ANNUAL REPORT
वार्षिक रिपोर्ट
2019-2020

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

Annual Report
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North Eastern Space Applications Centre
Department of Space, Government of India
Umiam, Shillong, Meghalaya

Annual Report 2019-20

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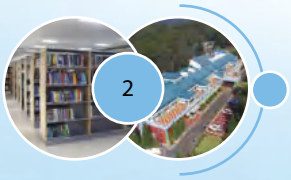

Vision

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

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Standard: ISO 9001:2015

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

Certificate No.: IRQS/1810526

Original Certification Date : 05/04/2017

Current Date of Granting : 18/04/2018

Expiry Date : 04/04/2020

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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 made significant progress in taking the benefits of space technology to the development support activities for different key areas like natural resources management, infrastructure planning, disaster management support, etc. in the North Eastern Region (NER) of India. During the year 2019-20, the scientific activities of the centre has increased 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.

It is an eventful year for NESAC with many activities, meeting user community of Northeast, like organizing national symposium, conducting BIMSTEC training course for the first time, expanding user projects and capacity building in all application domains. The second phase of the Central Silk Board (CSB) sponsored project on Applications of remote sensing and GIS in sericulture development covering 26 states in the country has successfully completed in collaboration with the State Remote Sensing Centres. A decision support system has been developed for early warning of selected Muga silkworm diseases. A new project on Geo-tagging of assets created under NERTPS program of CSB in NER has also been initiated during the year.

The first phase of the CHAMAN project work for NER has successfully completed. There were significant progress for a number of other projects in Agriculture and allied areas such as Maize area and production estimation in NER under SUFALAM Programme, Desertification and land degradation Monitoring, vulnerability assessment in six states of NER and West Bengal etc.

In the area of remote sensing applications in Forestry, NESAC has been carrying out different projects like RS and GIS inputs for preparation of forest working plan in Arunachal Pradesh and Mizoram, assessment of forest fire in Manipur, SAR applications in the estimation of above-ground biomass in forests of NER etc.

An average success score of 75% and an average alert lead time of 24 to 36 hours could be achieved for the flood warnings under the Flood Early Warning System (FLEWS) programme for flood-prone districts of Assam. The FLEWS is being extended to the other NE states. Meghalaya and Tripura were covered for the year 2019 on a pilot basis. Preparation of Assam river atlas and monitoring and evaluation of IWMP watersheds for NE India are also in progress.

As part of urban and infrastructure planning, the centre has contributed in preparation of master plan/development plan, transportation plan, urban site suitability analysis, urban environmental planning etc.

In the area of Geosciences, geospatial database has been prepared for planning and restoration of areas affected by coal mining in Meghalaya. Some other important studies like TEC anomalies assessment for earthquakes precursor detection, River dynamics and erosions of Manas-Beki river have been taken by the centre.

North Eastern Spatial Data Repository (NeSDR) is enriched with about 558 datasets on different themes which are made available in nine major categories. Geo-tagging and monitoring of NEC funded Projects/schemes in NER is progressing well. Artificial intelligence/machine learning/ deep learning techniques have been deployed

for monitoring of road conditions, status of construction sites, automatic extraction of water body and tree cover etc.

The centre has expanded its activities in the field of UAV remote sensing applications. UAV team has demonstrated some unique applications such as tethered UAV for continuous surveillance, drop mechanism for dropping of medicine, food and relief material at the time of disaster etc. NESAC has collaborated with IISc, Bengaluru to develop an amphibious UAV to collect multiple water samples from different locations in a single flight.

In the area of Satellite Communications, NESAC is implementing programs like Tele-Education, Tele-Medicine and Emergency Communication services. Under Tele-education project all the seven HUBs cum Teaching end and 350 Satellite Interactive Terminals (SIT) are operational in NE states.

In the Space and Atmospheric Science area, the group at NESAC is engaged in research to improve short and medium-range weather forecast for NE region of India. In addition, the group provides support and critical input in the management of major disasters like flood, severe storm, lightning, etc. using data from the S-band polarimetric radar, automatic weather stations, satellites, numerical models, etc.

NESAC is expanding its outreach activities addressing demands from the user departments, academia and students communities, particularly from the NE region. Two weeks training program on 'Capacity Building on earth observation applications and research: fundamentals, emerging technological tools and services for BIMSTEC Countries professionals' were organized at NESAC during Jan 6-17, 2020. 24 participants, 4 each from Bangladesh, Bhutan, Nepal, Srilanka, Thailand and Myanmar participated in the training. Scheduled regular courses of NESAC viz., Basics of RS & GIS, UAV Remote Sensing, and many other customized training programs have successfully been completed. The ISRO Young Scientist Programme 'YUVIKA' (YUva VIgyani KAryakram) was conducted from 13th May to 25th May, 2019.

As part of the ISRO's nationwide Vikram Sarabhai Centenary Program to mark the birth centenary of Dr Vikram Sarabhai, NESAC conducted three such programs in Tripura, Meghalaya and Sikkim from 2nd-4th January 2020, 25th-26th February 2020 and 4th-6th March 2020 respectively.

The National Symposium on "Innovations in Geospatial Technology for Sustainable Development with special emphasis on NER" and annual conventions of Indian Society of Geomatics (ISG) & Indian Society of Remote Sensing (ISRS) was organized jointly by North Eastern Space Applications Centre (NESAC) & North Eastern Hill University (NEHU) during November 20-22, 2019.

As a part of societal commitment and capacity building, NESAC contributes by taking up several social activities as well. The community toilet at Umiam market area was constructed by M/s Sulabh International Social Service Organization as a part of CSR activity of Antrix Corporation, Bangalore with the support from Construction and Maintenance Division of the Centre. A Blood donation camp was organized at NESAC, which was first of its kind in this locality. Ayurvedic and Homeopathic medicine camp was organized for the benefit of the local population here. NESAC scientists visited SOS children village and trained the children there on the benefits of Yoga and Meditation. Cleaning drives are regularly conducted at Umiam and nearby areas under the Swachh Bharat Abhiyan of Government of India. One Day Free Eye Check Up Camp was organized by NESAC, in association with Bansara Eye Care Centre, Shillong for the NESAC staffs and residents of Nongsder & Umiam village.

During the reporting period, significant steps have been taken to ensure use of Hindi in all areas of administrative and official communications. A Hindi Technical Seminar was also organized on 12th July 2019.

I convey my sincere appreciation for 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, Satnav Programme, ISRO, Bangalore

Director, S&T, North Eastern Council, Shillong

Joint Secretary (F), DOS, Bangalore

Member Secretary

Director, North Eastern Space Applications Centre

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ABOUT THE CENTRE

The 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 19 years of dedicated service to the eight states of 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 NE 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 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 NESAC Society and GC. During the current year, NESAC has taken up and completed several projects covering the NE 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 (Barapani) about 20 km from Shillong, Meghalaya State. NESAC Guest House and the residential complex is located about 1km 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 Geo-graphical 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 and hydrological modelling, GIS and GNSS 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 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 COTS (commercial off-the-shelf) 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

Over the years NESAC has established and enhanced IT infrastructures for carrying out research and outreach activities and also to provide operational services. The centre has a Local Area Network (LAN) with 1 Gbps Ethernet backbone connecting all the laboratories, facilities as well as administrative departments. Internet connectivity is provided throughout the NESAC office building with 1 Gbps OFC Link (NKN). Both NKN and ISRO Space-net connectivity are being used for video conferencing and other data streaming applications. The centre has established web hosting infrastructure with redundant servers and storage in order to provide various kinds of web services, including FTP under existing project activities. Recently, NESAC had established North Eastern Spatial Data Repository (NeSDR) at NESAC and State Data Spatial Data Repository at all the States of NER in order to enable data cataloging, sharing, retrieving, etc. in a decentralized mode from respective State Nodes. NeSDR facilitates users to visualize, retrieve, geo-process and publish geospatial layers of interest through online registration via secure authentication gateway. The centre is also equipped with a sufficient number of workstations, printers, plotters, scanners, GPS systems, GPS-enabled digital cameras, GAGAN GPS and high end DGPS for advanced and precise ground survey applications. In addition, sufficient numbers of image processing and GIS software along with other open source software and tools are available in the lab.

NESAC has setup HPC facility during 2014 with one master node (20 core) and six compute nodes (72 core) with 12 TB storage (SAN). The computing facility has been upgraded with another 4 compute nodes (80 cores) with the addition of 8 TB storage. The HPC is currently used by the various users of the organization under different R&D activities. 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. AgisoftPhotoScan software was also installed in a clustering environment to process and generation of 3D data acquired by UAV/Drones. The centre is in the process of establishing Deep Learning (DL) facility to address many research issues in various thematic areas.

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 24X7 basis as part of satellite navigation program of ISRO. The center also has various equipment like Beacon receiver, Radiometer, Laser Precipitation 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 equipments under the NAVIC SPS-GPS receiver experiment.

Space and Atmospheric Science Research

The centre has a dual polarized 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. 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 characterization of aerosols and its impact on weather and climate over the Himalayan region.

The centre hosts a Multi Wavelength Radiometer (MWR), Sun photometer, Aethalometer, MicroAeth, Integrating Nephelometer, Electric Low Pressure Impactor (ELPI), etc. for physical and optical characterization of aerosols. To study the atmospheric boundary layer physics and dynamics, the centre has Dr. Pisharoty Sonde (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 6m, 10.5m, 18m, and 30m). A Cloud Condensation Nuclei (CCN) counter and a Disdrometer has also been procured to study the aerosol-cloud interaction over NE region and 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. During the last year, one Ceilometer has been installed in collaboration with Physical Research Laboratory (PRL), Ahmadabad, to study on cloud microphysical properties and atmospheric boundary layers.

Unmanned Aerial Vehicle Facility

NESAC has also expanded the spectrum of activities in the field of UAV remote sensing and its applications. At present, there are six different types of UAVs platforms which include both multi-rotors & fixed wings and also promising sensors/ cameras such as RGB, multi band multispectral, thermal, etc. The centre has been providing end-to-end UAV services for various user communities in NER 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 more than 25 UAV surveys and mapping in the year 2019-20 for different users departments in NER.

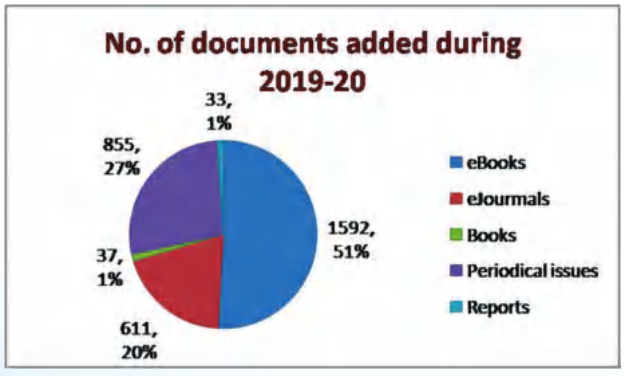
The center has also facilitated with research and development of UAV lab. With the advancement of 3D printing technology in NESAC, in-house mini UAVs for experimental purpose has been developed. UAV R&D team has successfully

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 disaster, etc. The team has also integrated NAVIC based VTS (vehicle tracking system) for monitoring of UAVs.

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 organization and houses varied subject collections in both print and online formats.

During 2019-20, the library has added 3128 documents, including 1592 eBooks, 37 books, 611 eJournals, 855 journal magazine/newsletter issues and 33 technical reports, including internship reports. The total holdings of the library are now increased to about 10 thousand physical documents. The library continues to have access to full-text databases like SPIE Digital Library & IEEE/IET Electronic Library, Springer Engineering ebooks collection, Springer Nature & Scientific American eJournals through Antariksh Gyaan (ISRO Library Consortium) and 40 periodicals through institutional subscription. Access to 611 Springer eJournals, 383 Springer Earth & Environmental Sciences eBooks (2019), 215 IOP Concise Physics eBooks and 457 Taylor and Francis eBooks through Antariksh Gyaan were added to the existing collection during this period.



Residential Facility

The centre has a residential facility comprising of staff quarters (Total 21 nos.- 4 C type, 12 D type, 4 E type and Director's residence), Guest House, Children park, Amenity building including shopping complex, community hall, gymnasium and sports facility, etc. The centre also has staff quarters for CISF personnel (Total 22 nos. -19 B type, 2 C type and 1 D type), staff barrack, Quarter Guard building, etc. for them as per norms.

Construction is under progress for 14 numbers of new staff quarters, a new annexe building for office space, a creche facility and a squash court facility.

Sports and Recreation Facilities

Various sports and recreation events were organized during 2019-2020 at the centre by NESAC Recreation Committee. Sports meet prior to NESAC Foundation day was organized for two weeks. Various competitions like Running, Cricket, Football, Volleyball, Badminton, Basketball, Table Tennis, Chess, Carrom, photography, Painting, etc. were organized. The staff of NESAC actively participated in the events. Prizes for the events were given away during Foundation day celebration. Various recreational programs were organized during Republic Day, Independence Day, Foundation day, etc. The staff of NESAC actively participated in such recreational events. NESAC Gymnasium and Recreational facilities were used by the staff of NESAC throughout the year. Three marathons were organized from NESAC in which people from nearby localities also participated.

AGRICULTURE AND ALLIED AREAS

Applications of geospatial technology in Sericulture development

Sericulture is an important allied activity of the agriculture sector and is considered as one of the important sectors of the economy in India. It plays an important role in programmes of poverty alleviation in the rural areas, the current production of silks is not adequate to meet the demand for silk in the country. Central Silk Board (CSB), under the Ministry of Textiles, Govt. of India is continuously pursuing various options for enhancing the production and quality of silk through the expansion of areas under host plants, an improved method of information collection, processing and dissemination with the use of geospatial technology. An ambitious project was taken up by CSB to identify and map additional potential areas for the development of silkworm food plants for 178 priority districts from 26 states in two phases. NESAC was assigned the responsibility of coordinating the project in the entire country. It was also envisaged to develop a geo-portal for integrating the potential area maps along with other required information for the expansion of sericulture at the district level.

The first phase of the project has already been completed and the project Atlas was released by the Hon'ble Union Minister of Textiles in Mysore on 17th November 2015. Now the second phase of the project has successfully been completed. To commemorate the successful completion of both phases of the project and to formally release the project outputs in the form of Project Atlas and SILKS portals (http://silks.csb.gov.in), a national level workshop was organized at NESAC during August 05-06, 2019 inviting all the collaborating institutions, State Directorates of Sericulture, CSB institutions, etc. About 90 delegates and participants attended the workshop.

Shri R.R. Okhandiar, Member Secretary & CEO, CSB, who graced the inaugural function as the Chief Guest stressed on the need of utilizing the valuable information brought out with this project by all the stakeholders to increase the silk production in the country. Member Secretary & CEO, CSB released the Project Atlas and launched SILKS portals. A new programme on geotagging of CSB assets launched during the inaugural function of the workshop. Under this programme, CSB intends geotagging of assets using geospatial technology.

Member Secretary, CSB releasing the Project Atlas

The inaugural function was followed by two Technical Sessions, Session-I and Session-II.

Following are the few important recommendations made by the panellists, which were accepted for taking them forward:

- It was observed that a number of representatives from State Sericulture Department suggested to include additional districts for mapping of potential areas for sericulture development. It was suggested that the concerned Sericulture department may write to Member Secretary, Central Silk Board, with the names of the districts along with the type of sericulture to be covered for consideration.
- A few of the representatives from State

Sericulture Departments, viz, Chhatisgarh and Jharkhand States that the site suitability analysis should have been carried out for Tasar sericulture instead of Mulberry Sericulture, which is having better prospects in these States. It was advised to the States to formally write a letter to CSB in this regard and accordingly, it may be taken for these districts.

- Socio-economic data along with market requirements should be integrated into the analysis, wherever possible for delineating the suitable areas.
- NESAC may play an important role in providing geospatial inputs in the successful implementation of Muga Missions in the states of Assam and Meghalaya and should work with the concerned State Directorates of Sericulture.
- State wise workshops to be organized to create awareness about the SILKS portal among grass root level workers.

Geotagging of assets created under NERTPS program of CSB in North Eastern Region

CSB has been supporting all the State Departments of Sericulture (DoS) in North East for cluster development, area expansion of silkworm food plants, production of quality silkworm seeds, construction silkworm rearing houses, cocoon processing units, establishment of weaving and reeling centres, marketing of seeds/silks, etc. CSB has been implementing an ambitious project called North Eastern Region Textile Promotion Scheme (NERTPS) for all round development of the Textile sector in NER. A large number of assets have been created in the NER and there is a requirement to have a spatial distribution of all the assets for monitoring the effectiveness of the programmes and to reach the unreached. With this background, CSB has approved a new project on Geo-tagging of assets created under the NERTPS program of CSB in North Eastern Region to be executed by NESAC.

Under this project, it is proposed to geotag all the assets created under the NERTPS (North Eastern Region Textile Promotion Scheme) program of CSB has been taken up for 8 states of NER.

The scope of the work includes the development of mobile app for collecting data, geotagging of all the assets created under the NERTPS program of CSB and hosting of the same in the dashboard system linked to SILKS Web Portal. GPS aided Geo-augmented Navigation (GAGAN) based mobile app for the Android operating system has been developed for field data collection and posting to server. This required the necessary interface design based on the latest and compatible design tools and preparation of forms for collecting structure data.

The GUI design is based on multi-touch gestures for touch enabled devices. A hybrid approach is being adopted to achieve the highest user experience and compatibility on different platforms and devices.

