for the projects on Sericulture development and North Eastern District Resources Plan with the National E-Governance award during the year 2015 and 2018. He wished that NESAC will continue to provide excellent support to the region by using space based technology and will receive many more awards and cross many milestones of success in coming years.

In the first technical session, Directors of various ISRO centres mentioned about the important role played by NESAC in taking space technology applications to the common man.

In the second session, Directors of all NER State Remote Sensing Application Centres (SRSACs)

mentioned that NESAC has been supporting the SRSACs in terms of providing technical guidance and finance through various projects. For this session, Directors of SRSACs in NER were invited to share their views and expectations from NESAC. For the third session, NESAC invited heads of major User departments and important academic institutions to share their views and requirements from NESAC. It was stated by the Director, NESAC that NESAC requires the support and collaboration of a large number of user departments and academic institutions to execute various projects and programs using space technology tools and techniques. In that process, NESAC needs to play a catalytic role and act as a building bridge among departments and academic institutions. In the fourth session, past Directors of NESAC shared their experiences on how NESAC started its humble journey twenty years back and has now established itself as a centre of repute in NER due to its constant efforts and achievements.

The second half of the day was celebrated through various cultural programs organised by the staff of NESAC.

9th Meeting of NESAC Society held under the Chairmanship of Hon'ble Union Home Minister

The 9th meeting of NESAC Society was held on January 23, 2021 at Conference Room of North Eastern Council (NEC) Secretariat, Shillong under the Chairmanship of Shri Amit Shah, Hon'ble Union Home Minister/Chairman, NEC and President, NESAC Society. At the beginning of the meeting, Hon'ble Union Home Minister Shri Amit Shah inaugurated the Outreach Facility of NESAC by virtual mode and dedicated the facility to the Nation. The Outreach Facility has been created to conduct training, workshops and skill development in the area of space technology applications for NE region.

Hon'ble Home Minister Shri Amit shah along with dignitaries at the 9th society Meeting of NESAC at NEC, Shillong

Dr. K. Sivan, Secretary DOS & Chairman, ISRO, as the Chairman of the NESAC Governing Council & Vice-President of the NESAC Society welcomed the President and the members of the Society. Dr. Jitendra Singh, Hon'ble Minister of State (Independent Charge) for DONER, Personnel, Public Grievances and Pensions; Department of Atomic Energy and Department of Space gave his opening remarks and lauded the space technology applications in wide range of areas in the country. He said that NESAC is a unique centre of the Department of Space providing space technology support to strategically important NE region, which is also known for its rich diversity. He also highlighted the major achievements of the NESAC. He appreciated the effort of NESAC in carrying out more than 120 UAV/Drone based surveys.

Shri PLN Raju, Director, NESAC presented the action taken report of the 8th meeting of NESAC Society. He presented activities and achievements of NESAC along with the Budget details.

Shri Naresh Kumar, IAS, Chief Secretary, Arunachal Pradesh, Shri M.S. Rao, IAS, Chief Secretary, Meghalaya, Shri Hemen Das, IAS, Secretary, S&T, Assam, and Shri Rajesh Kumar, IAS, Chief Secretary, Manipur offered their valuable comments and suggestions.

In his address, President, NESAC Society appreciated the wide range of activities carried out by NESAC to support the developmental planning of NER with space technology inputs. He reiterated the

vision of former Prime Minister Late Shri Atal Bihari Vajpayee, while establishing the NESAC to augment the development of the region with advanced space technology support. Hon'ble Home Minister opined that NESAC has considerable repository of data on various aspects/ sectors which should be used for planning and implementation for purposes like degraded unutilized lands, management of forest, restoration of water resources like lakes, check dams and ponds in appropriate locations as means for flood control, irrigation and development of tourism. He urged all the States to come forward with developmental Plan of Action (PoA) using Space Technology within 6 months. The PoA to have targets to be attained within three years. He also emphasized that NEC should organize interactions with Chief Secretaries of NE states once in every three months to review the status of space applications in their respective state.

The meeting ended with vote of thanks offered by Director, NESAC & Secretary, NESAC Society.

Inauguration of Space Corner at DBCIC Shillong established by NESAC

NESAC has established a 'Space Corner' at Don Bosco Centre for Indigenous Cultures (DBCIC), Shillong. The main objective of the 'Space Corner' is to create awareness and popularize space science, technology and applications in the NE region. The 'Space corner' consists of display panels viz. growth and development of Indian space technology, Indian launch vehicles & satellites, ISRO's interplanetary missions, science missions, Gaganayan mission, future of Indian Space Programme and applications of space technology, particularly for the north eastern region. Nine physical models of launch vehicles, satellites, Cryogenic engine and Vikash engine, along with a satellite view of NER are displayed for the visitors.

The 'Space Corner' was inaugurated by Dr. K. Sivan, Chairman, ISRO on 23rd January 2021 in the presence of Fr. Paul Olphindro Lyngkot, the Provincial of the Salesians, John D. Sohshang SDB, Assistant Director, DBCIC, Prof. S.K. Srivastava, Vice Chancellor, NEHU, Shri M. Maheshwar Rao, Jt. Secretary & Financial Adviser, Dept. of Space, Ms G. Jayanti, Jt. Secretary (Finance), Dept. of Space, Dr. Raj Kumar, Director, National Remote Sensing Centre (NRSC), Hyderabad, Shri P.L.N. Raju, Director, NESAC, Shri Vivek Singh, Asst. Scientific Secretary, Dept. of Space, Shri Shasikant Sharma, Group Director, Space Applications Centre (SAC), Ahmedabad, Mr. Sylvester Kurbah, Village Headman, Fr. Philip Barjo, Rector, Sacred Heart Theological College and Fr. Alister Marwein, Principal, Sacred Heart Boys Higher Secondary School.

Community Toilet Inauguration in Shillong as CSR Activity of Antrix Corporation

A community toilet was inaugurated near Additional Secretariat in Shillong on 15th

Chairman, ISRO Dr. K. Sivan inaugurating the Space Corner at DBCIC, Shillong

Inauguration of Community Toilet at Shillong by Ms. Iaswanda Laloo, D.C. of East Khasi Hills District, Meghalaya

January 2021 at 11 AM by Ms. Iaswanda Laloo, Deputy Commissioner of East Khasi Hills District, Meghalaya in the presence of Chief Executive Officer, Meghalaya State Government Officials as well as Officials from Sulabh International, who have constructed the toilet complex and Director and other Senior Officials of North Eastern Space Applications Centre.

Inauguration of new Staff Quarters at NESAC Residential Campus

The 2nd Phase NESAC Staff Quarters comprising of 02 E-type Quarters, 08 D-type Quarters and 04 C-type Quarters was inaugurated by Shri P.L.N. Raju, Director, NESAC on 1st January 2021 which was followed by an address to all NESAC employees by Director, NESAC at the NESAC Residential Complex Park.

New Staff quarters were inaugurated by Director, NESAC on 1st January 2021

72nd Republic Day Celebration at NESAC

72nd Republic Day of the nation was celebrated at NESAC on 26th January 2021 with a colourful program. Dr. K.K. Sarma, Sr. Scientist, NESAC hoisted the tricolour amidst singing of the national anthem by the staff of NESAC at 9 AM. The CISF unit of NESAC offered a guard of honour to Dr. K.K. Sarma and performed the Republic Day parade. Dr. Sarma addressed the staff of the Centre with an informative speech. This was followed by the distribution of sweets and snacks to the gathering by NESAC Canteen.

Flag hoisting at Republic Day celebration

NESAC signed MoU with Assam Survey and Settlement Training Centre (ASSTC)

NESAC signed an MoU with Assam Survey and Settlement Training Centre (ASSTC), Government of Assam on 1st February 2021 at ASSTC, Guwahati in the presence of Shri Jogen Mohan, Hon'ble Minister of State (Independent Charge), Revenue & Disaster Management Department for carrying out joint outreach and capacity building programmes.