The dashboard system is under development and will have necessary features for interactive visualization, navigation, map query based on a filtering based approach and visualization of statistics via charting tools. The dashboard will be responsive so that multiple devices or platforms can efficiently display the data or information. The platform will have the necessary database server

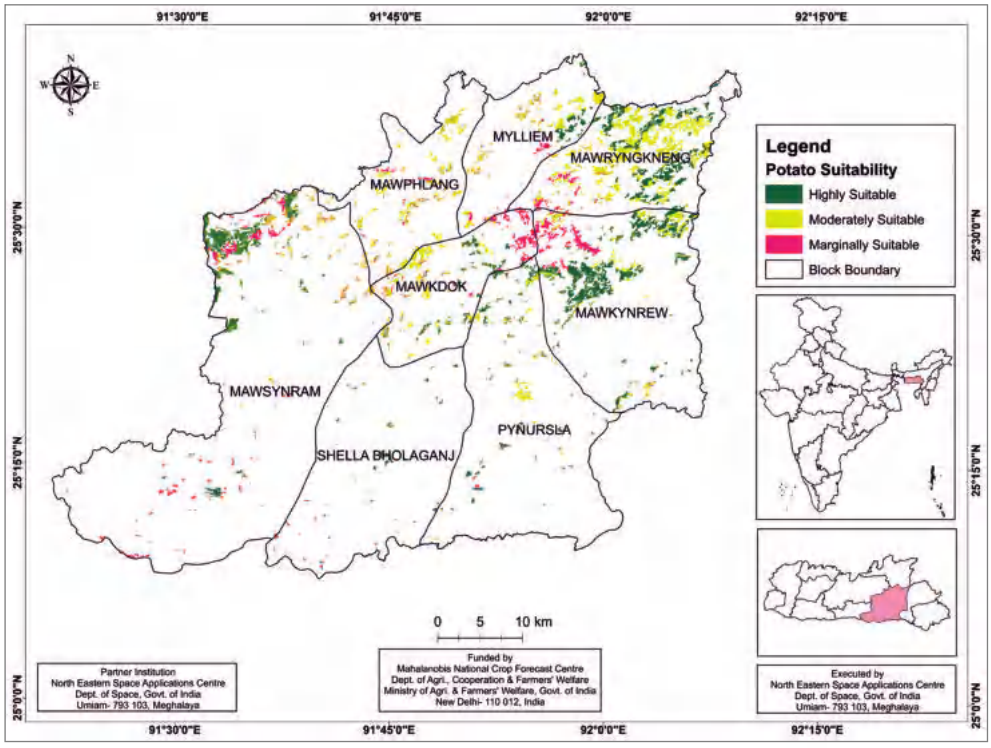
to interact with the incoming data posted from a mobile app.

As the large volume of assets have to be geotagged within a short period of time, 114 Project Assistants have been recruited with the help of State Remote Sensing Application Centres in NER for a duration of six months and deployed in their respective states.

Coordinated Horticulture Assessment and Management using geo-INformatics (CHAMAN) program for NER

Mahalanobis National Crop Forecast Centre (MNCFC) under the Ministry of Agriculture and Farmers' Welfare, Govt. of India initiated the programme with the objectives of creating crop inventory of major horticultural crops of India and site suitability analysis for major horticultural crops in North East India. North Eastern Space Applications Centre (NESAC) is coordinating the programme in the North Eastern States in collaboration with State Remote Sensing Application Centres (SRSACs) of respective states. In the first phase of the CHAMAN project, site suitability analysis was carried out for selected horticultural crops in 8 selected districts of North Eastern States (one district from each state).

With the successful completion of the first phase of the project, MNCFC approved the execution of the second phase of project for carrying out site suitability analysis for potential horticultural crops in 16 districts of North Eastern States. Site suitability analysis for potato in East Khasi Hills and areca nut in East Garo Hills district of Meghalaya was carried out under the second phase of the project. Multi-temporal and multi-spectral 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. A soil map of 1:50000 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 sites.



Suitable sites for potato cultivation in East Khasi Hills, Meghalaya

It has been observed that 7449.73 ha (36%) area is highly suitable, 3820.27 ha (18.6%) is moderately suitable, and 9277.12 ha (45.2%)

is marginally suitable for potato cultivation in East Khasi Hills district of Meghalaya. Again, 296.21 ha is highly suitable (1.5%), 9706.94 ha is moderately suitable (51.5%) and 8815.61 ha is marginally suitable (46.8%) for areca nut cultivation in East Garo Hills district of Meghalaya.

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

Directorate of Economics & Statistics (DES), Govt. of Meghalaya, Shillong has proposed for a feasibility study for estimating the area under major crops of the state by using geospatial technologies with a view to improve the existing system of crop acreage estimates. The present system of crop acreage estimation followed by the Directorate is based on the personal assessment of the grass root workers like Gram Sevaks/Sevikas, Agriculture/ Horticulture Development Officers, Sub Inspectors of Statistics, etc. which is seen to have various limitations. The proposed study has been funded under the programme SSS (Support for Statistical Strengthening) of the Ministry of Statistics and Programme Implementation (MOSPI).

In the joint meeting of DES and NESAC on 15th January 2019 at DES, Shillong, seven crops namely winter paddy, autumn paddy, spring paddy, maize, summer potato, winter potato and rubber have been selected for this study. The study on winter paddy, autumn paddy, spring 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 rubber, on the other hand, will be carried out in West Garo Hills District. The estimates on these crops will be more of a satellite based estimates, whereas the estimates of other minor crops covered under CCE (Crop Cutting Experiment) will be based mostly on the field survey. It was also decided to develop a mobile app and visualization dashboard system for better planning and monitoring of CCEs.

Acreage estimation of the field crops will be made using high resolution satellite data such as LISS-IV, Sentinel-2 supported with field surveys. Synthetic Aperture Radar (SAR) data (Sentinel-1 and 2, C-band) will be used to delineate the crop fields during the Kharif season when cloud free optical data are not available. Temporal SAR data will be taken from July onwards till November, covering sufficient phenological spacing in order to identify kharif crops. The development of suitable vegetation indices and appropriate classification techniques will be adopted for the delineation of selected crops. Features such as permanent water bodies, built-up, vegetation and shadow areas will be masked out using Land-use/ Land-cover classified map prepared using high resolution satellite data.

GAGAN based mobile app for Android operating system is being developed for field data collection and posting to server. This requires necessary Graphical User Interface (GUI) design based on the latest and compatible design tools and preparation of forms for collecting structure data. The features for the app are based on the requirement of the DES. The GUI design will be based on multi-touch gestures for touch enabled devices and will be user friendly with a better look and feel. The app will then be subjected to rigorous testing before final deployment for public users.

A web based spatial dashboard is also being developed for visualization of sampling plan and data collected during CCE. The dashboard will have necessary features for interactive visualization, navigation, map query based on a filtering based approach and visualization of statistics via charting tools. The dashboard will be made responsive to multiple devices.

Maize area and production estimation in NER and UAV based Experiments over Selected Crop Patches (Under SUFALAM Programme)

It is collaborative between Space Applications Centre (SAC) and NESAC under the project called SUFALAM (Space technology Utilization for Food Security, AgricuLtural Assessment and Monitoring) Programme has two activities. Activity-I is on the development of remote sensing based methodology for acreage and production estimation of maize crop in NER. The Activity-II relates to UAV based surveys for crop condition assessment for crop insurance.

Project Activity-I: Under the first activity, an integrated methodology is being adopted for identification & delineation of maize crop in NER using high resolution satellite and UAV data in conjunction with GPS-based field surveys through precise field boundary markings. Suitable sampling design and estimation procedure have been adopted for improving the acreage estimation of Maize crop. It is also planned to develop a plot to block level maize yield models using CCE data, UAV and satellite data. This pilot phase of 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, the Ri Bhoi district has been selected.

For Maize crop acreage estimation in Darrang district, Sentinel-1 SAR data with a spatial resolution of 10m downloaded from the ESA Sentinels Scientific Data Hub. The images were analyzed by using SNAP 7.0 and ENVI 5.4 software at SAC, Ahmedabad from 24th February 2020 to 29th February 2020. The training samples needed for the analysis were taken from various locations of the Darrang district. SANP 7.0 software was used for pre-processing of all 12 Sentinel-1 images and to run the Random Forest classification. Overall accuracy was 65.5 per cent with a Kappa coefficient of 0.53 was achieved for Maize crop classification. Lower accuracy is attributed mainly due to smaller field sizes with mixed cropping patterns in the district.

Project Activity-II: A pilot experiment on crop discrimination and crop condition in the selected patches of M.P., Maharashtra and Gujarat states is being carried out. A lightweight hexacopter DJI Matrix 600 was deployed with Mica sense MX Sensor. A joint team was constituted with Scientists/Engineers from NESAC and SAC for carrying out the UAV based surveys. NESAC had conducted UAV survey at Balva village Gujarat and Bakrol Badrabad village in Vidisha district of Madhya Pradesh in the last week of February 2020 and first week of March 2020. The survey employed Red Edge Multispectral Camera with Blue, Green, Red, Red edge and Near-IR bands along with conventional 20 megapixel RGB camera. The flying height was maintained at 120m from the take-off point which fetched 5cm per pixel (per band) of Ground sample distance (GSD). The data is being analyzed for crop discrimination and crop condition assessment for selected sites.

Identification of block wise Sali paddy (winter rice) areas in Meghalaya

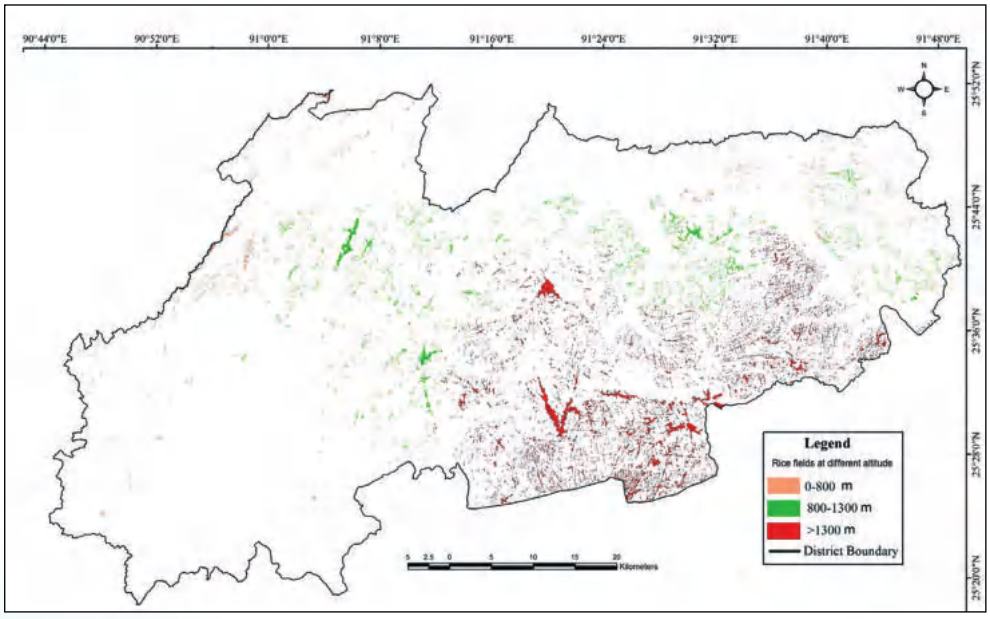
Directorate of Agriculture, Govt. of Meghalaya proposed to create a scientific database on the spatial distribution of winter paddy (*Sali*) areas and entrusted NESAC to take up the mapping of *Sali* paddy areas of Meghalaya using RS & GIS technique.

The *Sali* rice areas have been mapped by using standard visual interpretation techniques. ResourceSat-2A orthorectified LISS-IV (multispectral) image of the year 2017-18 and CartoDEM (10m) has been used for the study.

The map has been verified with field data collected from 350 locations covering the entire state, high resolution Komsat image (multispectral) and Google images. The map has been finalized in consultation with the user department. The village location maps have been prepared by using SIS DP database / Google earth images and Soil Health Card data.

The study shows that in Meghalaya, *Sali* rice is cultivated in 102574.3 ha area which is 4.6% of the total geographical area. *Sali* rice is cultivated in all 39 blocks of 11 districts of the state. Amongst 11 districts of the state, *Sali* rice cultivation is highest in West Garo Hills district that cover 21.9 % of the total *Sali* rice growing areas whereas the lowest area, i.e., 2117.5 ha (2.1%) is found in South West Khasi Hills district. Selsella block of West Garo Hills district is having the highest *Sali* rice growing areas followed by Betasang and Zikzak block. The lowest area is found in Pynursla block followed by Gambegre, Ranikor, Mylliem and Shella Bholaganj block.

Based on the rice growing ecosystem of Meghalaya, it is found that the cultivation of low altitude rice is highest in the state that covers 64.2% area followed by mid altitude (20%) and high altitude rice (15.8%). It is also observed that the low altitude rice is the highest in West Garo Hills district and lowest in the South West Khasi Hills district. Mid altitude rice is highest in West Jaintia Hills and Ri Bhoi district whereas high altitude rice is found only in 5 districts of Khasi and Jaintia hills.



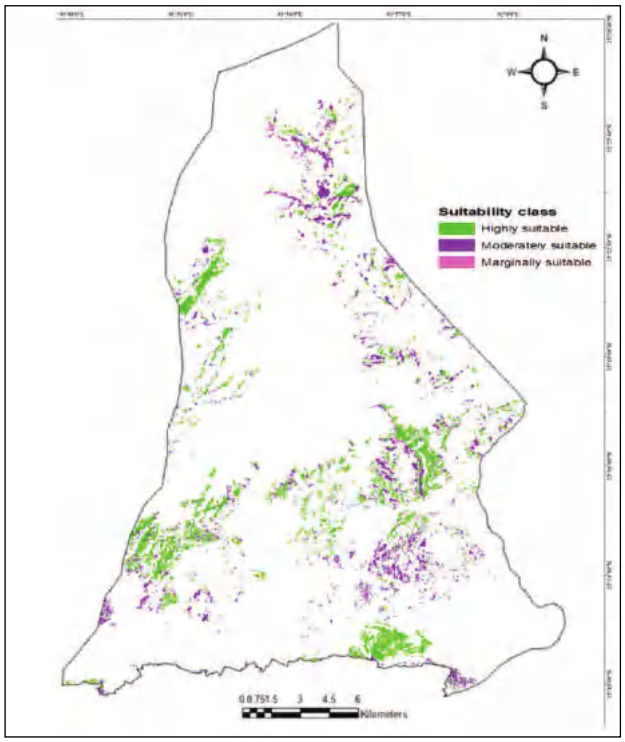
Distribution of Sali rice in West Khasi Hills district under different rice ecosystem

Identification of suitable areas for expansion of orange plantation in East Khasi Hills District of Meghalaya: A case study in Pynursla block

Pynursla block of East Khasi Hills district is an important block which is producing good quality Khasi mandarin orange. Directorate of Agriculture, Govt. of Meghalaya planned to expand orange plantation in this block and requested NESAC to identify the suitable areas for expansion of the areas for orange plantation. Land evaluation for soil site suitability analysis has been followed to identify suitable areas for the plantation. The existing soil map of 1:50,000 scale is updated to 1:10,000 scale by incorporating information collected from soil profile study by using Resourcesat-2 LISS IV images of 2017-18 along with CartoDEM. Different thematic maps viz., soil depth, drainage, flooding, texture, and gravel/stoniness have been derived from the soil map. Land use/land cover map has been prepared from Resourcesat-2 LISS IV images and the suitability analysis has been carried out in all land use classes except forest, built up, water body and barren rocky areas. CartoDEM version 3.0 has been used to prepare slope, aspect and elevation map. All these maps are transferred to the GIS environment and

overlay analysis has been carried out to evaluated suitability of soils for orange plantation by following FAO guidelines.

From the study it is found that the soils of the study area are mostly well drained, moderately deep to deep in depth, sandy clay loam to clay in texture and moderately acidic in nature. Since soils are developed on moderately slope to very steep slope areas, it is observed that soil erosion is a major problem and the study area is classified into land capability class II and III that covers 90% and 10% area respectively. Evergreen forest is the most dominant land use/land cover that occupies 67% area of the study area. Broom grass is cultivated in the block that covers 13% area. Barren rocky area is the third dominant land use that covers 4.8% area of the block. Based on the recommendation of the user department, soil site suitability analysis, for orange plantation has been carried out in the non forest areas excluding built up, water body and barren rocky areas. From the site suitability analysis it is found that about 3132 ha area is suitable for expansion of orange plantation. About 1954 ha (62.4%) area is highly suitable for orange plantation whereas 36% area is moderately suitable and 1.6% area is marginally suitable for expansion of orange plantation in the Pynursla block.



Suitable areas for expansion of orange plantation

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 (Physical parameters); N, P, K (Macronutrients); 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 Department of Agriculture & Co-operation under the Ministry of Agriculture, Directorate of Agriculture, Govt. of Meghalaya has requested NESAC to prepare district wise soil fertility maps of Meghalaya. In response to the request, NESAC has taken up this project and completed the work for Ri Bhoi district.

For the preparation of soil fertility maps, soil health data has been collected from SHC portal http://soilhealth.dac.gov.in. From the soil health card dashboard, grid wise soil health data has been downloaded and edited the data 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 9 parameters are available for the Ri Bhoi district.

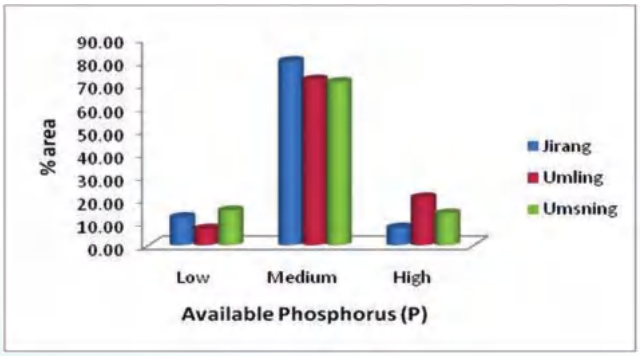
The available nine parameters are pH, EC, OC (Physical parameters); P, K (Macronutrients) and Zn, Fe, Cu, Mn (Micronutrients). These nine soil parameters have been used for the generation of nine fertility maps. The fertility maps have been generated by using the Spatial Analyst tools of

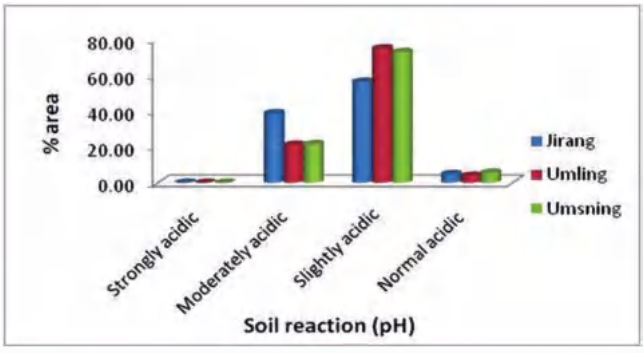
	Parameters	Class	Area(ha)	% area
Physical parameters	pH	Strongly acidic (<4.5)	8	0.0
		Moderately acidic (4.5-5.5)	61865	26.2
		Slightly acidic (>5.5-6.5)	162505	68.9
		Normal acidic (>6.5-7.3)	11570	4.9
	OC (%)	Low (<0.50)	229	0.1
		Medium (0.50-0.75)	1978	0.8
		High (>0.75)	233741	99.1
Macro-nutrients	P (kg/ha)	Low (<10)	28090	11.9
		Medium (10-25)	174442	73.9
		High (>25)	33416	14.2
	K (kg/ha)	Low (<120)	32083	13.6
		Medium (120-280)	156887	66.5
		High (>280)	46978	19.9
Micro-nutrients	ZN (ppm)	Deficient (<0.6)	36529	15.5
		Sufficient (>0.6)	199419	84.5
	Fe (ppm)	Deficient (<4.5)	612	0.3
		Sufficient (>4.5)	235336	99.7
	Cu (ppm)	Deficient (<0.2)	2406	1.0
		Sufficient (>0.2)	233542	99.0
	MN (ppm)	Deficient (<2.0)	14287	6.1
		Sufficient (>2.0)	221661	93.9

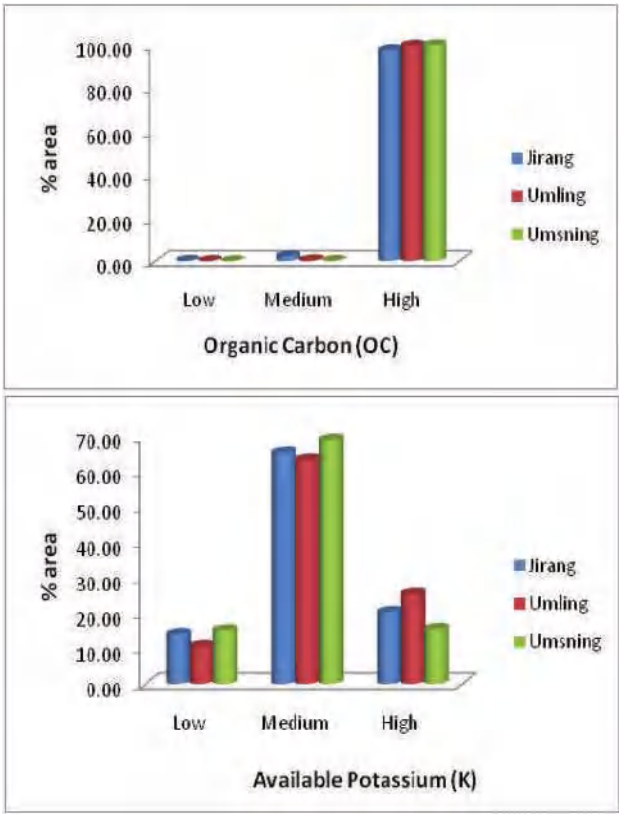
Area under different fertility classes in Ri Bhoi district

ArcToolbox. Inverse Distance Weighted (IDW) interpolation technique has been applied to generate fertility map of unknown locations based on information of known locations. Blockwise area statistics have been calculated. 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 69% soils of the district are slightly acidic in nature followed by moderately acidic soil that covers 26% area. Negligible area i.e., only 8.4 ha area, is found to be strongly acidic (<4.5) in reaction. It has also been observed that soils of the district are non Saline and rich in organic carbon. It is observed that 74% soils of the district is medium in available phosphorus followed by high and low that covers 14% and 12% area, respectively. The study showed that available potassium is medium in 67% area of the district, followed by high and low available potassium that covers 20% and 14 % area, respectively. The soils of the Ri Bhoi district are mostly rich in micronutrients; it is observed that more than 80% of areas are sufficient in micronutrient contents. Only about 16% area is deficient in zinc whereas iron, copper and manganese is deficient in <1%, 1% and 6 % areas, respectively.







Blockwise distribution of pH, P, OC and K classes

Development of Decision Support System for early warning of selected Muga Silkworm diseases and pests with Geospatial technique (Funded by CSB)

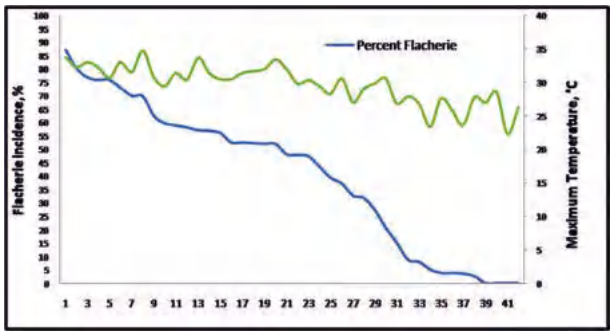
NESAC, in collaboration with Central Muga Eri Research & Training Institute (CMER&TI) had taken up this work to identify the various disease causing parameters and evolve strategies to overcome them in the form of a decision support system. This study has been carried out to evaluate the landscape and meteorological parameters of Muga rearing farms for selected Muga silkworm disease namely Flacherie by using geospatial techniques.

Five different farms are selected, three are in Assam (Jagduar, State Sericulture Farm, Jorhat; Regional Sericulture Research Station Boko, Kamrup; Research Extension Centre, CSB, Lakhimpur) and two in Meghalaya (MSSO P-3 Unit, Nongpoh from Ri Bhoi district and MSSO P-4 Unit, Tura from West Garo Hills district), which are reporting higher disease infestation and lower production rate. These farms are located in an urbanized area, contradicting its rearing environment, as Muga silkworms are wild in nature and cannot be reared domestically and bear slightest change in their habitat.

This correlation result explains the positive and negative correlation with different land use land cover classes. It has been observed that when the agricultural field increases near the Muga rearing farm, then the disease incident is found to have increased resulting low productivity of silk. On the other hand, the presence of forest cover near the selected farms shows a negative trend with the disease incidence.

The land surface temperature map was computed by taking the 3km buffer area from the center of the farms in order to observe the variation in surface temperature and its effect on Muga silkworms diseases. A negative relationship has been found between Flacherie incidence with the land surface temperature below 24°C, which implies that surface temperature ranging from 15–24°C is found to be optimum for the rearing of Muga silkworms.

The meteorological parameters such a humidity, temperature and rainfall have been analyzed taking ten year datasets of each farm. The average of each meteorological parameter has been taken prior to fifteen days of brushing till the date of harvest. Meteorological parameters such as minimum and maximum temperature and humidity were organized in the sequence of 15 days, 10 days and 5 days prior to harvest. From the study, it is found that temperature and humidity when crossing the threshold limit prior to 15 days of harvest when the larva are in their 3rd to 5th instar, the weather parameters play a significant role in their growth.



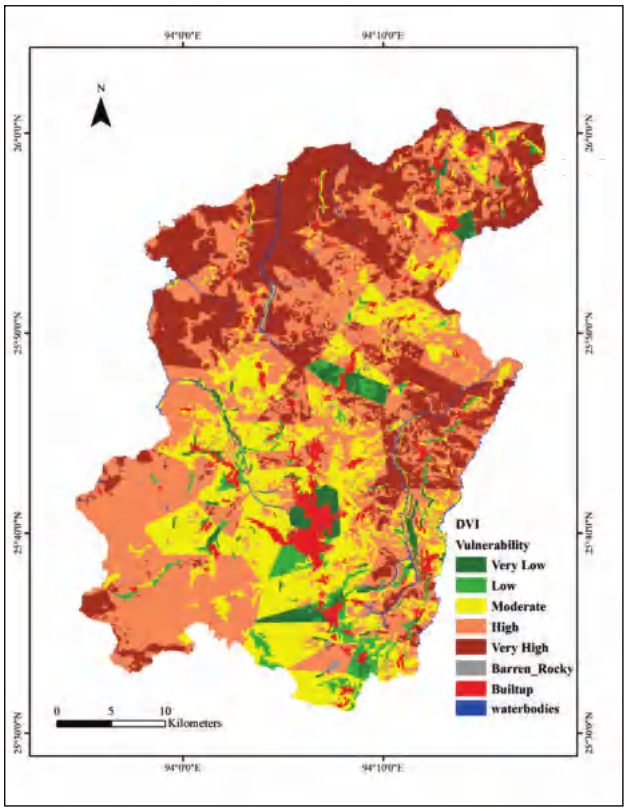
Incidence of Flacherie disease with variation in Maximum Temperature

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

Space Applications Centre (SAC), Ahmedabad is executing the project for the entire country. NESAC is implementing the project for six states of NER (excluding Assam and Meghalaya) and West Bengal. Under the project desertification and land degradation vulnerability assessment at 1:50K scale in 10 selected districts representing 6 NER states and West Bengal have been taken up. Action plans have been prepared for combating desertification and land degradation at 1:10K scale in one micro-watershed in each district selected for vulnerability assessment.

A number of indices such as Amenities Index (AI), Economic Development Index (EDI), Soil Index (SI) and Land Utilization Index (LUI) were generated and integrated into GIS environment to develop the Desertification Vulnerability Index (DVI). AI for each and every amenity available at villages such as educational institutions, health centres, financial institutions, communication service, transport, irrigation and other infrastructures has been generated. After that Cumulative Amenities Index (CAI) has been generated by integrating all the amenities. Again, EDI was generated from the total population, population density, number of the employed population, number of skilled workers, number of unskilled workers, etc.

Soil map of 1:50K scale prepared by Soil and Land Use Survey of India (SLUSI) and/or NESAC has been used to generate SI. Soil properties such as depth, texture, drainage, erosion and pH were considered for the development of SI. LUI was generated from the Normalized Difference Vegetation Index (NDVI) and Land Capability Classes (LCC). The average NDVI value generated from LANDSAT-8 for the period from 2013 to 2018 was used as input for LUI. Again, LCC was generated using soil properties such as texture, erosion, depth, permeability and slope.



DVI map on 1:50K for Kohima, Nagaland

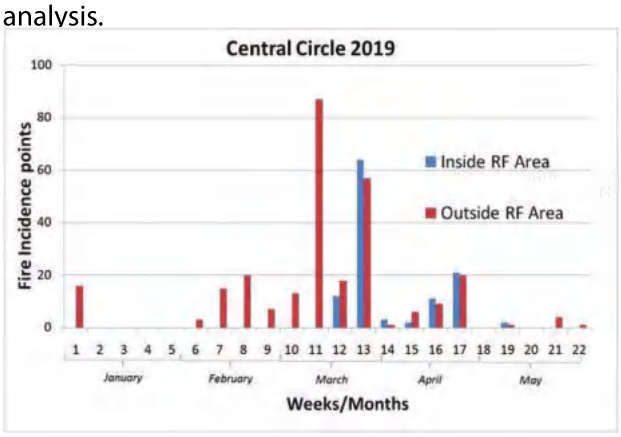
Finally, all the layers were integrated into a GIS environment to generate the DVI map at 1:50K. Multi-parametric criteria based method was adopted for deriving DVI, which was classified into five classes viz., very low, low, moderate, high and very high. The area under very low, low, medium, high and very high DVI in Kohima district has been found to be 34.73 sq. km, 44.38 sq. km, 288.62 sq. km, 518.93 sq. km, and 314.38 sq. km.

FORESTRY AND ECOLOGY

During the past 20 years of existence, NESAC has been carried out many R&D and user application oriented application projects using geospatial technology in the field of forestry and ecology. Some of the major projects being undertaken by this group during the current year are detailed as follows.

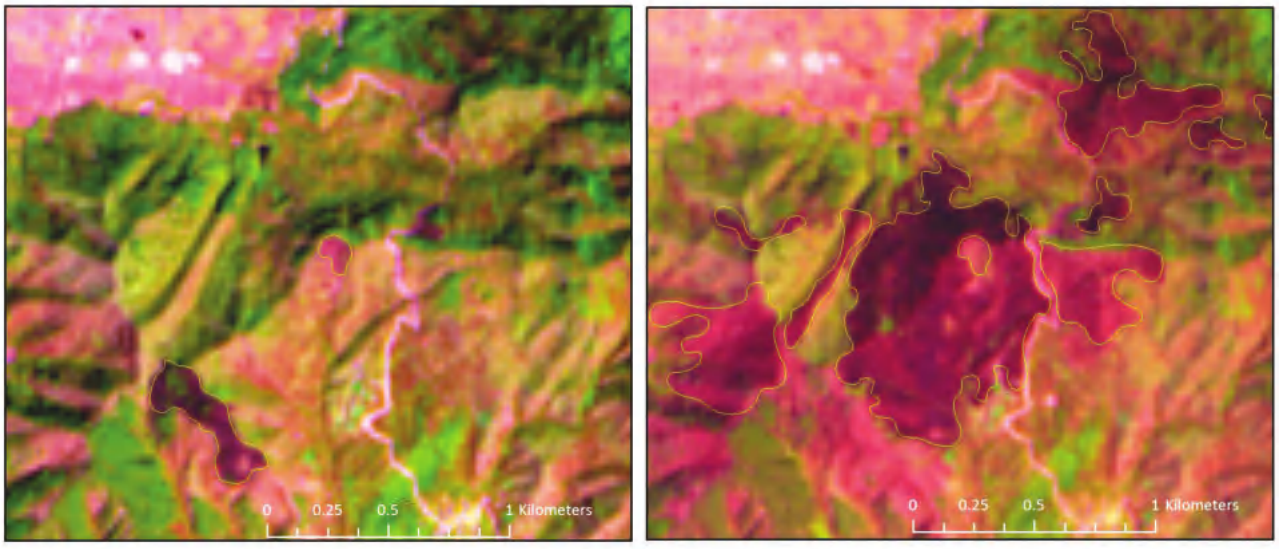
Geospatial assessment of forest fire in different forest divisions of Manipur

An assessment of the extent and intensity of forest fires under different forest divisions of Manipur is carried out for the Department of Environment and Forests, Manipur, using the active forest fire alerts issued from Forest Survey of India to the Department. The assessment has been done for the period from April 2019 to March 2020. Freely available temporal & latest high density medium resolution satellite data like Sentinel-2 with supplementation from coarser resolution data like Landsat 8 OLI and Landsat 7 ETM were used for this analysis.



Temporal distribution of fire occurrence in Central Forest Circle, Manipur

The newly burnt area extent was delineated in the GIS platform using multi-date satellite imagery. The location of fire alert points archived from Forest Survey of India (FSI) both for MODIS and SNPP were evaluated for the spatially matched burnt area extents derived from the satellite imagery. Out of the total fire points archived the actual fire points matched with the burnt area extent were updated in the attribute. Further processing and preparation of the report are going on. The database will be useful for the Manipur Forest

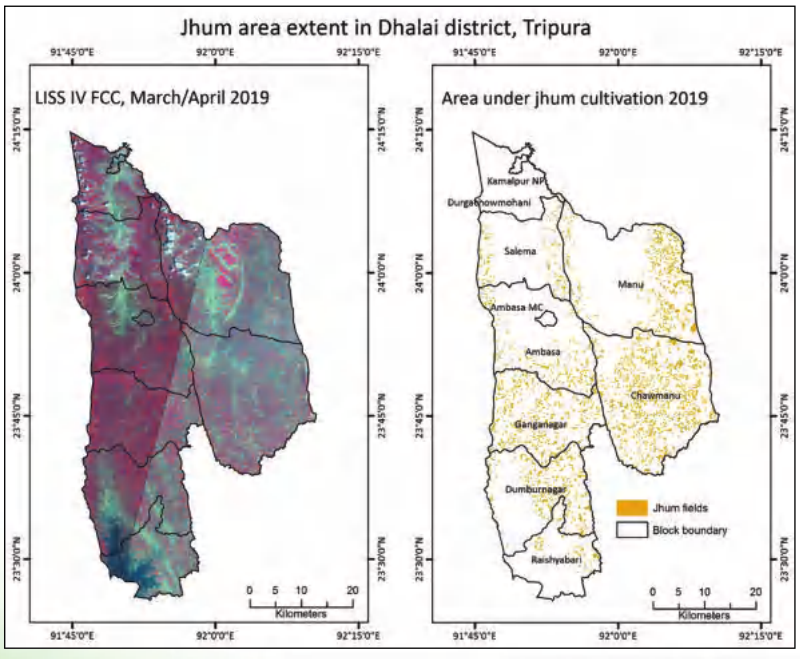


Sentinel 2A data showing burnt area as on 14th March 2020 (Left) and burnt area for the same area just days before 3rd April 2020 (Right)

Department in taking up precautions as well as for the burnt area regeneration program.

Jhum area mapping and monitoring 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 multi-date IRS LISS-IV data pertaining to March 2018 and March 2019. Field visits were made to verify the correctness of the interpretation. Interpretation error due to similar signatures of clearing forests for Arecanut plantation has also been rectified and due corrections made with similar characteristics in other polygons. Preliminary results show that there is a possibility of a linear relationship between the malaria cases with the jhum areas which need to be studied in detail.



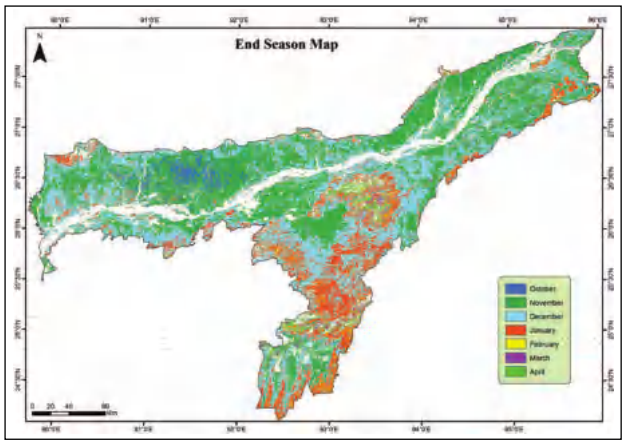
Jhum area extent in Dhalai District of Tripura

Inputs for preparation for wetland conservation: a case study of Umiam Reservoir, Meghalaya

Umiam Reservoir was constructed in 1965 for the Umiam Umtru Hydroelectric Power Project. Umiam reservoir is the biggest artificial reservoir in the State of Meghalaya. Besides serving as a hydroelectric power generation site, it provides several other valuable services like fisheries, drinking water, etc. It is one of the major tourist attractions in Meghalaya. Umiam reservoir is one of the 100 wetlands identified by the Ministry of Environment, Forest and Climate Change, Government of India for restoration as part of transformative ideas within the 100 days programme of the Government of India. The Meghalaya State Wetlands Authority has entrusted NESAC to prepare a detailed map of Umiam reservoir with its zone of influence/ catchment located within 500 meters buffer from its boundary using UAV. The survey part has been complete and the preparation of Land Use Land Cover map of the entire study area including the zone of influence is in progress.