Shri J. Mohan, Hon'ble Minister of Assam and NESAC team during signing of the MoU

Shri Manivannan, IAS, Commissioner & Secretary to the Govt. of Assam, Revenue & Disaster Management Department and Shri P.L.N. Raju, Director, NESAC have addressed the gathering as Guest Honors. The signatories of the MoU were Sri Pankaj Chakravarty, Principal, ASSTC and Shri P.L.N. Raju, Director, NESAC. Other dignitaries present at the occasion were Shri Nazrul Islam, Retired IAS officer and Mentor of ASSTC, Smt. Gitanjali Bhattacharyya, Additional Secretary, Revenue & Disaster Management Department, senior Scientists, and Engineers from NESAC.

NESAC conducted Fire Safety Mock Drill for its Staff

NESAC with CISF Unit, NESAC has organised an awareness class and rescue drill on fire accident on 22nd March 2021 at NESAC main campus as a part of the preparation for any emergency related to fire incident that may arise in the campus. Shri Merimee Rymbai, AFPO -1, F& ES, Shillong Headquarters has delivered a lecture on "Fire incident and preventive measures" at NESAC auditorium. The lecture was followed by a mock drill exercise on the use of fire extinguisher where NESAC staffs and CISG personnel were demonstrated and trained on the procedures to use different fire extinguishers in different categories of fire incidents. Shri. Ramadas M, Assistant Commandant, CISF NESAC Unit and Dr. Gopal Sharma, Alternate Safety officer NESAC have coordinated the programme. The mock drill exercises were followed by an exercise on rescue operations where CISF and home Guards were demonstrated on the procedure to carry out a rescue in the event of fire incidents. A large number of people has participated in the programme that include NESAC Scientists, staffs and researchers, CISF personnel's and their family members. Special attention was given to officers and staffs involved in safety management and work execution related to fire incidents such as CISF personnel's, safety officers, administrative staffs, electricians, etc. The programme ended with a humble thanks to the resource person Shri Merimee Rymbai by Shri. Ramadas M., CISF assistant commandant.

Hands on training on fire extinguishing given to staff of NESAC

Celebration of Anti-Terrorism Day

Every year the 21st May is observed as Anti-Terrorism Day. The objective behind the observance of this day is to wean away the youth from terrorism and cult of violence by highlighting the sufferings of common people and showing how it is prejudicial to the national interest. An important feature of the Observance of the 'Anti-Terrorism Day' is the "Pledge Taking Ceremony" in all Government Offices, Public Sector Undertakings and other public institutions. However, due to the spread of COVID-19 and as per the Government's guidelines to contain the spread of Corona Virus and also keeping in view the safety of participants and organizers and to avoid public gathering, all employees were requested to take the "Anti-Terrorism Pledge" solemnly in their rooms itself on 21st May 2020 at 11.00 AM.

Celebration of 6th International Yoga Day

Taking into account the prevailing restrictions due to the outbreak of the COVID-19 pandemic, NESAC celebrated the 6th International Yoga Day on 21st June 2020 with the theme "Yoga at Home and Yoga with Family". All Regular Staff/Research Scholars/ CISF Personnel/Outsourced Workers/ Trainees participated in the 6th International Yoga Day at home/hostels at 7 AM on 21st June 2020 (Sunday) by doing yoga as per the Common Yoga Protocol (CYP) using resources available online.

Celebration of Sadhbhavana Diwas 2020

Sadhbhavana Diwas 2020, to mark the birth anniversary of Prime Minister Late Rajiv Gandhi,

Sadbhavana Diwas Pledge taking ceremony

was observed in NESAC on 20th August 2020. Director, NESAC administered the Sadbhavana Diwas Pledge to all NESAC employees on this day.

NESAC celebrated Vigilance Awareness Week 2020

Vigilance Awareness Week 2020 with the theme 'Satark Bharat, Samriddh Bharat (Vigilant India, Prosperous India)' was observed at NESAC from 27th October to 2nd November 2020. The observance started with the Integrity Pledge taking ceremony which was administered by Shri P.L.N. Raju, Director, NESAC on 27th October 2020. Employees were also advised to take e-pledge. Banners, posters, handouts, etc. were displayed distributed. An essay writing competition on the theme 'Satark Bharat, Samriddh Bharat' was conducted for the NESAC employees.

Integrity Pledge taking ceremony

Celebration of Rashtriya Ekta Diwas

Rashtriya Ekta Diwas (National Unity Day) was observed in NESAC on 29th October 2020 (since 30th & 31st October 2020 being Saturday and Holiday). The Rashtriya Ekta Diwas pledge was administered by Shri P.L.N. Raju, Director, NESAC on 29th October 2020 at the NESAC Auditorium.

Celebration of Gandhi Jayanti

Pre-celebration of Gandhi Jayanti was organized in NESAC on 1st & 2nd October 2020. Dr Biswajit Mohapatra, Associate Professor, NEHU delivered a lecture through virtual mode to all NESAC employees on 1st October 2020 and a cleaning drive was conducted at NESAC on 2nd October 2020.

Observance of 70th year of adoption of the Indian Constitution

As part of the observance of the 70th year of the adoption of the Constitution – Awareness Campaign, Dr. Ishrat Hussain, Associate Professor of Law, National Law University and Judicial Academy (NLUJAA), Assam delivered a lecture through video conferencing mode to all NESAC employees on the topic "70 years of Indian Constitution" on 10th November 2020. A Signature Campaign on the Constitutional Wall (displayed at the Main Entrance) to show their commitments towards the Indian Constitution was open for signature of all NESAC employees from 9th–26th November 2020. Constitution Day was also celebrated on 26th November 2020 at NESAC. Reading of the Preamble of the Indian Constitution by all NESAC employees and a lecture delivered by Shri Himangshu Ranjan Nath, Assistant Professor of Law from National Law University and Judicial Academy (NLUJAA), Assam on the topic "Constitutional Values and Fundamental Principles of the Indian Constitution" were part of the programme of the day.

Observance of Communal Harmony Week

Communal Harmony Campaign Week was observed in NESAC from 19th to 25th November 2020 and Flag Day was observed on 25th November 2020. While Flag Day spreads the message of communal harmony and National Integration, it is also utilized for fundraising to enhance the resources of the Foundation to carry out activities on various schemes and projects. NESAC employees donated to the National Foundation for Communal Harmony (NFCH).

Observance of Swachhta Pakhwada 2021

Swachhta Pakhwada 2021 was observed in NESAC from 1st–15th February 2021. All NESAC Employees, Research Scholars and Outsourced Workers participated enthusiastically in the events to make our workplace and surroundings more clean and plastic-free.

Cleaning of NESAC Campus

VISIT OF DISTINGUISHED GUESTS

Brigadier T.S. Hothi from Umroi Army Cantonment visited NESAC on 11th February 2021

Brigadier TS Hothi from Umroi Army Cantonment visited NESAC on 11th February 2021. He interacted with the staff of NESAC and visited various facilities at the NESAC office campus. He also visited the 'Space on Wheels' Bus and a live demonstration

Brigadier TS Hothi along with staff of NESAC in front of 'Space on Wheels' Bus at NESAC

of UAV flight was given to him by the UAV team of NESAC. He congratulated NESAC on its wonderful array of activities and achievements.

Important Visitors

22.01.2021	Shri Inderjit Singh Secretary, Ministry of DONER
11.02.2021	Brig. Taj Hothi Umroi Military Station, Umroi

OFFICIAL LANGUAGE IMPLEMENTATION

Hindi Fortnight Celebration during 14th–28th September 2020

Following the Standard Operating Procedure (SOP) issued by the Central Government from time to time, NESAC Celebrated Hindi Fortnight during 14th–28th September 2020. The program was inaugurated by Shri P.L.N. Raju, Director, NESAC by the lighting of the lamp, which was followed by his opening remarks on the event. During the fortnight Celebration, Major Utterances were displayed in the Hindi Language in our Office and "Creative writing Competition" was organized. Along with this Online Hindi workshop was also conducted by Shri Avaneesh Shukla, Sr. Administrative Officer in which he gave a PPT presentation on the importance of Official Language Hindi as well as easy access to Official Language on the day of the closing ceremony i.e., 28.09.2020. During the fortnight, all employees were encouraged to sign in Hindi, to do their official work in Hindi, and to converse in Hindi. On 15th September 2020 Sr. Administrative Officer & In-charge, Hindi section read out the speech of Hon'ble Home Minister, Govt. of India on the occasion of Hindi day. On 28th September 2020, Winners were awarded by Prize Money and Certificates.