Analysis of Vegetation Phenology of NER using Time Series Satellite Data

The project is being carried out to analyze the distribution pattern and variation in vegetation phenology variables for several natural vegetation types in North East India using time series satellite data. MODIS 16-day composite NDVI time series data for a period of 18 years has been analyzed for the state of Assam. After smoothing the data, phenological parameters are computed 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, length of the season, base level, mid of the season, maximum NDVI value and seasonal amplitude have been calculated.



Spatial pattern of vegetation phenology in Assam

Preliminary analysis has been carried out in some of the major forest types of Assam with respect to seasonal variations such as start of season (SOS), middle of season (MOS) and end of season (EOS) in these major types and details are given in the table below.

Landcover dynamics of Kaziranga National Park

The project has been carried out in collaboration and funding by the Department of Environment & Forest, Govt. of Assam. Land cover analysis and dynamics of the Kaziranga National Park have been studied for the last 45 years at five years interval (1973 to 2018). The tall grassland area which occupies the largest area in the core area of the park viz., Eastern, Western and Central ranges and the major food plants for the Rhinos has been reduced significantly. The maximum reduction of tall grassland is observed in the Western range, while the increase in the tall grassland is found only in the Burapahar range. The reduction in tall grassland area is mainly due to erosion by river Brahmaputra while the other reason may be due to plant succession, thereby changing the tall grassland areas into woodland. Woodland areas were gradually declining till 1998 and then increasing after 1998. An increase in the woodland area is observed in the Central and Western range, whereas the area is decreased in the Eastern range, which is also due to erosion. Short grassland has also increased substantially in all the ranges except the northern range.

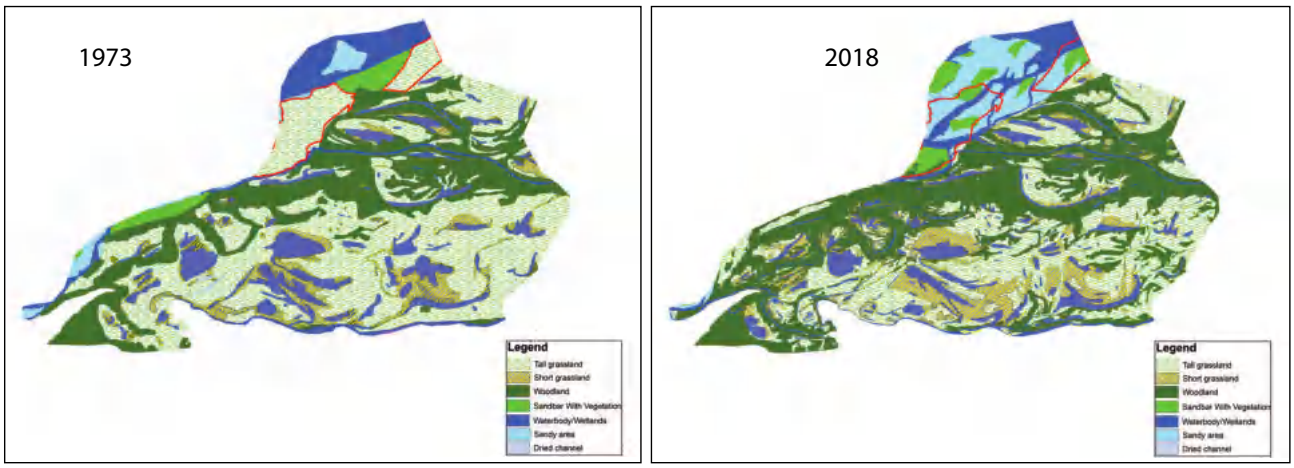
Grasslands are being burnt annually in Kaziranga National park for maintaining the seral stage of grassland for park management. As requested by the park authority, the annual grassland burnt area has also been analyzed in the park for the four years (2012, 2013, 2015 and 2018). It was observed that the burnt area during 2018 was very less as compared to 2012, 2013 and 2015 which is being attributed to the 2017 flood.

SAR applications in estimation of above ground biomass in forests of NER

Accurate measurement of vegetation biomass of forests and monitoring the changes in vegetation due to natural as well as anthropogenic activities is vital for the estimation of terrestrial carbon stock and carbon fluxes from forest ecosystems which have a major bearing on the regional and global climate change studies. Radar remote

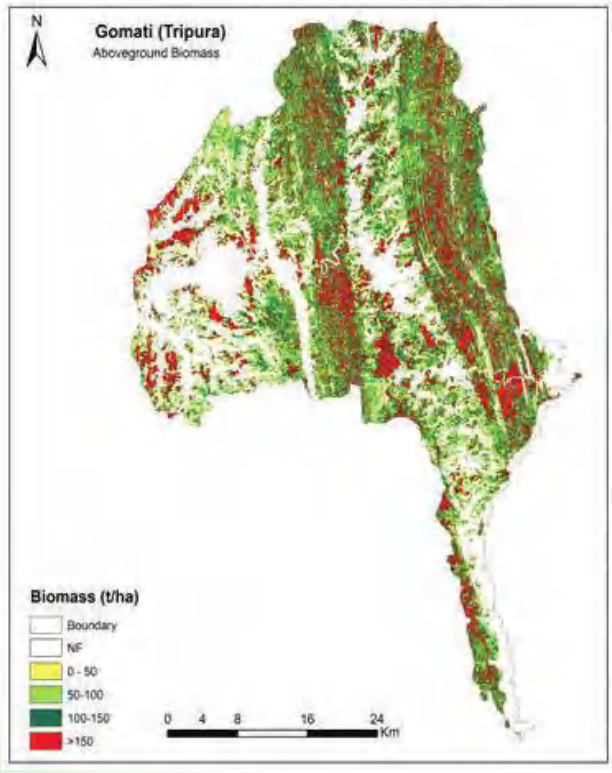
Table: Seasonal variability of major forest types of Assam

Major Forest Type	SOS	MOS	EOS
Kamrup Sal Forest	March-April	August	January
Assam Valley Tropical Wet Evergreen Forest	March-May	September-October	January-February
Cachar Tropical Evergreen Forest	July-August	November-December	May-June
Cachar Tropical Semi-Evergreen Forest	April-May	September	January-February
East Himalayan Moist Mixed Deciduous Forest	March-April	August	February
Sub-Himalayan Light Alluvial Semi-Evergreen Forest	March	August	January



Conversion of tall grassland to other land cover classes (highlighted in red colour) in the Western Range of KNP between 1973 and 2018

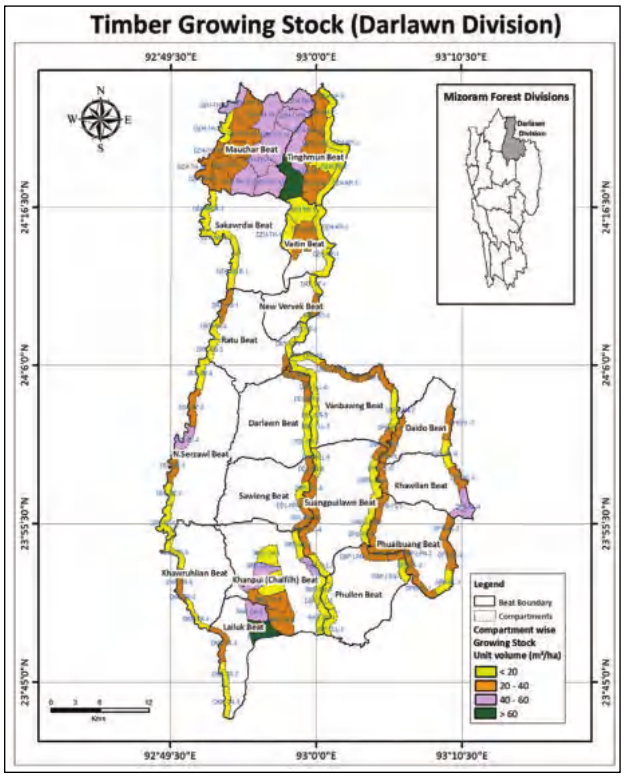
sensing is being widely used for the estimation of forest biomass. NESAC has initiated a pilot project titled "Development of polarimetric SAR model for estimating aboveground biomass of selected forests in Tripura" in collaboration with SAC, Ahmedabad and Tripura Forest Department. This project aims at providing robust models and methods for vegetation characterization and biomass estimation. Two districts of Tripura (Sepahijala and Gomati districts) are currently being mapped using ALOS PALSAR data with detailed ground sampling. Preliminary analysis of ALOS PALSAR data for biomass map generation (Level-1 map) using field inventory data and forest mask is shown for Gomati district, Tripura.



Estimated Aboveground Biomass of Gomati District of Tripura

Forest growing stock assessment using geospatial techniques for preparation of forest working plan in Mizoram

Based on the field data input, the growing stock in different reserved forests of Darlawn Division was estimated and provided to the Working Plan Officer, Mizoram Forest Division in tabular form under different girth classes for each compartment as well as in map forms. As per the requirements of the user agency to generate the working plan report in its complete form, maps were composed for the division showing land use land cover, elevation gradient, slope, aspect, drainage network, wastelands, spatial distribution of precipitation and temperature, soil types, bamboo bearing area, forest fire prone area, burnt area map, range-wise maps for compartment level growing stock estimates of timber as well as bamboo, compartment wise estimates of biomass and carbon (below ground, above ground, litter, soil and deadwood). Field visits for ground verification were also made to verify the interpreted data. The final working plan report is being submitted to the regional office of the ministry for approval and work for another division (Kawrthah) has been



Compartment level growing stock distribution for Darlawn Division

initiated. Inventory sampling points have been generated for the two riverine reserved forests of the division for initiating the preliminary works by the user department.

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 for the divisions of Anjaw, Tawang and Deomali division. Data preparation for deriving the estimates of Pasighat, Likabali and Banderdewa is ongoing.

A large area in Anjaw Division is under snow cover and forest cover accounts for about 60% of the area. A major portion of the forests (57.84%) are recorded in the higher elevation (>2400 m above msl) while minimum forest cover as well as other landuse were recorded minimum at the lower altitudes (<800 m above msl). In Deomali Division, nearly half of the area is under the lower altitudinal zone while it was least in the high elevations (16.2%). A large portion of the division is under forest cover (78.6%) with different canopy densities and open forest canopy occupies the maximum area (35.56%). 57.65% area of the division is under Village Forest Reserve, Borduria VFR and Mopaya VFR. Fire occurrence maps for some of the divisions have also been prepared based on archive MODIS data.

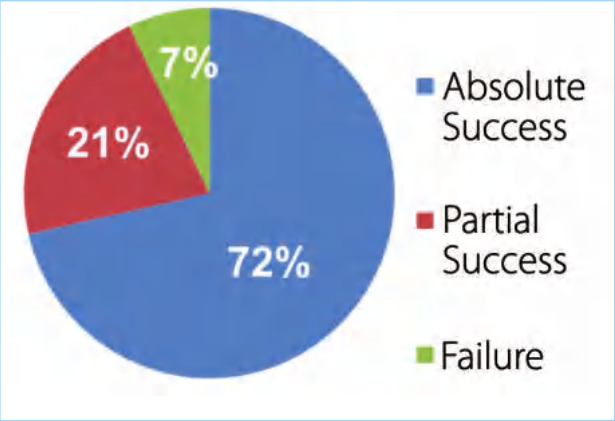
Forest canopy densities under different elevation zones in Deomali Division

Elevation Class (m above MSL)	**Density Class (ha.)**					
	D1 (Canopy >70%)	**D2** (Canopy 40-70%)	**D3** (Canopy 10-40%)	**D4** (Canopy <10%)	**Other Land Use**	**Grand Total**
< 800	2380.71	3585.30	7213.00	1546.93	3292.41	18018.35
800-1800	2122.92	2081.68	4466.37	1856.39	3034.32	13561.69
> 1800	1084.26	772.19	1734.61	800.69	1746.27	6138.00
Total	**5587.89**	**6439.17**	**13413.98**	**4204.01**	**8073.00**	**37718.04**

HYDROLOGY & WATER RESOURCES

Flood Early Warning Systems (FLEWS)

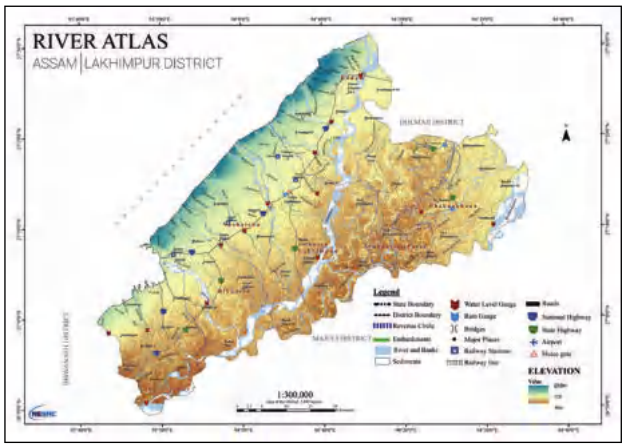
Flood Early Warning System (FLEWS) was initiated in the year 2009 on a pilot basis and became fully operational for Assam in a phased manner from 2012 to 2016. Today, the project covers all flood prone districts of Assam with actionable flood alerts in revenue circle level. All these years since the beginning, an average year to year alert success score of 75% and an average alert to alert lead time of 24 to 36 hours have been maintained. At the successful completion of the first operational period (2012-14) and second operational period (2015-17), with the strong request from Govt. of Assam, the third operational period is under progress (2018-20).



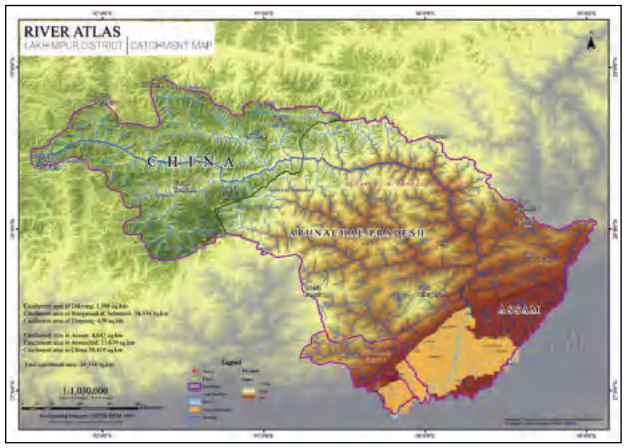
FLEWS success rate in 2019

Preparation of Assam River Atlas

The river atlas preparation for Assam has been initiated during 2017. In this project, all the major and minor rivers within the administrative boundary of Assam have been mapped at a scale of 1:5000. Mapping includes the incorporation of left and right bank, sediments, embankments, hydro-meteorological observatories, sluice gates, P&RD bunds, major locations, roads, railway lines, etc. The LULC map for all the rivers has been created with a defined buffer. In addition to this, district wise river catchment maps (in 1:25,000 scale) are being prepared which even shows the origin of all the rivers entering the respective districts of Assam. To utilize the generated layers up to the maximum possible extent, the generated layers are uploaded in a robust and user-friendly web portal (www.riveratlas.nesdr.gov.in) which can be accessed by the public for general river related information as well as by concerned river management stakeholder offices for taking engineering and field level decisions.

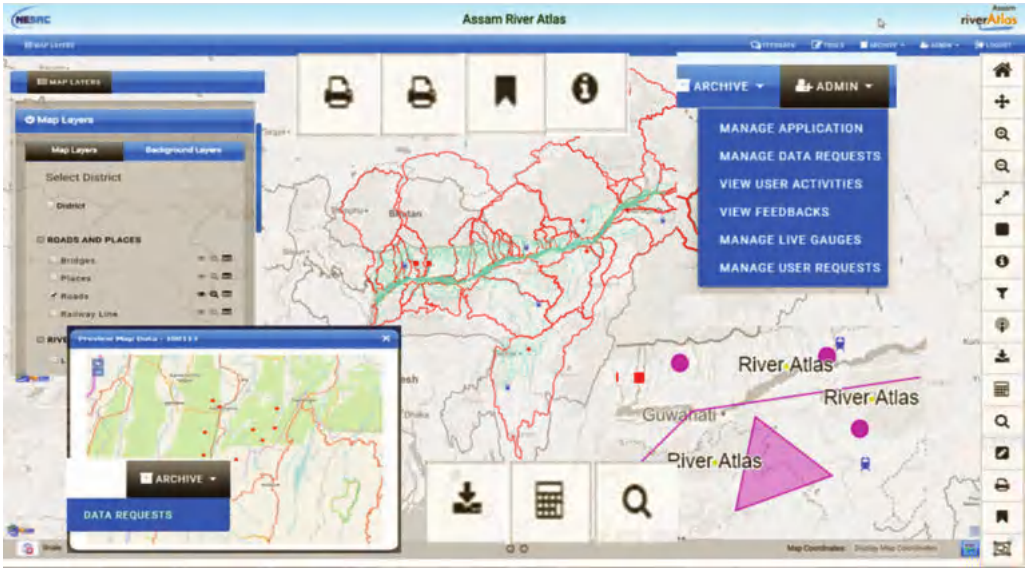


District river map



District catchment map

All the maps and layers generated in this project have been submitted to the user and funding agency. The Hon'ble Chief Minister has shown keen interest in this project, and the developed maps



Assam River Atlas Geoportal

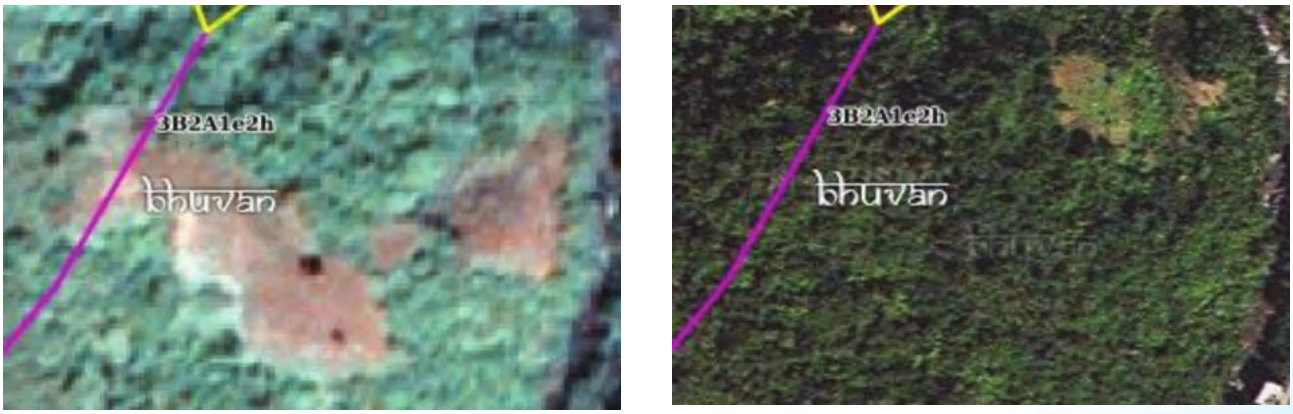
will be inaugurated by Hon'ble CM of Assam and officially handed over to Government of Assam.