Celebration of World Hindi Day

NESAC celebrated World Hindi Day from 10th to 15th January 2021. The program was inaugurated by Shri P.L.N. Raju, Director, NESAC by the lighting of the lamp followed by the opening remarks of Shri Sk. J. Abdul Aziz, Head P&GA, NESAC, thereafter, a short brief description about the World Hindi Day celebration and details regarding the competitions of the World Hindi week celebration. Hindi workshop was organized on the topic "Samanya Hindi Gyan, Tippani Lekhan aur Prashashanik Shabdawali" at NESAC on 14.01.2021 for Sci./Eng. 'SC' and Administrative staffs. During the celebration, several activities like Hindi competitions, Painting Competition, Hindi Poem recitation competition, Quiz competition (Administrative terminology) etc. were organized in which officers/employees of NESAC participated with full zeal. The valedictory of the celebration was concluded on 15th January 2021 in which Director NESAC Inaugurated the

NESAC's first Hindi in-house Magazine "ISHAAN" and congratulated all staffs. It was followed by the distribution of certificates to the winners of the competition by Shri P.L.N Raju. To conclude the World Hindi Week celebration, a vote of thanks was given by Shri Avaneesh Shukla, Senior Administrative Officer, NESAC.

Welfare of SC & ST

i) The welfare of SC & ST is being taken care of in this Centre. This Centre has been observing the guidelines for recruitment, promotion and welfare of Scheduled Castes and Scheduled Tribes.

ii) A Liaison Officer for SCs, STs, OBCs and Minority of this Centre has been nominated in accordance with Chapter-9 of Brochure on Reservations to SCs, STs, OBCs and Minority in the PSUs/Autonomous Bodies Grant-in-aid organization.

iii) 43% (Approx.) of Group B employees are from the ST community.

iv) Some of the Research Scholars are from the SC/ST Community.

v) Many of the outsourced manpower such as Data Entry Operators, O&M, Gardening, Housekeeping and Canteen have been outsourced and a maximum of the workers deployed by the outsourcing firms belong to SC/ST.

vi) Two posts are reserved for PwD and at present, only one candidate had been appointed.

Right to Information:

NESAC is receiving RTI Applications through online and offline mode. The following table showing the number of RTI Applications received and disposed of.

Status of representations of employees belonging to Scheduled Castes and Scheduled Tribes

Sl No	Centre / Unit	Total strength of employees 2020-2021	Strength of SC employees 2020-2021	Strength of ST employees 2020-2021	Strength of PwD employees 2020-2021
01	NESAC	51	02	05	01

Year	Information		Replied		No. of application transferred to other Public Authority	No. of application rejected
	No. of application received	No. of appeal	No. of application disposed of	No. of appeal disposed of		
2020-2021	42	04	38	04	Nil	Nil

Details of RTI Officials:

Particulars	Name and designation
First Appellate Authority (FAA)	Dr. K.K. Sarma Sci/Engr 'SG', NESAC Email: kk.sarma@nesac.gov.in
Central Public Information Officer (CPIO)	Shri Avaneesh Shukla Sr. Administrative Officer, NESAC Email: admin@nesac.gov.in
Assistant Public Information Officer (APIO)	Smt. Emica Marbaniang Sr. Assistant 'A', NESAC Email: emica.marbaniang@nesac.gov.in

PUBLICATIONS

Journal Publications:

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AUDITOR'S REPORT AND STATEMENT OF ACCOUNTS FOR THE FINANCIAL YEAR 2020-2021

SSD & CO.
CHARTERED ACCOUNTANTS

Re-Do-Ria Cottage :: MG Road :: Shillong — 793001 :: Meghalaya :: Email — ssd.shillong@gmail.eom :: Phone - +91-9402131843//9863085878

INDEPENDENT AUDITORS' REPORT

To,

The Members of North Eastern Space Applications Centre
Shillong

Report on the Audit of the Standalone Financial Statements

Opinion

1. We have audited the standalone financial statements of **North Eastern Space Applications Centre** which comprise the Balance Sheet as at 31st March 2021, and the statement of Income and Expenditure then ended, and notes to the financial statements, including a summary of significant accounting policies and other explanatory information.

2. In our opinion and to the best of our information and according to the explanations given to us, the aforesaid standalone financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India, of the state of affairs of the organization as at March 31, 2021, and surplus/deficit, for the year ended on that date.

Basis for Opinion

3. We conducted our audit in accordance with the Standards on Auditing (SAs) issued by the Institute of Chartered Accountants of India (ICAI). Our responsibilities under those Standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Institution in accordance with the Code of Ethics issued by the Institute of Chartered Accountants of India (ICAI) together with the ethical requirements that are relevant to our audit of the financial statements and we have fulfilled and we have fulfilled our other ethical responsibilities in accordance with these requirements and the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Management's Responsibility for the Financial Statements

4. Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance of the organisation in accordance with the accounting principles generally accepted in India. This responsibility includes the design, implementation and maintenance of internal controls relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatements, whether due to fraud or error.

Auditor's Responsibilities for the Audit of the Financial Statements

5. Our objectives are to obtain reasonable assurance as to whether the financial statements as a whole are free from material misstatement, either due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

Opinion

6. In our opinion and to the best of our information and according to the explanations given to us, **subject to the Observations hereinafter attached**, the aforesaid financial statements give the information in the manner so required and give a **true and fair view** in conformity with the accounting principles generally accepted in India in case of :
   (a) The Balance Sheet, of the **state of affairs** of the organisation as at 31st March 2021; and
   (b) In the case of the Statement of Income and Expenditure, of the **Net Deficit** for the year ended on that date.

Emphasis of Matter:

7. Without qualifying our opinion as stated above, we report that the following matters require attention:

   (a) Attention may be drawn to Ponit No.-8 of Significant Accounting Policies forming part of Balance Sheet as at March 31, 2021 whereby the organisation is adding grants received for purchase of assets to their capital fund in the year of receipt.

   (b) Fixed Assets which have been found damaged and obsolete during physical verification as per report dated 15-06-2020 are yet to be written off from books of accounts.

   Examples of some fixed assets which became obsolete as per aforementioned report are Bolero Diesel Engine, Printers – HP (Laserjet , Deskjet, etc), Computers (IBM) – 4 Nos. , Computers (HP) – 4 Nos.

   (c) Third party confirmation with respect to project balance viz. National Remote Sensing Centre state that balance outstanding as on 31.03.2021 is Rs. 874146/- whereas the balance as appearing in the accounts stand at 2562102/-. The difference may be reconciled with immediate effect.

   (d) The accounting of accrued interest on MOD and tax deducted thereon requires improvement. There should be three way reconciliation between Interest Certificate issued by the Bank, Form 26AS and actual bank receipt entries.

   (e) The payment for Advertisement and Publicity amounting to Rs. 738598/-, dated 14.05.2020, bill no. – NESAC/ADMN/PRO/NA/I/1/2020 as informed to us was made at approved DAVP rates. Although, we have been informed that tendering processes have been put in place for the ongoing financial year, yet, we are of the opinion that such supply orders pertaining to FY 2020-21 should have been made after issuing requisite tenders/quotation.

(f) Separate bank accounts are operational only for DST Splice Project and NESAC- UAV-IIDS. The following are the balances :

Project Name	Project Balance	Bank Balance	Difference
UAV- IIDs	4483777.30	5236891.30	753114.00
DST Splice	464907.00	490367.00	25460.00

Difference is on account of expenditures made out of general bank account.