Monitoring and Evaluation of IWMP watersheds for NE India

Department of Land Resources, Government of India is implementing a monitoring and evaluation system using space technology for the watersheds under IWMP (Integrated Watershed Monitoring Programme) and has signed an MoU with Department of Space for the same. For this purpose, National Remote Sensing Centre (NRSC), Hyderabad has developed a Geospatial tool called Sristi - a web GIS interface on Bhuvan and Drishti – a mobile based android application. This project is being carried out in collaboration with State Remote Sensing Centres of the corresponding state except Meghalaya. The work components for NER have been entrusted to NESAC. MoUs have been signed with all State Remote Sensing Centres in NER. NESAC is carrying out following activities in collaboration with SRSACs of NER:

- Processing of high resolution LISS-IV and Cartosat satellite data.
- Correction/ fine tuning of watershed boundaries based on SIS-DP Satellite Image.
- Generation of LULC maps, NDVI, evaluation and assessment based on Dristi photographs, change detection maps coupled with ground truth as well as year-wise report generation for each project area.

A summary report is being 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



Conversion of fallow land to forests

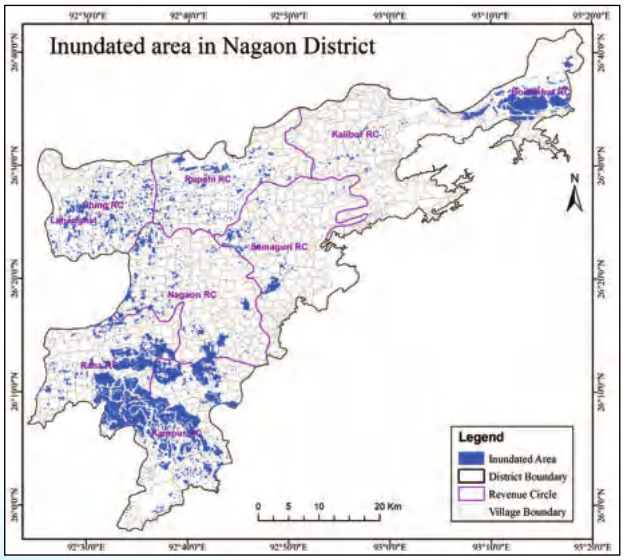
State wise progress of the project

State	No. of Projects	Shape File Collected	Accepted Geotags	Report Prepared
Arunachal Pradesh	156	88	0	
Assam	372	292	8520	36
Manipur	102	68	2577	29
Meghalaya	62	62	1334	17
Mizoram	89	103	5694	6
Nagaland	111	98	5526	2
Sikkim	15	16	1058	0
Tripura	65	65	4989	28

project. Major IWMP activities like construction of check dam, pond, development of horticulture, agriculture, afforestation, etc. are also shown with temporal satellite images.

Flood Inundation scenario of Assam as on 19th July 2019

The flood inundation map generated in near real-time by National Remote Sensing Centre, Hyderabad for Assam is being value-added in a GIS environment. The area affected due to flood inundation was estimated for every flood prone district at the village level. The flood inundation map was further analyzed to estimate the crop and built up land under flood at the district level. The administrative boundaries like district boundary, revenue circle, village boundary and thematic information on land use/land cover has been utilized from the SIS-DP project. During the 3rd week of July 2019, 9,697 villages and four revenue circles were under flood inundation in 31 districts of Assam covering an area of 4758 Ha under the settlement and 2,82,852 Ha area under agricultural land. Morigaon, Kamrup Metro, Dhubri, Barpeta, Nagaon, Hailakandi, Majuli, Kamrup Rural, Hojai, Goalpara and Salmara-Mankachar districts were reported to be worst affected.



Inundated area in Nagaon District

Nagaon District Built-up and crop land area under flood inundation

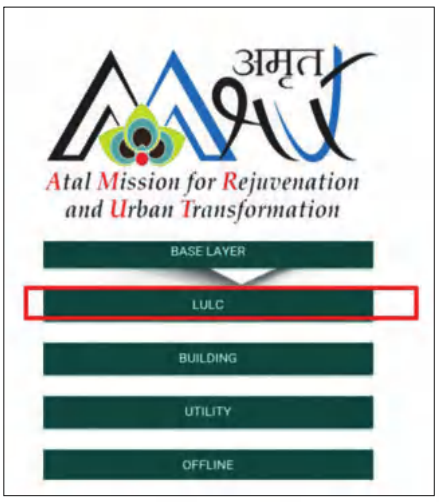
	Revenue Circle (RC)	RC Area (Ha)	LULC	Inundated Area (Ha)
1	**Dhing**	26007.8	Agricultural land	2345.16
			Built up	2.91
			Other	53.42
2	**Kaliabor**	59898.7	Agricultural land	561.47
			Built up	0.15
			Other	2769.73
3	**Kampur**	35181.1	Agricultural land	6960.07
			Built up	74.83
			Other	856.80
4	**Nagaon**	37509.7	Agricultural land	2216.89
			Built up	1.45
			Other	231.09
5	**Raha**	30063.8	Agricultural land	5958.6
			Built up	121.38
			Other	1130.39
6	**Rupahi**	27891.4	Agricultural land	1363.69
			Built up	1.17
			Other	1079.35
7	**Samaguri**	37011.2	Agricultural land	795.59
			Built up	0.81
			Other	9.74

URBAN AND REGIONAL PLANNING

Planning and development mean physical and economic growth, which meets the social needs of human society effectively. 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 synthesized 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.

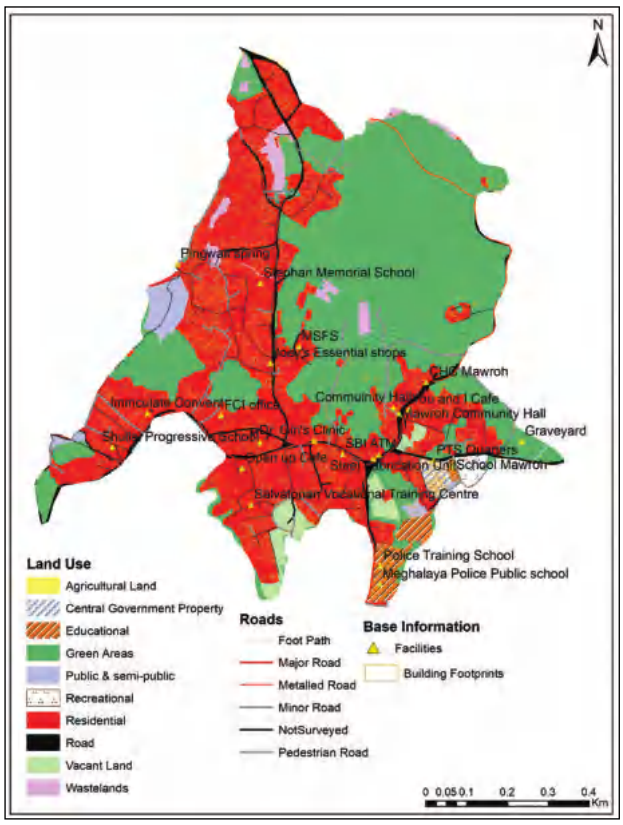
Geodatabase creation of Shillong planning area, Meghalaya under AMRUT sub-scheme

Creation of GIS-based Master Plan/ Development Plans for Shillong Planning area covering an area of 312 km at 1:4000 scale is being carried out at NESAC.



AMRUT Mobile Application

The project is funded by Urban Affairs Dept., Govt. of Meghalaya. Base layers and Urban land use layers have been generated in the planning area. Information on the infrastructure and utilities were collected from the field using a mobile application.



Base information and land use of a locality in Shillong Planning Area

A GIS based approach towards assessment of traffic congestion in Kohima city

Kohima has witnessed a giant leap in the field of development over the last decade, which has resulted in a large scale influx of rural population to the urban. Also, the popularity of the Hornbill festival and the World War-II saga globally attracts tourists from the domestic and international sectors. The increase in the traffic intensity along with the absence of any control mechanism of ever increasing infrastructure development in the town, is choking the city to its limit. The vehicular movement is at its snail's pace, which is found to have reached its saturation point.

Kohima city being capital of Nagaland, is the leading destination for a number of trips which originate from all over North-East India. Because of the absence of bypass road, traffic has to pass through the city. So during peak hours, traffic on the road exceeds the design road capacity leading to traffic congestion. This required formulation and adoption of a serious and urgent remedial measure making use of all available modern technologies, taking into account the alarming rate of increase in traffic volume and population.

One of the fundamental measures of traffic on a road system is the volume of traffic using the road in a given interval of time. It is also termed as flow and is expressed in vehicles per hour or vehicles per day. When the traffic is composed of a number of types of vehicles, it is the normal practice to convert the flow into equivalent passenger car units (PCUs), by using certain equivalency factors. The flow is then expressed as PCUs per hour or PCUs per day. Knowledge of the vehicular volume using a road network is important for understanding the efficiency at which the system works at present and the general quality of service offered to the road users. Knowing the flow characteristics, one can easily determine whether a particular section of the road is handling traffic much above or below its capacity. If the traffic is heavy, the road suffers from congestion with a consequent loss in journey speeds. Lower speeds cause economic loss to the community due to time lost by the occupants of the vehicles and the higher operational cost of the vehicles. Congestion also leads to traffic hazards. Volume counts are, therefore, indicators of the need to improve the transport facilities and are an invaluable tool in the hands of a transport planner.

The Highway Capacity Manual (HCM) has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating characteristics and traffic volumes. The Highway Capacity Manual utilizes (i) travel speed and (ii) the ratio of the service volume to capacity, depending upon the particular problem in identifying a particular level of service.

The HCM terms the traffic volumes that can be served at each level of service as the service volume. After having selected a particular level of service for design purposes, the corresponding service volume then logically becomes the design capacity, which signifies that if the traffic volume using the road exceeds that value, the operating conditions will fall below the level of service selected for the design.

Tinpatti junction is a Y shaped 3-legged junction with predominant commercial land use. The stretch of road from Tinpatti junction towards High School has a volume to capacity ratio (V/C) value of 1.07, proving that this road segment has exceeded the design capacity and has forced flow with jammed conditions. However, the other two stretch of roads i.e Tinpatti Junction towards Kohima Town & Tinpatti junction towards Don Bosco School, has derived a V/C ratio value of 0.71 and 0.49 respectively establishing nonsaturation of design capacity and relatively free flowing traffic conditions and needs minimal intervention.

Level of Service benchmarking

Level of service operating characteristics	
A	Relatively free flowing, with service volume capacity ratio of 0.60 or less.
B	Stable flow. Slight delay is common. Service volume/capacity ratio is 0.70 or less.
C	Stable flow, with acceptable delays. Service volume/capacity ratio is 0.80 or less.
D	Approaching unstable flow, with tolerable delay. Service volume/capacity ratio about 0.90 or less.
E	Unstable flow with congestion and intolerable delay. Service volume is at capacity, or near about.
F	Forced flow, with jammed conditions. Design volume/capacity ratio may well exceed 1.0. Intersections overloaded.

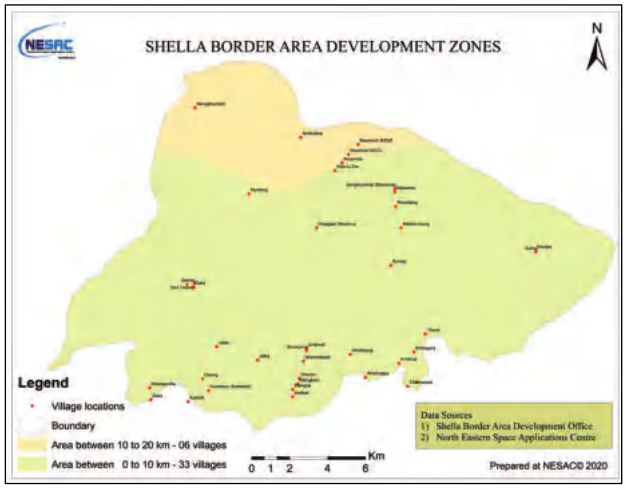
Observed peak volume and total PCU count from 7am to 7pm at Tinpatti junction

Name of the Road	Type	Observed Peak Volume 2019 (PCU/Hr)	Total PCU 2019 (7am-7pm)	Total PCU 2015 (6am-6pm)
DBS To Tinpatti Junction	2-lane	354	3077	1204
Tinpatti Junction To DBS		447	3303	1241
High School Junction To Tinpatti	2-lane	843	7469	6721
Tinpatti To High School Junction		905	6613	6749
Town To Tinpatti	2-lane	616	5882	7990
Tinpatti To Town		460	4680	7924

Volume/capacity ratio, LOS, observed peak volume away and towards the junction and total PCU count at Tinpatti junction

Border Area Development Plan, Meghalaya

On request of the Border Area Development Department Govt. of Meghalaya, the project was taken up to identify the villages covered within different zones with border areas – 10 km, 20 km and 50 km. The border areas in the state were divided into several Border Area Blocks and the location of villages in each block was represented in a map based on the information collected from the Border Area Development office. The inputs will be useful for the Dept. to identify the coverage and impact of different programs.



Shella Border Area Development Zones

Creation of Geospatial database of Shifting Cultivation/ Jhum cultivation in Meghalaya

Government of India has mandated the up-gradation of statistical data and data sources including filling in the gaps of data availability for all State Statistical Departments with the objective to ensure that (i) all vital statistical data of the state are available and up-to-date; (ii) data are accurate and meaningful for various developmental planning; (iii) gaps in data availability are filled-in. Soil & Water Conservation Department, Govt. of Meghalaya being the concerned department for control of jhum/bun/shifting cultivation, does not have up-to-date accurate data on the current spatial distribution and allied information of the cultivation practices. With this background, NESAC, Umiam in collaboration with the Soil & Water Conservation Department, has taken up the project in preparing the geospatial database of jhum/bun/shifting cultivation at 1:5000 scale. The geospatial database is being prepared and it will be linked with the socio-economic data collected from the field.

GEOSCIENCES

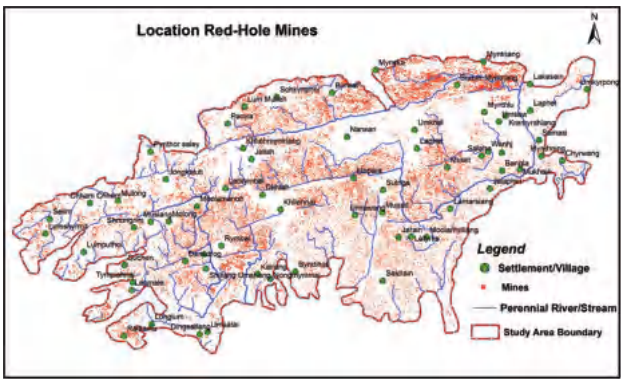
Geospatial database inputs for planning and restoration of areas affected by coal mining in Meghalaya

NESAC executed mapping of coal mining areas for planning and restoration of areas affected by coal mining using geospatial technology in the state of Meghalaya sponsored by the Meghalaya State Pollution Control Board (MSPCB) under the direction of the Independent Committee constituted by Hon'ble National Green Tribunal (NGT).

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. For this exercise, very high resolution TripleSat and GF-2 satellite data having 0.8 m panchromatic and 3.2 m multispectral resolution were used. The project was carried out in a phased manner.

Jaintia Hills (undivided) district has been covered in the first phase. A number of thematic maps such as road and settlement map, drainage map, land use/land cover map, rat hole mining area maps, etc. have been prepared for planning and restoration of coal mines affected areas as requested by the user department.

The study area covers an area of about 470 sq. km and falling in parts of East and West Jaintia Hills. About 95% of the area falls in East Jaintia Hill District. The first phase has been completed successfully and submitted the report to the user dept. for planning. The second phase of the project, which covers the parts of South West Khasi Hills as well as in East and South Garo Hills, is in progress.



Location of Rat-Hole Mines

TEC anomalies assessment for earthquakes precursor detection

NESAC has collaborated with North Eastern Hill University (NEHU) for earthquake precursor detection studies in North East India. NEHU has been working with Earth Observatory of Singapore

TEC anomalies and rate of success

Stations	ABNG	CRPJ	KPRA	MPUR	MTWR
Earthquakes of Mw > 6	3	8	7	1	1
Anomalies observed for Mw > 6	3	8	7	1	1
Rate of success for Mw > 6	100%	100%	100%	100%	100%
Earthquakes of Mw 5-6	9	48	47	19	32
Anomalies observed for Mw 5-6	8	45	39	16	27
Rate of success for Mw 5-6	87.5%	68.75%	82.97%	84.21%	84.37%
Earthquakes of Mw< 5	14	104	96	43	68
Anomalies observed for Mw < 5	6	57	38	22	30
Rate of success for Mw < 5	42.85%	54.80%	39.58%	51.16%	44.11%

(EOS), Nanyang Technological University in GPS based deformation studies. EOS, Nanyang Technological University has installed 6 Continuous Operating Reference Stations (CORS) over North East India, which are utilized in present collaborative work. A total of 160 earthquakes in the NE region and surroundings were analyzed for earthquake precursor detection using GPS based Total Electron Content (TEC) estimation in the Ionosphere. Abnormality in TEC variations was observed by constructing boundary limits using the statistical method with the values crossing the limits being the anomaly. Analysis of 160 earthquakes suggests that the rate of success in TEC based anomaly detection for earthquake precursor increases with an increase in Magnitude of earthquakes. In average, Mw>6 earthquakes were found to be 100% detectable, Mw 5-6 were found to be 81.56% detectable and Mw<5 earthquakes were 46.50% detectable. Rate of success with reference to CORS was also computed and was found in the order of Cherrapunjee, Meghalaya > Madan Kamdev, Assam > Mohanpur, Agartala > Mawtawar, Meghalaya > Khanapara, Assam. Therefore present investigations confirmed TEC anomalies prior to earthquakes and presented the expected rate of success, making it imperative to set up an automated system for real-time monitoring of TEC for Earthquake precursor detection and appropriate forewarning in the near future.