The remaining projects are not represented by separate bank accounts. Their expenses are also made from the organsation's general bank account (E.g., Rs. 618589/- paid on 30.03.2021 under UAV- IIDS-118). Thus, matching of project balances vide equivalent bank and cash balances could not be arrived at by the organisation. We recommend that fund transfer entries for such amounts be made.

For M/s SSD & CO.
Chartered Accountants
FRN: 0326761E

(Diksha Purkayastha)
FCA, DISA (ICAI)
Partner
ICAI Mem. No. 307881
UDIN: 21307881AAAAGZ5135

Place: Shillong
Date: 29.09.2021

भारत सरकार / GOVERNMENT OF INDIA
अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

BALANCE SHEET AS AT 31-MARCH-2021

(Amount - ₹)

CAPITAL FUND AND LIABILITIES	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Capital Fund	1	78,95,53,234.12	79,07,81,827.32
Current Liabilities & Provisions	2	32,52,58,712.30	31,63,44,600.00
Pension Fund as per contra*		1,31,38,537.00	1,08,73,182.00
TOTAL		**1,12,79,50,483.42**	**1,11,79,99,609.32**
ASSETS			
Fixed Assets	3	67,99,86,401.96	69,34,46,876.96
Current Assets, Loans & Advances etc.	4	43,48,25,544.46	41,36,79,550.36
Pension Fund as per contra*		1,31,38,537.00	1,08,73,182.00
TOTAL		**1,12,79,50,483.42**	**1,11,79,99,609.32**
Significant Accounting Policies	10		
Contingent Liabilities & Notes on Accounts	11		

This is the Balance Sheet to in our report of even date

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

Date: 29.09.2021

भारत सरकार / GOVERNMENT OF INDIA
अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2021

(Amount - ₹)

INCOME	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Grants	5	20,69,00,000.00	23,78,00,000.00
Other Incomes	6	1,62,09,035.75	1,61,14,949.01
Incomes from Services	7	62,64,091.00	1,99,84,532.00
TOTAL		**22,93,73,126.75**	**27,38,99,481.01**
EXPENDITURE	**SCHEDULE**	**CURRENT YEAR**	**PREVIOUS YEAR**
Establishment Expenses	8	15,73,38,776.36	15,57,67,936.00
Other Administrative Expenses & etc.	9	4,06,92,140.59	4,68,17,516.15
"Depreciation *(Net total at the year-end – corresponding to schedule 3) (Column 7)"		7,62,95,907.00	7,70,73,945.00
TOTAL		**27,43,26,823.95**	**27,96,59,397.15**
BALANCE BEING SURPLUS (+)/ DEFICIT (-)		**(4,49,53,697.20)**	**(57,59,916.14)**
Less: Prior period expenses - Establishment Expenses		-	-
Less: Prior period expenses - Other Administrative Expenses		30,01,526.00	17,48,968.00
Less: Provision for Pension, Gratuity & Leave Encashment		1,13,73,370.00	3,90,43,520.00
NET SURPLUS (+)/ DEFICIT (-) CARRIED TO CAPITAL FUND		**(5,93,28,593.20)**	**(4,65,52,404.14)**

This is the Income & Expenditure Account to in our report of even date

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

Date: 29.09.2021

भारत सरकार / GOVERNMENT OF INDIA अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31-MARCH-2021

(Amount - ₹)

	RECEIPTS	CURRENT YEAR	PREVIOUS YEAR		PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I.	**Opening Balances**			**I.**	**Expenses**		
	a) Cash in Hand	-	-		a) Establishment Expenses	13,09,55,754.36	13,45,58,579.00
	b) Bank Balances:				b) Other Administrative Expenses	3,62,27,616.95	4,63,74,637.15
	i) In Current Accounts, SBI Shillong	12,48,07,803.45	10,44,52,852.41	**II**	**Investments and Deposits**		
	ii) In Current Accounts, SBI Umiam	-1,14,15,280.60	12,87,37,589.05		a) Deposit with MeSEB/ NRSC/ BSNL	-	-
	iii) In Current Accounts, Canara Bank	99,48,912.00	50,83,093.00				
	iv) MOD With Canara Bank	10,99,64,630.00	12,98,46,190.00	**III**	**Fixed Assets & Capital Work-In-Progress**		
	v) MOD with SBI Umiam	15,99,16,593.51			a) Purchase of Fixed Assets	5,66,77,405.00	14,42,88,180.96
II	**Grants Received**						
	From Government of India:			**IV**	**Other Payments**		
	a) Department of Space, Bangalore				a) ISRO Projects	1,69,35,660.00	6,31,28,845.00
	i) For Salaries	9,69,00,000.00	9,00,00,000.00		b) USER Projects	6,31,84,611.00	4,50,76,791.00
	ii) For General	11,00,00,000.00	14,78,00,000.00		c) "UAV" IIDS Projects	6,35,017.70	-
	iii) For Creation of Capital Assets	5,81,00,000.00	14,00,00,000.00		d) "DST Splice" Projects	7,54,216.00	-
	b) Ministry of DONER, NEC Shillong	-	-		e) In-House Projects	21,26,749.00	24,23,009.00
					f) Advances to Staffs	15,57,656.00	44,73,190.00
III	**Interest Received**				g) Advances to Projects	6,29,493.00	22,60,526.00
	a) On Fixed Deposits & Other Interests	95,69,111.00	91,32,918.00		h) Training	53,19,766.00	73,48,381.00
					i) Payment of Recoveries	2,39,21,821.00	1,98,34,570.00
IV	**Other Incomes**				j) Prior Period Expenses	28,26,090.00	17,11,376.00
	a) Others Income	78,36,851.30	20,81,219.01		k) Security Deposits	23,60,388.00	39,84,692.00
					l) ISTRAC Expenses	17,57,611.00	24,17,501.00
					m) DWR Cheerapunji	26,02,829.00	-
					n) Assam ISRO Centre	-	4,20,603.00
V	**Other Receipts**			**V**	**Closing Balances**		
	a) Miscelleneous Recoveries	11,70,673.36	12,72,351.00		a) Cash in Hand	-	-
	b) Recovery of Advances and Deposits from:				b) Bank Balances:		
	i) Staffs (Cont., Imprest, TA/ DA & LTC Advance)	1,65,908.11	15,52,870.00		i) In Current Accounts, SBI Shillong	74,56,580.45	12,48,07,803.45

	ii) Others Receipts from ISTRAC/ NRSC/ DWR	1,20,18,582.00	1,83,19,733.00		ii) In Current Accounts, SBI Umiam	3,69,54,316.02	-1,14,15,280.60
	c) Receipts on ISRO Projects	2,69,51,788.00	2,97,85,000.00		iii) In Current Accounts, Canara Bank	3,37,27,507.00	99,48,912.00
	d) Receipts on USER Projects	4,30,11,729.00	5,91,03,272.00		iv) MOD with Canara Bank	10,99,70,901.00	10,99,64,630.00
	e) Receipts on "DST Splice " Projects	12,77,708.00	-		v) MOD with SBI Umiam	9,65,02,505.35	15,99,16,593.51
	f) Receipts on "UAV" IIDS Projects	52,36,909.00	-		vi) MOD with SBI Shillong	12,91,66,000.00	-
	g) Security Deposits	25,15,834.00	43,56,452.00		vii) Punjab National Bank "UAV-IIDS"	52,36,891.30	-
					viii) State Bank of India "DST-Splice Projects"	4,90,367.00	-
	TOTAL	**76,79,77,752.13**	**87,15,23,539.47**		**TOTAL**	**76,79,77,752.13**	**87,15,23,539.47**

This is the Receipts & Payments Account referred to in our report of even date

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

Date: 29.09.2021

भारत सरकार / GOVERNMENT OF INDIA
अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2021

(Amount - ₹)

SCHEDULE 1 - CAPITAL FUND	CURRENT YEAR		PREVIOUS YEAR	
Balance as at the beginning of the year	79,07,81,827.32		69,73,34,231.46	
Add: Balance of Surplus (+)/ Deficit (-) transferred from the "Income & Expenditure Account"	(5,93,28,593.20)		(4,65,52,404.14)	
Add: Grant-In-Aid for Creation for Capital Assets	5,81,00,000.00	78,95,53,234.12	14,00,00,000.00	79,07,81,827.32
BALANCE AS AT THE YEAR END		**78,95,53,234.12**		**79,07,81,827.32**
SCHEDULE 2 – CURRENT LIABILITIES AND PROVISIONS	**CURRENT YEAR**		**PREVIOUS YEAR**	
CURRENT LIABILITIES:				
1 Other Current Liabilities				
a) Establishment Expenses	1,71,27,811.00		1,03,09,794.00	
b) Other Administrative Expenses	59,62,406.00		22,38,167.00	
c) Others	1,81,38,811.00		1,64,02,894.00	
d) Audit Fee	87,900.00	4,13,16,928.00	70,200.00	2,90,21,055.00
2 Deposit from Contractors	62,16,376.00	62,16,376.00	59,02,828.00	59,02,828.00
3 Project Accounts: USER Project				
Balance as at the begining of the year	7,18,14,086.00		7,89,62,938.00	
Add: Received during the year	4,98,56,875.00		6,25,12,376.00	
Less: Utilised during the year	7,35,71,026.70	4,80,99,934.30	6,96,61,228.00	7,18,14,086.00
4 Project Accounts: ISRO Project				
Balance as at the begining of the year	1,99,91,953.00		5,44,34,614.00	
Add: Received during the year	2,75,81,023.00		3,17,21,381.00	
Less: Utilised during the year	1,89,35,550.00	2,86,37,426.00	6,61,64,042.00	1,99,91,953.00
5 PROVISIONS:				
Pension, Gratuity & Leave Encashment	20,09,88,048.00	20,09,88,048.00	18,96,14,678.00	18,96,14,678.00
TOTAL		**32,52,58,712.30**		**31,63,44,600.00**

for **S S D & Co**
Chartered Accountants

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

Date: 29.09.2021

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

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उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2021

SCHEDULE 3 – FIXED ASSETS

(Amount- ₹)

	DESCRIPTION	GROSS BLOCK					DEPRECIATION				NET BLOCK	
Sl. No	Particular	Cost/ Valuation as at the beginning of the year	Additions during the year	Sale/ Disposal	Cost/ Valuation as at the end of the year	Rate (%)	As at the beginning of the year	During the year	On deduction during the year	Total up to the year-end	As at the Current year-end	As at the previous year-end
		1	2	3	4=(1+2-3)	5	6	7	8	9=(6 +7- 8)	10=(4-9)	11
1	Land & Land Devolopment	5,02,62,139.00	-	-	5,02,62,139.00	0%	-	-	-	-	5,02,62,139.00	5,02,62,139.00
2	Boundry of New Land	36,43,529.00	14,79,975.00	-	51,23,504.00	10%	11,11,096.00	3,27,242.00	-	14,38,338.00	36,85,166.00	25,32,433.00
3	Renovation of lease Buildings	52,40,087.00	-	-	52,40,087.00	10%	42,99,002.00	94,109.00	-	43,93,111.00	8,46,976.00	9,41,085.00
4	Machinery & Equipment	95,40,622.00	-	-	95,40,622.00	15%	83,79,824.00	1,74,120.00	-	85,53,944.00	9,86,678.00	11,60,798.00
5	Furniture & Fixtures	3,01,45,976.76	3,19,653.00	-	3,04,65,629.76	10%	1,18,35,301.76	18,63,033.00	-	1,36,98,334.76	1,67,67,295.00	1,83,10,675.00
6	Office Equipments	87,29,683.00	10,99,574.00	-	98,29,257.00	15%	48,49,529.00	7,48,405.00	-	55,97,934.00	42,31,323.00	38,80,154.00
7	Computer & Pheripherals	7,03,79,784.60	1,11,842.00	-	7,04,91,626.60	40%	6,45,79,193.60	23,46,381.00	-	6,69,25,574.60	35,66,052.00	58,00,591.00
8	Library Books	6,06,33,280.93	7,94,534.00	-	6,14,27,814.93	40%	5,16,18,909.93	37,66,379.00	-	5,53,85,288.93	60,42,526.00	90,14,371.00
9	Telephones Installation	19,02,230.00	-	-	19,02,230.00	15%	10,93,910.00	1,21,248.00	-	12,15,158.00	6,87,072.00	8,08,320.00
10	Other Equipments	10,17,84,287.96	1,06,22,923.00	-	11,24,07,210.96	15%	4,22,90,537.00	1,02,53,816.00	-	5,25,44,353.00	5,98,62,857.96	5,94,93,750.96
11	NE-SAC Complex	17,84,80,687.00	35,73,416.00	-	18,20,54,103.00	10%	9,48,84,763.00	86,31,064.00	-	10,35,15,827.00	7,85,38,276.00	8,35,95,924.00
12	Vehicles	45,38,332.00	16,200.00	-	45,54,532.00	15%	20,32,763.00	3,77,800.00	-	24,10,563.00	21,43,969.00	25,05,569.00
13	Air Conditioner (Heating & Cooling)	27,28,835.00	7,75,977.00	-	35,04,812.00	15%	11,05,463.00	3,59,903.00	-	14,65,366.00	20,39,446.00	16,23,372.00
14	Apple I-Pad	71,250.00	-	-	71,250.00	15%	50,122.00	3,169.00	-	53,291.00	17,959.00	21,128.00
15	Aquarium	35,630.00	-	-	35,630.00	15%	25,065.00	1,585.00	-	26,650.00	8,980.00	10,565.00
16	CISF Barrack	27,08,604.00	-	-	27,08,604.00	10%	9,27,547.00	1,78,106.00	-	11,05,653.00	16,02,951.00	17,81,057.00
17	Mobile Set	48,100.00	-	-	48,100.00	15%	28,562.00	2,309.00	-	30,871.00	17,229.00	19,538.00
18	Motorised Treadmill	1,26,000.00	-	-	1,26,000.00	15%	88,637.00	5,604.00	-	94,241.00	31,759.00	37,363.00
19	SMF Batteries	15,12,600.00	-	-	15,12,600.00	15%	5,91,936.00	1,38,100.00	-	7,30,036.00	7,82,564.00	9,20,664.00

20	Vending Machine	20,500.00	-	-	20,500.00	15%	14,914.00	838.00	-	15,752.00	4,748.00	5,586.00
21	Water Dispenser	1,02,200.00	-	-	1,02,200.00	15%	27,573.00	11,194.00	-	38,767.00	63,433.00	74,627.00
22	Wifi Connectivity	14,45,666.00	-	-	14,45,666.00	15%	4,01,081.00	1,56,688.00	-	5,57,769.00	8,87,897.00	10,44,585.00
23	Residential complex	15,97,49,009.00	-	-	15,97,49,009.00	10%	3,66,94,150.00	1,23,05,486.00	-	4,89,99,636.00	11,07,49,373.00	12,30,54,859.00
24	Outreach Facilities	23,02,62,540.00	-	-	23,02,62,540.00	10%	4,00,54,744.00	1,90,20,780.00	-	5,90,75,524.00	17,11,87,016.00	19,02,07,796.00
25	CISF Quarter/ Barrack	9,69,79,654.00	-	-	9,69,79,654.00	0%	94,16,195.00	87,56,346.00	-	1,81,72,541.00	7,88,07,113.00	8,75,63,459.00
26	Residential Complex Phase II	3,78,02,829.00	2,95,73,303.00	-	6,73,76,132.00	0%	-	60,32,625.00	-	60,32,625.00	6,13,43,507.00	3,78,02,829.00
27	Creche Buidling	6,67,629.00	-	-	6,67,629.00	0%	-	66,763.00	-	66,763.00	6,00,866.00	6,67,629.00
	Capital Work In Progress:											
28	Annex Building OffIce	81,41,754.00	1,43,74,035.00		2,25,15,789.00	0%	-	-		-	2,25,15,789.00	81,41,754.00
	Intangible Assets:											
29	Software	60,44,691.00	94,000.00	-	61,38,691.00	25%	38,80,435.00	5,52,814.00	-	44,33,249.00	17,05,442.00	21,64,256.00
	TOTAL FOR CURRENT YEAR	**1,07,37,28,130.25**	**6,28,35,432.00**	**-**	**1,13,65,63,562.25**		**38,02,81,253.29**	**7,62,95,907.00**	**-**	**45,65,77,160.29**	**67,99,86,401.96**	**69,34,46,876.96**
	TOTAL FOR PREVIOUS YEAR	**92,46,32,948.29**	**14,90,95,181.96**	**-**	**1,07,37,28,130.25**	**-**	**30,32,07,308.29**	**7,70,73,945.00**	**-**	**38,02,81,253.29**	**69,34,46,876.96**	**62,14,25,640.00**

for **S S D & Co**
Chartered Accountants

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

Date: 29.09.2021

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

भारत सरकार / GOVERNMENT OF INDIA
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उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2021