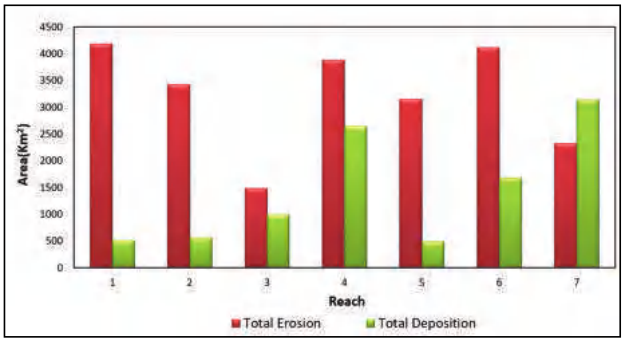
River dynamics and erosions of Manas-Beki River, Assam, India

The soil erosion of the Manas-Beki river has become a major problem, especially for Barpeta and Baksa districts of Assam as the river is characterized by frequent erosion and deposition hence experiencing a change in the river dynamics. An effort was made to identify as well as quantify the amount of erosion and deposition along the bank of Manas-Beki river during a period of seven years (2008-2015). Almost 75km of Manas-Beki river starting from the foothills of Bhutan has been studied. To acquire the bank line, right and left banks of the river from both years were digitized at the scale of 1:25,000 to compare the bankline and visually identify the erosion and deposition sites. To quantitatively calculate the amount of erosion and deposition, the study area was divided into seven reaches.

When erosion and deposition occur, they are accompanied by change in the width of the channel. The shifting of the bank lines indicates the occurrence of erosion and deposition. The results of river dynamics and erosion/deposition activity along the bank of the river will help in planning for the design and implementation of drainage development programmes and erosion control schemes for the areas near the river.

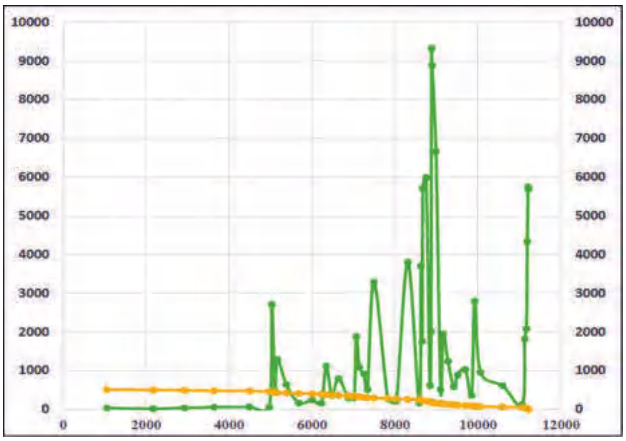
Morphotectonic analysis for tectonic study along Dawki Fault, Meghalaya

A quantitative morphotectonic analysis and identification of drainage anomalies for the active tectonic study has been carried out at five basins along Dawki Fault, Meghalaya based on geomorphic indices such as Stream Gradient



Total erosion and deposition (m^2)

Index (SL), Drainage Basin Asymmetry Factor (AF), Transverse Topography Asymmetry Factor (T), hypsometric integral (HI), Bain Shape Index (BS) and Mountain-front Sinuosity Index (Smf) using Cartosat-1 (10m) digital elevation model (DEM) and Landsat data images. The SL index in the study area along Dauki fault was found in the range of 12.6465 to 10903.7539.

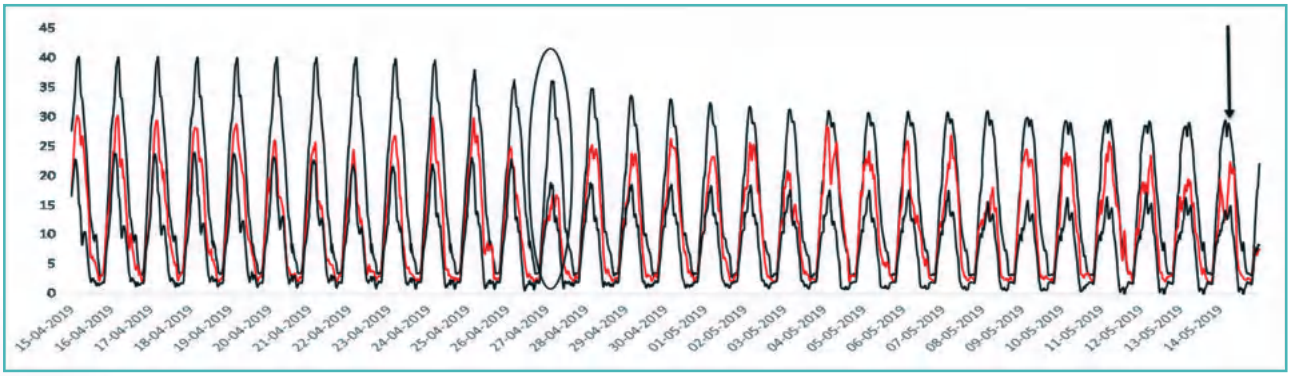


SL index from basin 1 in study area.

The values for drainage basin asymmetry factor (Af) ranges from 23.072 to 61.0375 for different basins. The drainage basin asymmetric factor (Af) reflects the existence of tectonic tilting at the scale of a drainage basin. If the values are below or above 50, it results in the basin tilting. The basin shape index value ranges from 1.911640355 to 2.54022096 for different basins. Relatively young drainage basins in active areas tend to be elongated in shape parallel to the topographic slope of a mountain. The drainage basin widths are much narrower near the mountain front in tectonically active areas where the energy of the stream is directed primarily to down cutting. The transverse topography symmetry factor (T) is another factor like drainage basin asymmetry factor (Af) that can be used to decipher small basin scale disturbances or responses due to tectonic activity. Transverse topography asymmetry index has been observed to be within 0.258310744 to 0.556293789 for different basins in the study area. Both Af and T are used as indicators of ground tilting due to deformation.

Pre-seismic perturbations in the ionosphere prior to 7.6 Mw Papua New Guinea earthquake

This study was conducted to understand Total Electron Content (TEC) as a seismic precursor. The study was carried out considering 7.6 Mw earthquake occurred in Papua New Guinea on May 14, 2019. The earthquake was located at 46km SSE of Namatanai, on the coast of the island of New Ireland, Papua New Guinea, at a focal depth of 10 km from the ground along the transform boundary of the Weitin fault. In order to detect the seismo-ionospheric perturbations, 120 days diurnal variation of GPS-TEC data was examined at three IGS stations in the pacific, namely PNGM, NAUR and POHN. The study shows that the impact of large earthquakes on the ionosphere have greater fluctuations in ionospheric TEC variations, and can be interpreted that these vertical TEC anomalies are seismogenic in nature. The results indicate a prominent vertical TEC anomaly 35 days prior to an earthquake. Variations in the TEC and magnitude of the anomalies with distance from epi-centre were also analyzed, which showed a linear trend towards the epicentre. When the stations lie closer to the epicentre of the earthquake, Slant TEC can also be used for the accurate identification of pre-seismic signals along with the vertical TEC. Thus, continuous ionospheric TEC monitoring from a large number of GNSS observations may open up a new opportunity towards effective precursor monitoring.



vTEC enhancement chart from 15 Apr-14 May for the station PNGM, black arrow denotes the day of earthquake. Identified negative anomaly is rounded in black

IT & GEOINFORMATICS

North Eastern Spatial Data Repository (NeSDR)

The NeSDR is one of the major programmes of NESAC taken up as per the directive of North Eastern Council (NEC), Ministry of DoNER with the objective to establish a geospatial network among State Remote Sensing Applications Centres (SRSACs) of NE region through augmentation of existing IT infrastructures as well as creating the catalogue of existing geospatial data generated at different scales, different time frame available with SRSACs or user and line departments. NESAC as Central Node hosts regional database, including State data, whereas respective State Nodes will be responsible for State data generated by SRSACs or other Line Departments. The NeSDR is enriched with a large number of data, web services, applications and external data links for the benefit of the various User Groups. Around 558+ datasets on different themes are made available in nine major categories – base and administrative information, infrastructures, land resources, water resources, assets & utilities, terrain, disaster management support inputs and action plan inputs.

It provides the datasets as per OGC standards for visualization 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 various users for seamless data accessibility, data visualization, interactive analysis, search and discovery of spatial data based on user's interest. The beta version is ready for release with the URL https://www.nesdr.gov.in.

List of datasets available at NeSDR

Thematic modules	List of datasets	Total numbers
Base & Administrative information	Villages, Census villages, settlement extents, boundaries for blocks, districts and states, block and district headquarters, state capitals, Assembly & Parliamentary Constituencies, polling stations, roads & drainages, etc.	**135**
Infrastructures	Road and railway networks, bridges, telecom towers, etc.	**11**
Land resources	Land use land cover, wastelands, agriculture crop and forest areas, soil, land degradation, shifting cultivation, horticulture and afforestation, biodiversity, etc.	**225**
Water Resources	Drainages and rivers, canals, catchment, watershed, micro/mini/sub-watersheds, water bodies, wetlands	**61**
Assets & Utilities	Health, police stations, tourist points, etc.	**30**
Terrain	Contour, slope, aspect and hill shed derived from satellite data	**36**
Weather	Rainfall and temperature	**18**
Disaster Management Support inputs	Floods inundated maps, landslides, hydro geomorphology, rainfalls, crop damage areas, etc.	**32**
Action plan inputs	Sub-watershed prioritization, groundwater prospect maps, etc.	**10**
	Total datasets	**558**

NeSDR 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 various Government User Departments of the region. They are mainly; Geotagging and monitoring of NEC funded projects, Election e-ATLAS for the Offices of the Chief Electoral Officers of NE states, Geotagging app for Bodoland Territorial Council (BTC), Assam, river atlas of Assam State Disaster Management Authority (ASDMA), dashboard cum mobile application for geotagging of sericulture assets for the Central Sericulture Department (CSB), Data collection cum surveillance app for controlling malaria disease for the Indian Council of Medical Research (ICMR), Regional Medical Research Centre (RMRC), Development of COVID19 dashboard application, etc. NeSDR is also integrated with data analytics capability to provide quick and informed decisions for planning activities on an experimental basis.

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 easy to use pictorial, Kokborok language based app for real-time malaria and other health surveillance, drug compliance and other health monitoring issues from village level workers. Currently, in-field trial is successfully going on in different 15 tribal villages under Gurudhan and Shikaribari sub-centres of Ambassa PHC of Dhalai district, Tripura. The village health volunteers found this app very simple and effective as it requires minimum typing, mostly picture-based and self-explanatory and local language supported. The app would help in early detection and treatment in remote areas by ensuring real-time surveillance as SMS would be received for each test, positive or negative, along with the photo and latitude and longitude of the place of test so that it can be verified and monitored remotely and regularly in real-time.

Bhu-Health Mobile App

GeoTagging and Monitoring of NEC funded Projects/schemes in NE region using Geospatial Technology and Tools

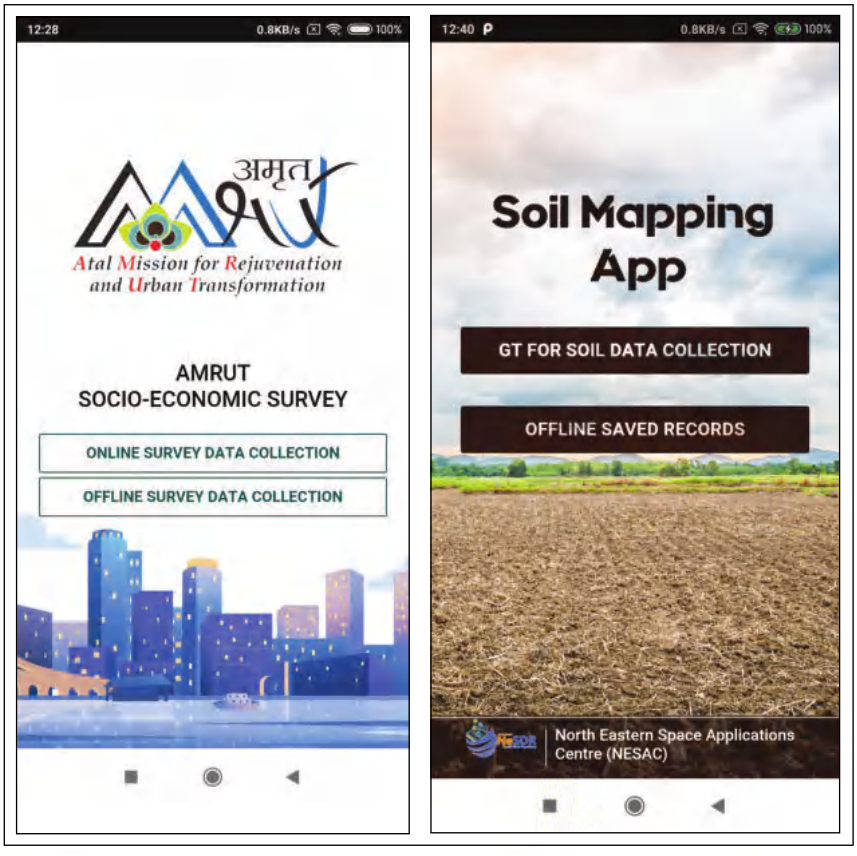
NEC GeoMonitoring App

At the request of NEC, NESAC has developed a project on monitoring GeoWeb application on the status of the projects/schemes funded by NEC for various developmental activities of NER. Based on the success of prototype monitoring application, NEC has sanctioned a major project to NESAC for full-fledged implementation of an application for geotagging and monitoring 500+ schemes sponsored to various User Departments. Those schemes are categorized in different sectors like Agriculture & Allied, Education, Sports, Medical &

Health, and Power, etc. The above schemes will be monitored in every quarter using a mobile app, satellite/UAV images and videos. The MoU with the SRSACs of NER has been signed to execute the work in collaboration. The development of both dashboards and mobile app is under the final stage of completion.

Other governance applications developed for the user department of NE region

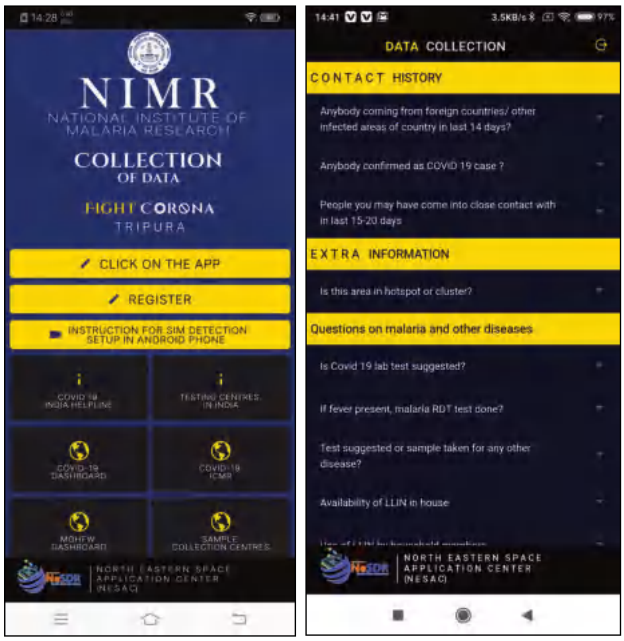
NESAC has been supporting a number of User Departments in planning and monitoring their Governance activities through dashboard and mobile applications. The Election e-ATLAS for the Offices of the Chief Electoral Officers (CEO) of NE states, Geotagging Dashboard cum mobile application for geotagging of schemes of BTC, Dashboard cum mobile application for geotagging of sericulture assets for the Central Sericulture Department (CSB), Muga disease early warning system, CrimeGIS for Shillong, Geotagging app for Assam Soil Department, etc. Currently, BTC has geotagged around 1555+ project sites using the mobile app developed by NESAC. The e-ATLAS is currently used by the Offices of CEOs for their operational activity. The dashboard cum geotagging applications have been released for operational geotagging activity. The applications are currently used by the Department for geotagging their sericulture assets. The soil mapping app is currently used by the Meghalaya Government for the collection of soil related data along with GPS coordinates. The mobile app developed under Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is currently used for socio-economic surveys in the State of Meghalaya.



User interfaces of few Governance Apps of NE region

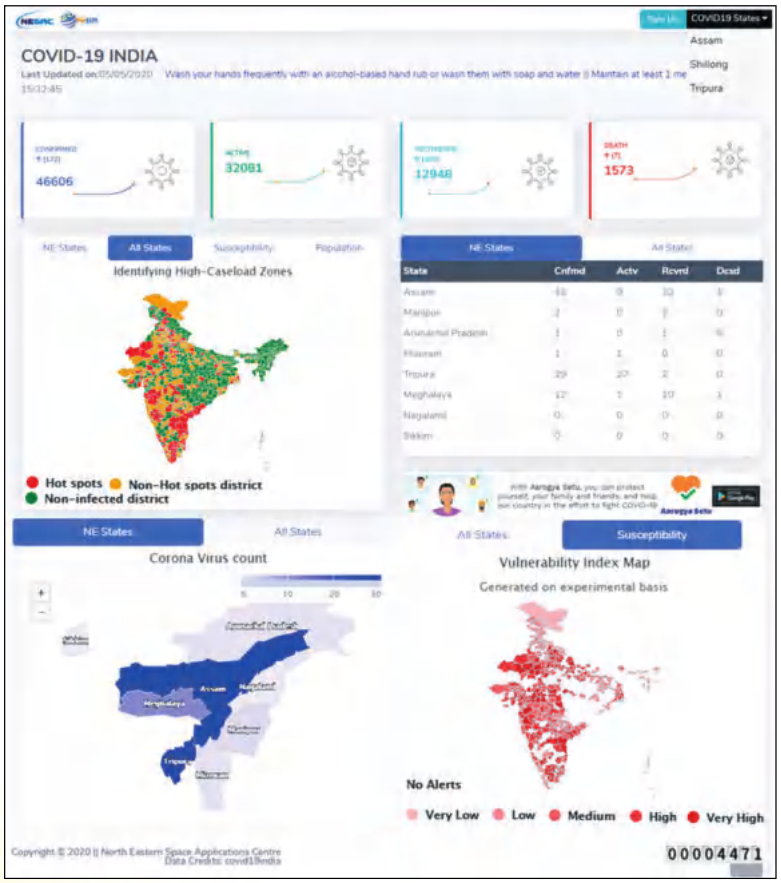
Development of Covid19 web application

NESAC has initiated the development of decision support based web applications to support the concerned Government Departments of Assam, Meghalaya and Tripura to fight against COVID19. Both NESAC and RMRC (Regional Medical Research Centre), Indian Council of Medical Research (ICMR), Dibrugarh, Assam are jointly coordinating with the Government Departments of the region and provides necessary support to fight against Corona pandemic spread. Initially, NESAC has developed a mobile app known as 'FIGHT CORONA' as per the guidelines of ICMR with an aim to combine the community and health worker



User interface of FIGHT CORONA app

risk assessment with the response of the health system. Subsequently, NESAC has developed a covid19 dashboard and hosted at https://covid19.nesdr.gov.in to provide the state-wise statistics



Landing page of Covid19 dashboard

on the spreads of COVID19 on a real-time basis. The dashboard application developed for Shillong city is ready to receive the live tracking data to be posted by the mobile app developed by IIT Bombay (Meghalaya Government has given necessary instruction). The FIGHT CORONA mobile app was demonstrated to the Tripura Government by ICMR and Tripura Government has directed the health workers to utilize the mobile app. ICMR is coordinating with other State Government Departments of India for utilization of the FIGHT CORONA app.

Utilization of Artificial Intelligence/ Machine Learning/Deep Learning Techniques

NESAC is utilizing 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 is actively participating as a core member of the Inter Centre Task Team of ISRO on AI and Big Data analytics towards the implementation of pilot application oriented projects and effective use of ML/DL techniques. The centre is in the process of acquiring a very high-end GPU server with 40 core CPUs, 1024GB RAM, 256GB GPU memory for implementing various DL applications.

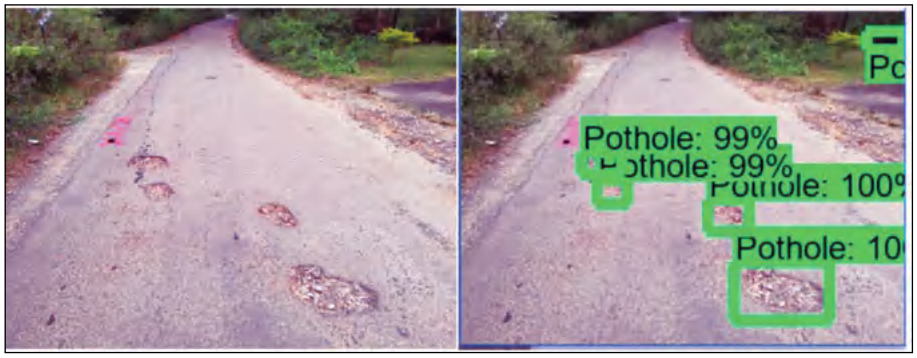
Some of the application oriented techniques developed by NESAC are illustrated below:

a) Monitoring conditions of roads, status of construction sites etc.

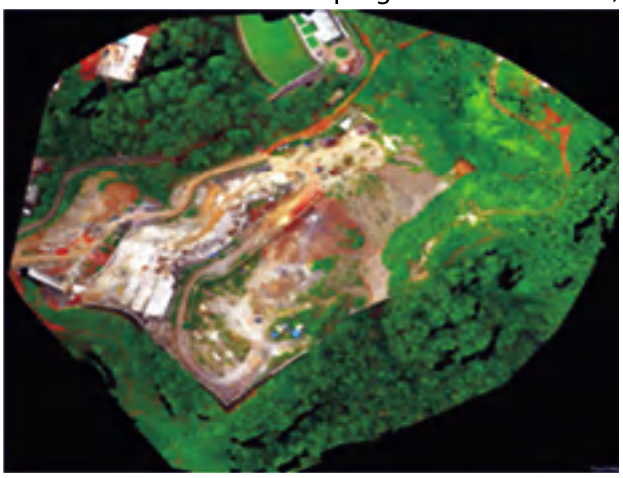
NESAC has developed a framework for monitoring the condition of the roads and the construction status of buildings

etc. using DL techniques. The potholes in the roads are detected from the real-time images captured by an IoT device mounted in the vehicle. The trained models for pothole detection are integrated into the IoT device, where GPS tracker is used to track the location of the potholes. The whole experiment is under testing for any operational use.

Another case study was taken to monitor the status of the construction sites of the upcoming Inter-State Bus Terminal (ISBT) of Meghalaya. Two sets of UAV images captured during the year 2018 and 2019 were used for classification of the area covered under vegetation and target area for construction. The accuracy of the model is enhanced with more number of training samples and the model gets refined with the new datasets. This mode of monitoring mechanism using DL techniques will be quite useful for the concerned Government Department as it can quickly give the accurate status on the construction progresses. In addition,



Automatic detection of potholes from the roads using DL embedded IOT device



UAV image of ISBT (27-7-2018)

NESAC has developed a DL based approach, which is based on the deep residual networks for the extraction of building footprints from satellite images. The neural network was trained with the sample image patches of CARTOSAT and Worldview data. The study was carried out in Shillong city of Meghalaya.

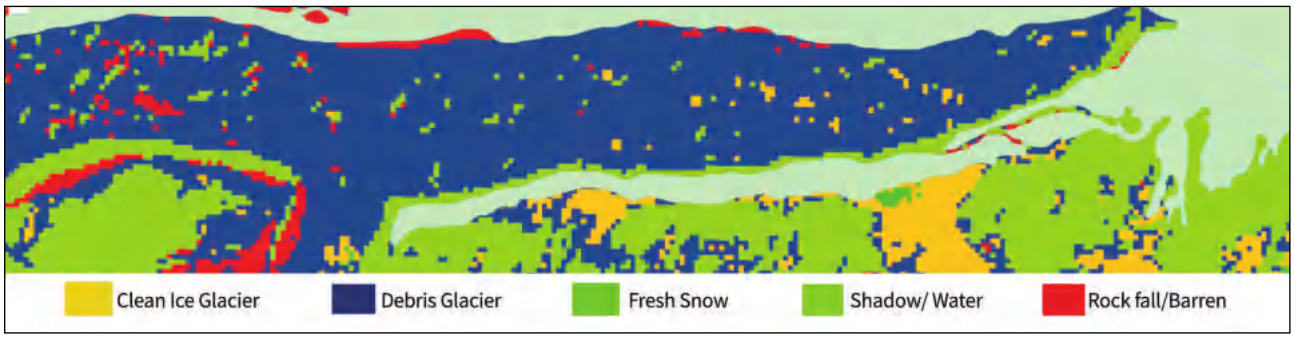
b) Automatic extraction of water body and tree cover

An attempt was made to extract the water body from multi-temporal Sentinel-2 data using the DL technique. The DL model was trained with the 100 scenes of Sentinel-2 data over the NE region and corresponding ground truth images have been generated. Presently, RGB bands of Sentinel-2 data of March, October, December of the year 2019 are used. Another case study was carried out to extract the tree cover from UAV images in a few selected areas of Ri Bhoi and East Khasi Hills district. The DL model was trained with the input dataset comprised of 300 patches of UAV images.

c) Google Earth Engine for large-scale remote sensing analysis

Two case studies have been attempted using the Javascript and Python APIs of Google Earth Engine (GEE). The first case study attempts to identify and map of glaciers in the Sikkim Himalayas using GEE. For this process, two techniques were adopted: thresholding using index values and supervised classification. It was observed that the Normalized Difference Snow Index (NDSI) provided maximum variations between glaciers and debris. Using simple supervised classification techniques such as the Naive Bayes classifier, the distinction between the glacier and related land cover features were evident.

Blue is debris glacier, yellow is clean ice, red is rockfall and green is snow.



Identification of glaciers in the Sikkim Himalayas using GEE platform

Other case studies assess the forest fire burn patches during the fire season 2020 using the Sentinel-2 and Landsat-8 data of the period March-November 2019. The algorithm successfully removed the shadow and water regions as demarked by yellow arrow.

d) Drone derived point clouds its classifications using computer vision and OS tools

The computer vision-based technique such as Structure from Motion (SfM) with its variety of feature extraction algorithms can be used on different drone datasets to effectively detect, describe and match unique features on these images. Further, the dense point clouds thus derived can be used for precise segmentation and classifications of points representing different features in the 3D scene. A case study was carried out for automatic classification of buildings, vegetation and land surface features from a 3D point cloud generated from the drone datasets. The high-resolution UAV images and their corresponding point clouds of some parts of East Khasi Hills, West Khasi Hills and Ri Bhoi districts of Meghalaya were utilized for the experiment.

Other Technology development projects on AI/IoT technology

As part of the technology development programme (TDP), NESAC is collaborating the following projects with the different academia of the country in the areas of AI and IoT applications:-

a) Design and development of a Physical Working Prototype to showcase an optimized algorithm and software for image acquisition and processing using Swarm of Autonomous UAVs (Drones): This is one of the unique initiatives taken up as part of Hackathon 2018 problem conceptualized by NESAC. The work is initiated in collaboration with the Department of Computer Science & Engineering, K. J. Somaiya College of Engineering, Mumbai to develop an optimized AI/DL based framework for image acquisition and processing using a swarm of autonomous UAVs.

b) Development of IoT and Android Based Location Aided Flash Flood monitoring System for Anil Nagar area of Guwahati city: The project is initiated in collaboration with the School of Technology, Assam Don Bosco University, Azara, Guwahati. The IoT framework is realized using 5 base stations (Raspberry Pi, Camera, LoRa Receiver module) and 30 nodes (Water level Sensor, Arduino, LoRa Sender, Temperature, Humidity, Rainfall, Air Quality) using LoRa gateway.

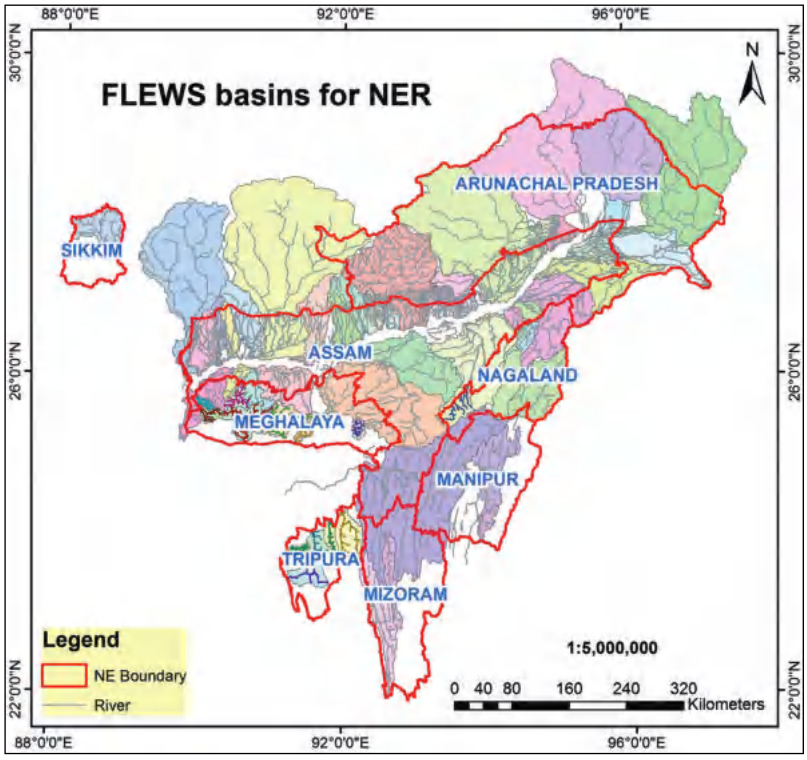
c) Development of UAV with real-time object detection & onboard data processing capabilities: The major objective of this work is real-time object detection using an IoT sensor integrated on a UAV device. Procurement of the associated devices including sensors etc. has been under finalization.

DISASTER MANAGEMENT SUPPORT

NESAC has been providing all possible space based support for management of disasters in NER of India, by building a comprehensive geospatial database, developing decision support tools, actionable products and services for disaster risk reduction under the North Eastern Regional Node for Disaster Risk Reduction (NER-DRR) programme. During the last year, NESAC worked on various disaster related activities which are briefly described below:

Flood Early Warning Systems (FLEWS)

On the advice from Chairman, ISRO, there is an additional focus on the extension of FLEWS services to other North Eastern states based on priority under the NER-DRR program. The quasi distributed models have been built for states of Arunachal (7 rivers), Nagaland (3 rivers), Tripura (5 rivers), Manipur (2 rivers), Mizoram (2 rivers), Meghalaya (8 rivers) and Sikkim (1 river). Presently the models have been built and made ready for calibration and validation. Simultaneously institutional arrangements are getting established through a series of stakeholder meetings, especially with the state level disaster management authorities and Remote Sensing Centers. During 2019 monsoon, several experimental alerts have been issued for Meghalaya, Arunachal Pradesh and Tripura.



Catchments covered under FLEWS for NER

Assessment and monitoring of embankment breach locations under FLEWS in Assam (2019-2020)

River embankments are also known under various nomenclatures as Levees, Dykes, etc. They are essentially flood control structural measures constructed along the river banks. As a part of 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 July 2019 to identify the embankment breaches due to the floods. Using Sentinel-1 SAR data, 18 breach locations were identified in 8 districts of Assam.

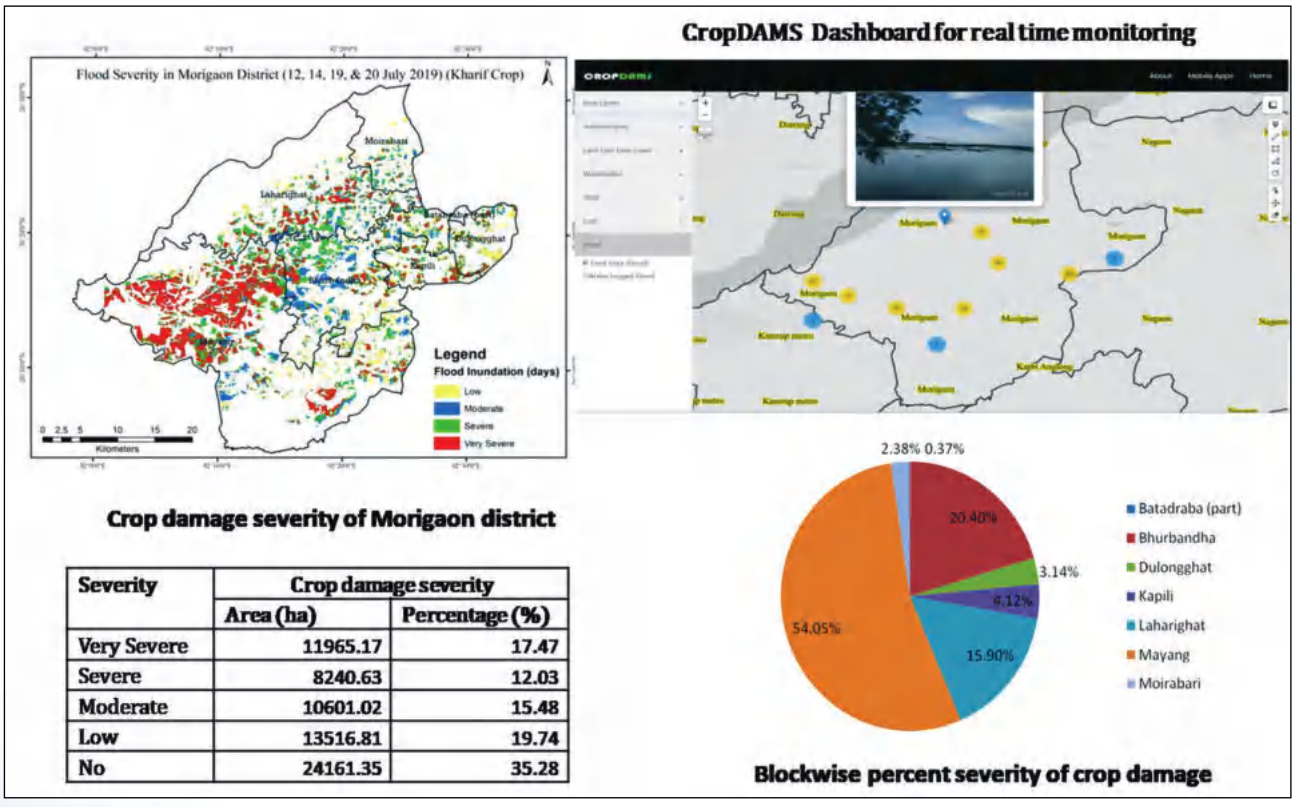
An attempt has also been made to evaluate the embankment breaches using Planet Lab archive data acquired during the month of January to April 2020 and the status of plugged or unplugged breaches

have been evaluated. 18 numbers of breach locations that were identified using sentinel-1 data are relooked for monitoring its status. Out of 18 breaches, 15 are plugged and the remaining 3 are unplugged.

Crop Damage Assessment and Monitoring Service (CropDAMS)

The Crop Damage Assessment and Monitoring Service (CropDAMS) is one of the recent additions of the North Eastern Space Applications Centre (NESAC) under the North Eastern Disaster Risk reduction (NER-DRR) programme. The major aim of the work is to get a comprehensive understanding regarding the crop loss (model based) in near real-time due to the floods and other factors. It uses multi-temporal satellite images of different sources for assessment and monitoring activities on a real-time basis. It is comprised of a GeoWeb Dashboard application integrated with the Mobile App. Dashboard application provides visualization of assessment and monitoring services in the spatial domain with analytical tools. CropDAMS Mobile App is being used for validation as well as field data collection both in online and offline mode.

In 2019, Morigaon was one of the worst affected districts of Assam due to floods. CropDAMS mobile app was used to collect field data about the disaster and its severity in the district. Monitoring, assessment and analysis of the propagation of floodwater in the agricultural area were done using multi-temporal Radarsat data. The extraction of flood severity layer has been done using spatial data modeling. Blockwise severity distribution was estimated and a detailed report was submitted to the concerned department for their planning purposes. This work was carried out with support from the District Agriculture Office, Morigaon district, especially during field visits to all the affected areas.