(Amount- ₹)

SCHEDULE 4 – CURRENT ASSETS, LOANS & ADVANCES etc.	CURRENT YEAR		PREVIOUS YEAR	
A. CURRENT ASSETS:				
1) Cash balances in hand		-		-
2) Bank balances with scheduled banks				
a) On Current Accounts	7,81,38,403.47		12,33,41,434.85	
b) MOD with Canara Bank	10,99,70,901.00		10,99,64,630.00	
c) MOD with SBI Umiam Bank	9,65,02,505.35		15,99,16,593.51	
d) MOD With SBI Shillong	12,91,66,000.00			
e) On Project Accounts	57,27,258.30	41,95,05,068.12		39,32,22,658.36
B. LOANS, ADVANCES AND OTHER ASSETS:				
1) Advances to:				
a) Staffs:				
TA/ DA	2,08,510.00		3,12,500.00	
Contingencies	65,100.00		71,500.00	
Others	2,31,738.00	5,05,348.00	3,52,205.00	7,36,205.00
b) Projects: (User & ISRO)	-	4,99,115.89	-	6,57,949.00
c) Others	-	47,70,329.00	-	35,48,967.00
d) Imprest amount to staff		15,000.00		15,000.00
2) Claims Receivable/ Recoverable	1,22,800.00	1,22,800.00	21,13,152.00	21,13,152.00
3) TDS receivable	12,32,060.00	12,32,060.00	5,25,163.00	5,25,163.00
4) Interest receivable	55,47,563.45	55,47,563.45	95,69,111.00	95,69,111.00
5) Deposits for:				
a) Telephone with BSNL	1,15,658.00		1,15,658.00	-
b) Deposit with MeECL	-		-	-
c) Satellite Data's with NRSC	25,12,602.00	26,28,260.00	31,75,687.00	32,91,345.00
6) Closing Stock of Cartridges	-	-	-	-
TOTAL		**43,48,25,544.46**		**41,36,79,550.36**

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
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DIRECTOR

Date: 29.09.2021

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उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2021

(Amount - ₹)

SCHEDULE 5 - GRANTS	CURRENT YEAR	PREVIOUS YEAR
Central Government:		
a) Department of Space, Bangalore	20,69,00,000.00	23,78,00,000.00
b) North Eastern Council, Shillong	-	-
TOTAL	**20,69,00,000.00**	**23,78,00,000.00**
SCHEDULE 6 - OTHER INCOMES	**CURRENT YEAR**	**PREVIOUS YEAR**
Miscellaneous	43,25,867.20	27,52,861.84
Maintenance Charges	4,45,784.73	5,58,020.17
Guest House Rent	83,214.08	6,06,554.00
Interest from Bank	1,13,54,169.74	1,21,97,513.00
TOTAL	**1,62,09,035.75**	**1,61,14,949.01**
SCHEDULE 7 - INCOME FROM SERVICES	**CURRENT YEAR**	**PREVIOUS YEAR**
Service of Scientists	23,29,107.00	59,95,974.00
Infrastructure Usage	6,79,070.00	4,20,200.00
Institutional Overhead	32,55,914.00	1,35,68,358.00
TOTAL	**62,64,091.00**	**1,99,84,532.00**

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2021

(Amount - ₹)

SCHEDULE 8 - ESTABLISHMENT EXPENSES		CURRENT YEAR		PREVIOUS YEAR	
a)	Salary & Allowances	7,82,38,571.36		7,69,99,426.00	
b)	Honorarium	1,58,800.00		5,71,620.00	
c)	Employer Contributions towards NPS	46,65,018.00		45,11,766.00	
d)	Wages	40,08,051.00		43,58,128.00	
e)	LTC	12,14,583.00		9,52,499.00	
f)	Leave Encashment Expenses	1,69,326.00		2,41,812.00	
g)	Children Education Allowance	3,78,000.00		27,000.00	
h)	Outsourced DEO	34,91,402.00		40,04,339.00	
i)	Outsourced Electrician	18,68,196.00		18,85,920.00	
j)	Outsourced Worker for Various Services	1,48,01,038.00		1,36,10,362.00	
k)	NER-DRR (Salary)	24,22,529.00		60,26,645.00	
l)	CISF Salary	4,15,71,595.00		3,79,88,501.00	
m)	Retirement Pension	11,93,916.00		12,01,261.00	
n)	DWR-Outsourced worker	16,29,836.00		22,29,601.00	
o)	DWR-(Salary)	15,27,915.00	15,73,38,776.36	11,59,056.00	15,57,67,936.00
	TOTAL		**15,73,38,776.36**		**15,57,67,936.00**

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2021

(Amount - ₹)

SCHEDULE 9 - OTHER ADMINISTRATIVE EXPENSES & etc.		CURRENT YEAR		PREVIOUS YEAR	
1	Postage, Courier & Telephone Charges	11,54,135.00		7,43,676.00	
2	Bank Charges	15,393.59		30,974.15	
3	Electricity & Power Charges	79,31,360.00		74,84,757.00	
4	Maintenance of Garden	61,074.00		1,74,449.00	
5	Printing & Stationery	18,73,954.00		28,26,173.00	
6	Advertisement & Publicity	19,20,425.00		17,75,692.00	
7	Hiring of Vehicles	25,71,289.00		26,85,853.00	
8	Travelling & Conveyance	11,11,630.00		27,85,456.00	
9	Professional Charges	21,77,698.00		11,49,166.00	
10	Project Expenses [In-house]	23,08,078.00		24,93,888.00	
11	Repair & Maintenance	46,93,761.00		1,16,34,878.00	
12	Books & Periodicals	49,075.00		68,329.00	
13	Trainings/ Seminars & Workshops	2,70,545.00		1,57,603.00	
14	Medical Expenses	17,57,911.00		14,36,809.00	
15	DWR Cherrapunji Expenses	33,94,354.00		26,89,120.00	
16	Other Charges	2,97,004.00		11,44,560.00	
17	POL	16,25,043.00		13,95,592.00	
18	Sanitary Items	4,96,289.00		6,54,057.00	
19	Hindi Week Celebrations/ Hindi Technical Seminar	23,750.00		4,21,972.00	
20	Annual Maintenance Contracts	28,72,284.00		16,00,965.00	
21	Miscellaneous Expenses	16,19,569.00		13,96,302.00	
22	Repair & Maintenance of Vehicles	1,41,473.00		1,03,723.00	
23	Operational Charges & Maintenance of Canteen	4,77,877.00		3,79,866.00	
24	Rent Rate & Taxes & ICRB Examination	3,87,000.00		2,50,330.00	
25	NER-DRR Expenses	3,94,736.00		2,54,674.00	
26	CISF Expenses	10,46,483.00		10,57,652.00	
27	Supply of Water for Hostels	19,950.00	4,06,92,140.59	21,000.00	4,68,17,516.15
	TOTAL		**4,06,92,140.59**		**4,68,17,516.15**

for **S S D & Co**
Chartered Accountants

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

Date: 29.09.2021

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

भारत सरकार / GOVERNMENT OF INDIA
अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH-2021

SCHEDULE 10 – SIGNIFICANT ACCOUNTING POLICIES

1. **Accounting Convention:** The Financial statements have been prepared on the basis of historical cost convention and on accrual basis.

2. **Revenue Recognition:** - Income from Consultancy Projects is accounted on cash basis.

3. **Fixed Assets And Depreciation**

   3.1 Fixed Assets has been stated at cost and accounted for at historical cost.

   3.2 Depreciation on assets acquired during the year is provided for as under:
   - Assets acquired up to 30.09.21 – 100% as per the applicable rate.
   - Assets acquired after 30.09.21 – 50% as per the applicable rate.

   3.3 Depreciation has been provided on written down value method as per the rates prescribed in the Income Tax Act 1961.

4. **Retirement Benefits:** Pension, Gratuity and Leave Encashment liability is provided on the basis of Actuarial Valuation as at the end of each financial year the retirement benefits in respect of deputationists are accounted for on Cash basis.

5 **Foreign Currency Transaction:** Foreign exchange transaction arising during the year is recorded at the exchange rates prevailing at the transaction date.

6 **Research & Development:** Revenue and Capital Expenditure which is of revenue nature is charged to the Income & Expenditure Account while the capital expenditure added to fixed in the year in which these are incurred. For USER and ISRO Funded Projects, fund received and utilized during the year are accounted in the Project Account and the unutilized balances is reflected as under Current Liabilities.

7 **Inventories:** Store and spares are valued at cost.

8 **Grant-In-Aid:** Grant-In-Aid are accounted on realization basis and Grant-In-Aid in nature of contribution towards capital cost are added to Capital Fund.

for **S S D & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

SD/-
(DIKSHA PURKAYASTHA)
PARTNER
Membership No-307881
UDIN:21307881AAAAGZ5135

SD/-
(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

Date: 29.09.2021

भारत सरकार / GOVERNMENT OF INDIA
अंतरिक्ष विभाग / DEPARTMENT OF SPACE

उत्तर-पूर्वी अंतरिक्ष उपयोग केंद्र / NORTH EASTERN SPACE APPLICATIONS CENTRE

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SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH-2021

SCHEDULE 11 – NOTES ON THE ACCOUNTS & CONTINGENT LIABILITIES

NOTES ON THE ACCOUNTS

a) The previous year's figure was re-arranged/ regrouped where ever necessary to make them comparable.

b) Pension, gratuity and leave encashment liability has been provided till 31.03.2021.

c) Prior period items have been disclosed separately so that the effect thereof on the net expenditure during the year is known.

d) The Centre has received an Exhibition Bus in kind from Department of Space Govt of India and the same has not been accounted at nominal value during the year as the vehicle has not yet been registered in the name of the Centre.

e) Schedules 1 to 11 are annexed to and form an integral part of the Balance Sheet as at 31-March-2021 and Income & Expenditure Account for the year ended as on that date.

These are the notes to Accounts referred to in our report of even date.

As per our report of even date.

for **S S D & Co**
Chartered Accountants

for and on behalf of
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SD/-
(DIKSHA PURKAYASTHA)
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(AVANEESH SHUKLA)
ACCOUNTS OFFICER

SD/-
(DR SHIV PRASAD AGGARWAL)
DIRECTOR

Date: 29.09.2021

ACRONYMS

3DVAR	:	Three-Dimensional Variational
AAE	:	Absorption Ångström Exponent
AAS	:	Agromet Advisory Services
ABL	:	Atmospheric Boundary Layer
AI	:	Artificial Intelligence
AI	:	Amenities Index
ALOS	:	Advanced Land Observation Satellite
AMRUT	:	Atal Mission for Rejuvenation and Urban Transformation
AMV	:	Atmospheric Motion Vectors
AOD	:	Aerosol Optical Depth
API	:	Application Programming Interface
ASC	:	Administrative Staff College of India
ASDMA	:	Assam State Disaster Management Authority
ASLV	:	Augmented Satellite Launch Vehicle
ASP	:	Atmospheric Science Program
ATMA	:	Agricultural Technology Management Agency
AWS	:	Automatic Weather Stations
BC	:	Black Carbon
BEC	:	Background Error Covariance
BIMSTEC	:	Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation
BRIDGE	:	Building River Dialogue and Governance
BRO	:	Border Roads Organization
BTC	:	Bodoland Territorial Council
CAI	:	Cumulative Amenities Index
CALIOP	:	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	:	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CAPE	:	Convective Available Potential Energy
CARTOSAT	:	Cartographic Satellite
CAU	:	Central Agricultural University
CBH	:	Cloud Base Height
CCE	:	Crop Cutting Experiment
CCN	:	Cloud Condensation Nuclei
CEGIS	:	Centre for Environmental and Geographic Information Services
CEPO	:	Civil Engineering Programme Office
CHAMAN	:	Coordinated Horticulture Assessment and Management using geoiNformatics
CISF	:	Central Industrial Security Force
CMD	:	Construction and Maintenance Division
CMER&TI	:	Central Muga Eri Research and Training Institute
CMOS	:	Complementary Metal Oxide Semiconductor
CNES	:	National Centre for Space Studies
CORS	:	Continuous Operating Reference Stations
COTS	:	Commercial Off-The-Shelf
CROPC	:	Climate Resilient Observing Systems Promotion Council
CropDAMS	:	Crop Damage Assessment and Monitoring Service
CRU-NCEP	:	Climatic Research Unit - National Centers for Environmental Prediction
CSB	:	Central Silk Board
CSIR	:	Council of Scientific and Industrial Research
NEIST	:	North East Institute of Science & Technology
CSR	:	Corporate Social Responsibility
DDMA	:	District Disaster Management Authority
DEM	:	Digital Elevation Model
DES	:	Directorate of Economics & Statistics, Govt. of Meghalaya
DGPS	:	Differential Global Positioning System
DInSAR	:	Differential InSAR
DL	:	Deep Learning
DMS	:	Disaster Management Support
DoNER	:	Development of North Eastern Region
DOS	:	Department of Space
DoS	:	Department of Sericulture
DSM	:	Digital Surface Model
DTM	:	Digital Terrain Model
DVI	:	Desertification Vulnerability Index
DWR	:	Doppler Weather Radar

EDI	:	Economic Development Index
ELPI	:	Electric Low Pressure Impactor
ENVI	:	Environment for Visualizing Images
EO-A	:	Earth Observation Applications
EOS	:	Earth Observatory of Singapore
EOS	:	End of Season
ESA	:	European Space Agency
FAO	:	Food and Agriculture Organization
FLEWS	:	Flood Early Warning Systems
FOD	:	Flash Origin Density
FORTRAN	:	Formula Translator
FOV	:	Field of View
FSI	:	Forest Survey of India
FTP	:	File Transfer Protocol
GAGAN	:	GPS Aided Geo Augmented Navigation
GBM	:	Ganga-Brahmaputra-Meghna
Gbps	:	Gigabits per second
GC	:	Governing Council
GCP	:	Ground Control Point
GEE	:	Google Earth Engine
GIS	:	Geographical Information System
GIT&DL	:	Geoweb Services, IT and Distance Learning
GNSS	:	Global Navigation Satellite System
GPM	:	Global Precipitation Measurement
GPM-MS	:	GPM-multi satellite
GPS	:	Global Positioning System
GPU	:	Graphics Processing Unit
GSAT	:	Geostationary Satellite
GSD	:	Ground Sampling Distance
GSI	:	Geological Survey of India
GSLV	:	Geosynchronous Satellite Launch Vehicle
GTOPG	:	Geospatial Technology and Outreach Programme Group
GUI	:	Graphical User Interface
HCA	:	Hydrometric Classification
HCM	:	Highway Capacity Manual
HFOV	:	Horizontal Field of View
HPC	:	High Performance Computing
HTS	:	High Throughput Satellites
HVS	:	High Volume Sampler
ICAR	:	Indian Council of Agricultural Research
ICAR RC NEH	:	ICAR Research Complex for North Eastern Hill Region
ICAR-ATARI	:	ICAR-Agricultural Technology Application Research Institute
ICFAI	:	Institute of Chartered Financial Analysts of India
ICMR	:	Indian Council of Medical Research
ICMR-RMRC	:	ICMR-Regional Medical Research Centre
IDY	:	International Day of Yoga
IEEE	:	Institute of Electrical and Electronics Engineers
IEG	:	Institute of Economic Growth
IET	:	Institution of Engineering and Technology
IGS	:	International GNSS Service
IIRS	:	Indian Institute of Remote Sensing
IISc	:	Indian Institute of Science
IIST	:	Indian Institute of Space Science and Technology
IMD	:	India Meteorological Department
IMS	:	Indian Meteorological Society
InSAR	:	Interferometric Synthetic Aperture Radar
INSAT	:	Indian National Satellite
IoT	:	Internet of Things
IRS	:	Indian Remote Sensing (Satellite)
ISBT	:	Inter-State Bus Terminal
ISG-SC	:	Indian Society of Geomatics-Shillong Chapter
ISRO	:	Indian Space Research Organisation
ISRS-SC	:	Indian Society of Remote Sensing-Shillong Chapter
IST	:	India Standard Time
ISTRAC	:	ISRO Telemetry, Tracking and Command Network
IT	:	Information Technology
ITI	:	Industrial Training Institute
IWMP	:	Integrated Watershed Monitoring Programme
JSA	:	Jal Shakti Abhiyan
KUFOS	:	Kerala University of Fisheries and Ocean Studies
LAN	:	Local Area Network
LCL	:	Lifting Condensation Level
LISS	:	Linear Imaging Self-Scanning System
LLJ	:	Lower Level Jet
LPI	:	Lightning Potential Index
LPM	:	Laser Precipitation Monitor
LSM	:	Land Surface Model

LUI	:	Land Utilization Index
LULC	:	Land Use and Land Cover
MAMETI	:	Meghalaya Agricultural Management & Extension Training Institute
MBDA	:	Meghalaya Basin Development Authority
MeECL	:	Meghalaya Energy Corporation Limited
ML	:	Machine Learning
MNCFC	:	Mahalanobis National Crop Forecast Centre
MODIS	:	Moderate Resolution Imaging Spectroradiometer
MoEF&CC	:	Ministry of Environment, Forests and Climate Change
MOS	:	Middle of Season
MOSDAC	:	Meteorology and Oceanographic Scientific Data Archival System
MOSPI	:	Ministry of Statistics and Programme Implementation
MoU	:	Memorandum of Understanding
MSPCB	:	Meghalaya State Pollution Control Board
MSSO	:	Maintenance and Support Services Organization
MSWS	:	Mean Sustained Wind Speed
MWR	:	Multi Wavelength Radiometer
NAVIC	:	NAVigation with Indian Constellation
NCSC	:	National Children's Science Congress
NDEM	:	National Database for Emergency Management
NDMA	:	National Disaster Management Authority
NDRF	:	National Disaster Response Force
NDSI	:	Normalized Difference Snow Index
NDVI	:	Normalized Difference Vegetation Index
NE	:	North Eastern
NEC	:	North-Eastern Council
NEEPCO	:	North Eastern Electric Power Corporation Limited
NEHU	:	North Eastern Hill University
NEIAH	:	North Eastern Institute of Ayurveda and Homeopathy
NER	:	North Eastern Region
NER-DRR	:	North Eastern Regional node for Disaster Risk Reduction
NERIST	:	North Eastern Regional Institute of Science and Technology
NERTPS	:	North Eastern Region Textile Promotion Scheme
NESAC	:	North Eastern Space Applications Centre
NeSDR	:	North Eastern Spatial Data Repository
NGO	:	Non-Governmental Organisation
NGT	:	National Green Tribunal
NIC	:	National Informatics Centre
NKN	:	National Knowledge Network
NMHS	:	National Mission on Himalayan Studies
NRSC	:	National Remote Sensing Centre
NWP	:	Numerical Weather Prediction
OFC	:	Optical Fiber Communication
OGC	:	Open Geospatial Consortium
ONERA	:	Office National d'Etudes et de Recherches Aérospatiales
ONGC	:	Oil and Natural Gas Corporation
P&RD	:	Panchayat & Rural Development
PALSAR	:	Phased Array type L-band Synthetic Aperture Radar
PCU	:	Passenger Car Unit
PHC	:	Primary Health Centre
PHE	:	Public Health Engineering Department
PMO	:	Prime Minister's Office
PolInSAR	:	Polarimetric InSAR
PRL	:	Physical Research Laboratory
PSLV	:	Polar Satellite Launch Vehicle
QCM	:	Quartz Crystal Microbalance
R&D	:	Research and Development
REG GCM	:	Regional Global Climate Model
RGB	:	Red, Green and Blue
RHEP	:	Ranganadi Hydro Electric Power Project
RIST	:	Regional Institute of Science & Technology
RLV-TD	:	Reusable Launch Vehicle – Technology Demonstrator
RMC	:	Regional Meteorological Centre
RMRC	:	Regional Medical Research Center
RMSE	:	Root Mean Square Error
RS	:	Remote Sensing
RTI	:	Right to Information

RTTOV	:	Radiative Transfer for the TIROS Operational Vertical Sounder
S&T	:	Science & Technology
SAC	:	Space Applications Centre
SAN	:	Storage Area Network
SAR	:	Synthetic Aperture Radar
SATCOM	:	Satellite Communication
SBI	:	State Bank of India
SCERT	:	State Council of Educational Research and Training
SCSTE	:	State Council of Science, Technology & Environment
SDMA	:	State Disaster Management Authority
SfM	:	Structure from Motion
SHC	:	Soil Health Card
SHS	:	Swachhata Hi Seva
SI	:	Soil Index
SILKS	:	Sericulture Information Linkages And Knowledge System
SIS-DP	:	Space based Information Support for Decentralised Planning at Panchayat level
SIT	:	Satellite Interactive Terminal
SLV	:	Satellite Launch Vehicle
SMIT	:	Sikkim Manipal Institute of Technology
SMR	:	Satellite Mobile Radio
SMS	:	Short Message Service
SNAP	:	Sentinel Application Platform
SNPP	:	Suomi National Polar-orbiting Partnership
SOI	:	Survey of India
SOS	:	Start of Season
SPA	:	School of Planning and Architecture
SPIE	:	Society of Photographic Instrumentation Engineers
SPS	:	Standard Positioning Service
SRSAC	:	State Remote Sensing Application Centre
SSE	:	Safe Shutdown Earthquake
SSS	:	Support for Statistical Strengthening
SUFALAM	:	Space technology Utilization for Food Security, AgricuLtural Assessment and Monitoring
TDP	:	Technology Development Programme
TEC	:	Total Electron Content
TIFR	:	Tata Institute of Fundamental Research
TKE	:	Turbulent Kinetic Energy
TOVS	:	TIROS Operational Vertical Sounder
TRMM	:	Tropical Rainfall Measuring Mission
UAV	:	Unmanned Aerial Vehicle
UAV-RS	:	UAV Remote Sensing
URDPFI	:	Urban and Regional Development Plans Formulation and Implementation
URL	:	Uniform Resource Locator
UTC	:	Universal Coordinated Time
VPN	:	Virtual Private Network
VSAT	:	Very Small Aperture Terminal
VSSC	:	Vikram Sarabhai Space Centre
VTS	:	Vehicle Tracking System
WRF	:	Weather Research and Forecasting
WRF-ELEC	:	WRF-Electric Model
WWLLN	:	World Wide Lightning Location Network
YuViKA	:	YUva VIgyani KAryakram
ZVWS	:	Zonal Vertical Wind Shear

Published by

North Eastern Space Applications Centre

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