Severity	Crop damage severity	
	Area (ha)	Percentage (%)
Very Severe	11965.17	17.47
Severe	8240.63	12.03
Moderate	10601.02	15.48
Low	13516.81	19.74
No	24161.35	35.28

Crop Damage Assessment and Monitoring Service (CropDAMS)

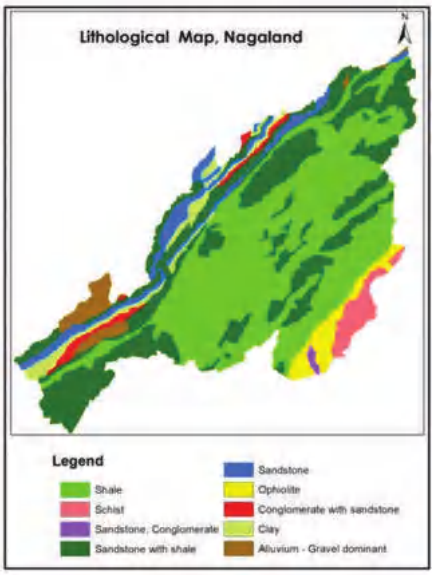
Landslide susceptibility mapping in NER

Landslide is one of the major natural hazards which are commonly found in mountainous regions of the world. Considering the current scenario of frequent occurrences of landslides pertaining in this region, NESAC initiated the preparation of landslide susceptibility map of NER using remotely sensed data and GIS with limited ground surveys as well as existing collateral data. The preparation of the susceptibility map will be carried out in a state-wise manner based on priority. The map will provide information on the spatial likely-hood of occurrences of the landslide of any area of the state qualitatively.

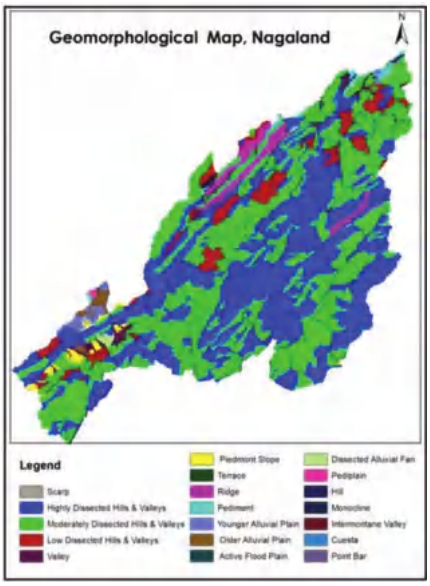
In the first phase, the preparation of a landslide susceptibility map for the state of Nagaland has been completed. Some of the important parameters used in the preparation of the susceptibility map are lithology, geomorphology, etc. The final susceptibility map thus prepared from a scientific database, especially for undertaking landslide mitigation measures. In addition, it can be important information in various infrastructural planning and development activities such as alignment/realignment of a new route, site investigation for a hydropower plant, dam, bridges, mega building structures, etc.

Forest fire assessment in NER

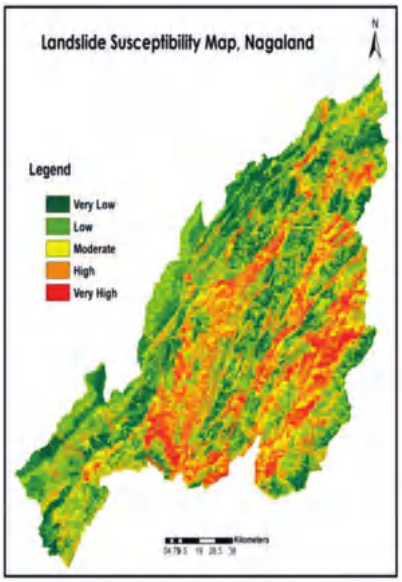
Forest fire hazard alerts based on fire occurrence for each state were given from the month of February to April every year. The forest fire locations are obtained from NRSC Bhuvan. Additional information on site characteristics like forest type, forest density, elevation, slope, road connectivity, etc., are added for evaluation of the fire spread. During the year 2019, the entire NE region of India has witnessed around 9568 numbers of fire incidents. The state of Mizoram showed the highest number of fire incidents with 2349 fire counts, followed by Assam, Manipur, Meghalaya, Tripura, Nagaland and Arunachal Pradesh. Forest fire burnt area assessment is also being attempted for NER. An example of a burnt area observed in Churachandpur & Pherzawl discricts of Manipur is shown in the figure. Churachandpur is one of the 16 districts in the south-western corner of Manipur, covering an area of 4,750 sq. km an area of 341 sq. km burnt patches observed in the district during March 2019. For comparison, November 2018 is taken as a pre-fire satellite image.



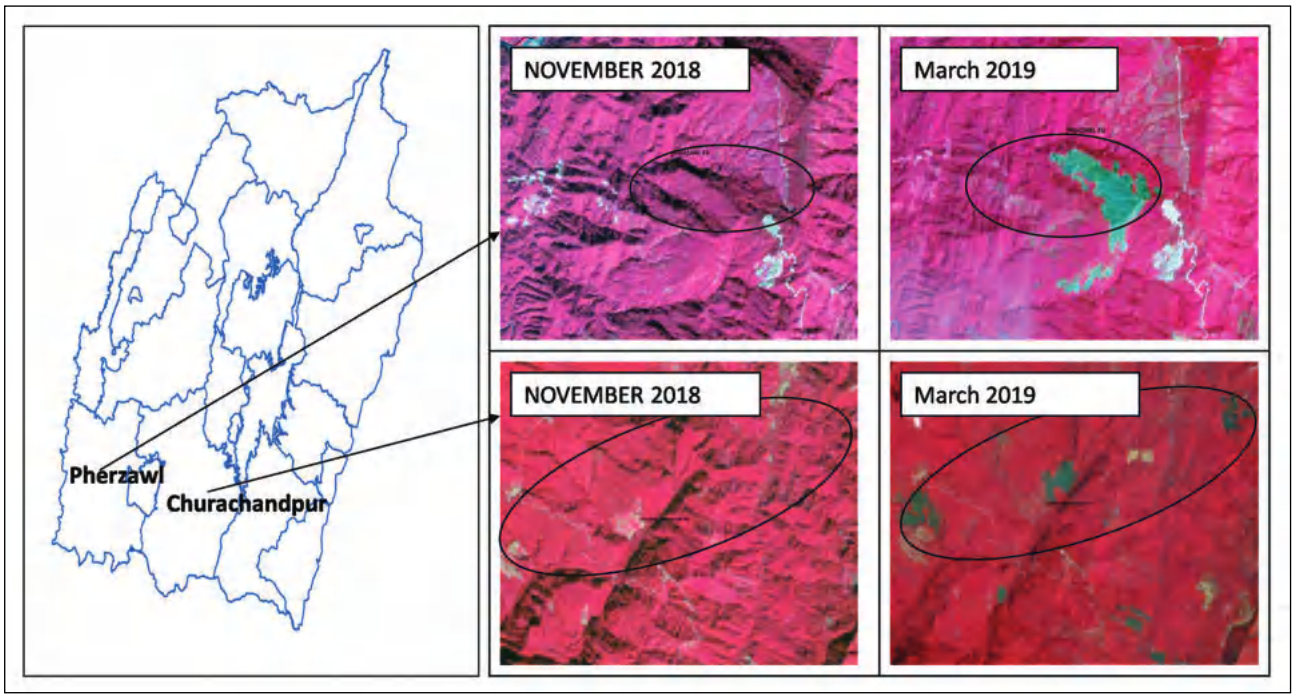
Lithology



Geomorphology



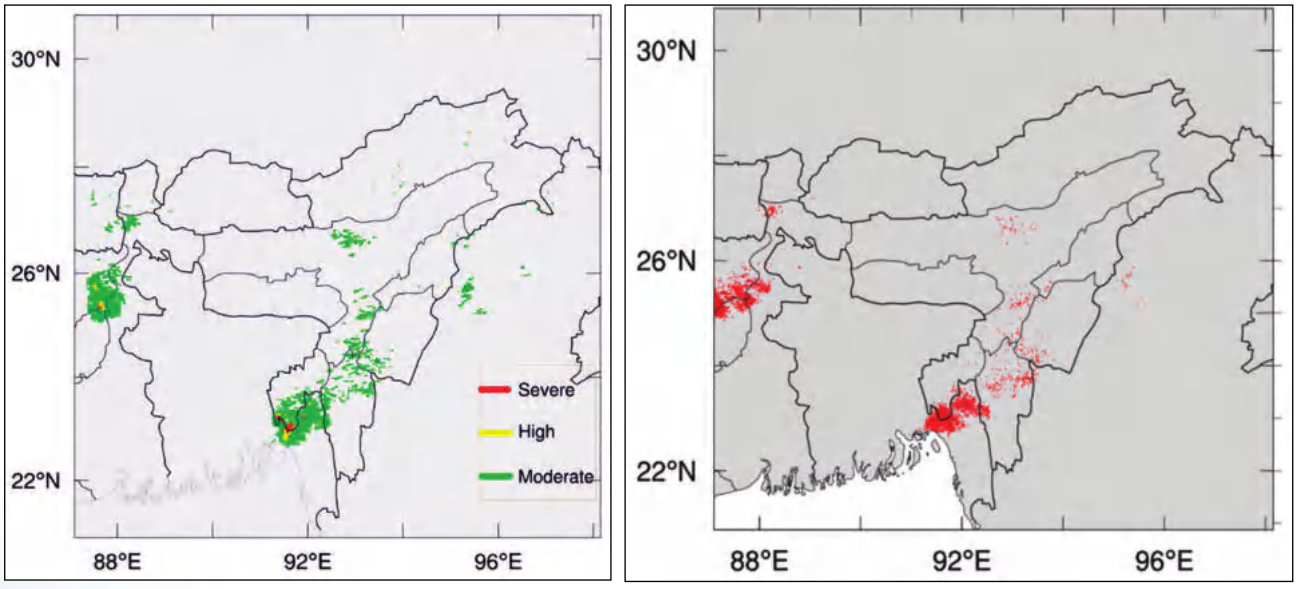
Landslide Susceptibility



Burnt area observed in Churachandpur district

Severe Storm and Lightning Nowcasting Services

NESAC, through its NER-DRR initiative, has been providing severe thunderstorm nowcasting services for the entire NE region of India. NESAC has recently initiated location based early warning of lightning. Severe storm nowcasting was done like last year in a two tier system consisting of the preparation of "Thunderstorm Potential Map" and "Thunderstorm Nowcasting Bulletin". Thunderstorm Potential Map was prepared using the WRF (Weather Research and Forecasting) model forecasts on Convective Available Potential Energy (CAPE), Convective Inhibition Energy (CIN), Lifting index, K-index, and columnar moisture. The thunderstorm potential map identifies the regions having high potential to generate a thunderstorm of different intensity. The



Forecasted lightning flash density (Left) and observed lightning locations (right) with two hour lead time on 9th April 2019

thunderstorm nowcasting bulletin is also prepared by near real-time monitoring of weather conditions using data from Satellites, Doppler Weather Radars, Lightning Sensors, and Automatic Weather Stations. Both the potential maps and bulletins are generated thrice daily during pre-monsoon season (15 March–15 June), with a lead time of three and four hours, respectively. The services are delivered to the concerned stakeholders directly by e-mail and also through the NER-DRR website.

During the year 2019, an attempt has also been made to provide location specific lightning strike warnings with a lead time of up to 6 hours. This has been done by the assimilation of real-time lightning location data in a numerical model with a spatial resolution of 3 km. The lightning location data provided by M/s Earth Networks has been extensively used to generate such a forecast. The forecasts have been shared with the district administration in near real-time. The forecasts till 3 hours lead time were seen to correlate well with the observed thunderstorm events and are used for operational nowcasting.

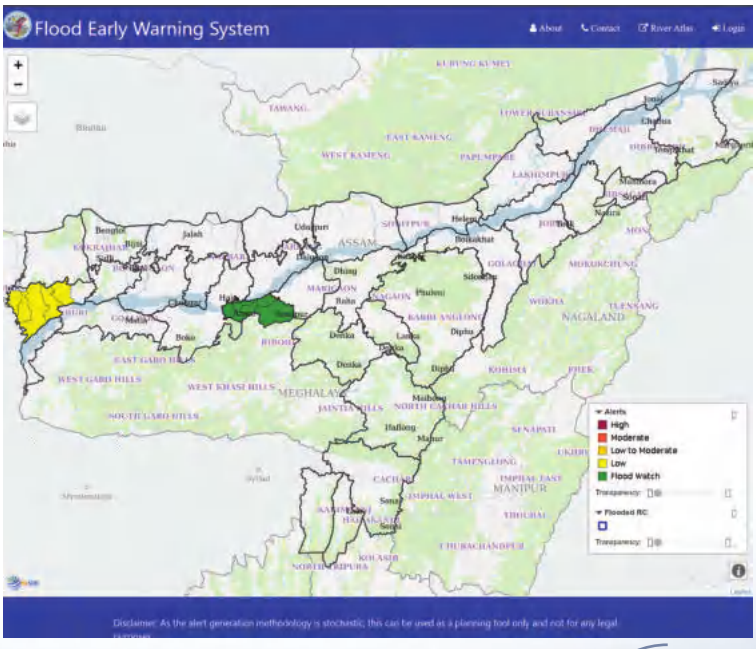
IT Support and Services under NER-DRR

The NER-DRR centre 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 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 NER-DRR programme of NESAC are highlighted below:

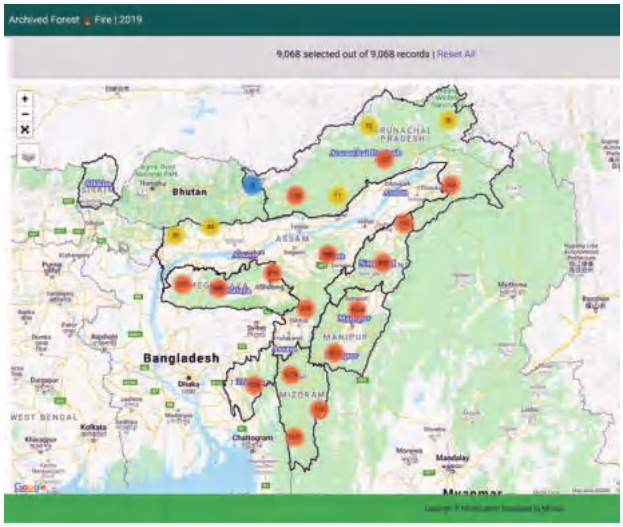
FLEWS Dashboard

A web portal has been developed using open source tools the user can visualize the alerts for different districts of Assam as well as visualize the flooded and non-flooded areas. The administrator of the portal uploads the alerts along with the validity period. Once the validity of the alert expires, the alerts are automatically removed from the portal. The administrator also has the provision for reporting the areas affected by a flood. The figure below shows the different districts in Assam affected by the flood as visualized by the FLEWS geoportal.



Forest Fire Dashboard

A geospatial dashboard has been developed to visualize the current forest fire alerts along with the



Forest Fire Dashboard showing clusters of fire occurrences during 2019 in NER

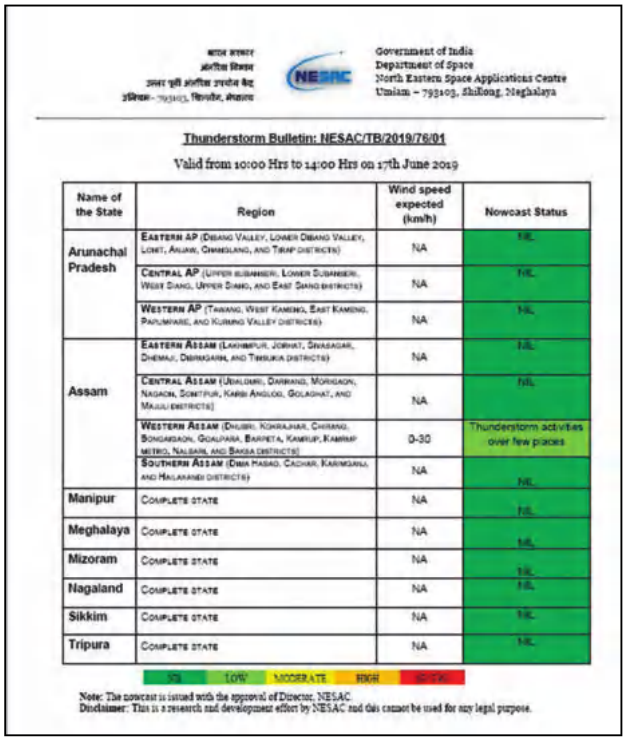
historical/past alerts. The reported alerts of forest fire have many associated variables along with it, some of them being State, LULC type, Distance from nearest Roads, Villages and water bodies and also date and time of occurrence. The user can query based on the above parameter also.

Severe Thunderstorm and Lightning Nowcasting

Severe thunderstorms (TS) and lightning nowcasting services are disseminated using the NER-DRR web portal on a near real-time basis. TS nowcasting services are uploaded in the NER-DRR portal since 2017 under the NER-DRR initiatives at NESAC. The services are provided from 15th March to 15th June every year with three times updation of the nowcasting services.

Experimental Short Range Weather Forecast

The Weather Research and Forecasting (WRF) model is being run at NESAC since 2010 to give 24 hour weather forecast specifically for Flood Early Warning System (FLEWS) project and weather advisory services. The model is presently run at a 9km resolution for domains covering NER by assimilating surface and upper air observations from in-situ measurements and satellite data. During the flood season, the NER-DRR Portal disseminates different WRF forecasts such as 24 Hr accumulated rainfall, hourly accumulated rainfall, relative humidity and temperature at 2m Height and hourly winds at various levels (200 hPa, 500 hPa, 700 hPa, 850 hPa, 900 hPa) for 48 Hrs.



Government of India
Department of Space
North Eastern Space Applications Centre
Umiam – 793103, Shillong, Meghalaya

Thunderstorm Bulletin: NESAC/TB/2019/76/01

Valid from 10:00 Hrs to 14:00 Hrs on 17th June 2019

Name of the State	Region	Wind speed expected (km/h)	Nowcast Status
Arunachal Pradesh	Eastern AP (Dibang Valley, Lower Dibang Valley, Lohit, Anjaw, Changlang, and Tirap districts)	NA	NIL
	Central AP (Upper Subansiri, Lower Subansiri, West Siang, Upper Siang, and East Siang districts)	NA	NIL
	Western AP (Tawang, West Kameng, East Kameng, Papumpare, and Kurung Kumey districts)	NA	NIL
Assam	Eastern Assam (Lakhimpur, Jorhat, Sivasagar, Dhemaji, Dibrugarh, and Tinsukia districts)	NA	NIL
	Central Assam (Udalguri, Darrang, Morigaon, Nagaon, Sonitpur, Kamrup Anglong, Golaghat, and Majuli districts)	NA	NIL
	Western Assam (Dhubri, Kokrajhar, Chirang, Bongaigaon, Goalpara, Barpeta, Kamrup, Kamrup metro, Nalbari, and Baksa districts)	0-30	Thunderstorm activities over few places
	Southern Assam (Dima Hasao, Cachar, Karimganj, and Hailakandi districts)	NA	NIL
Manipur	Complete state	NA	NIL
Meghalaya	Complete state	NA	NIL
Mizoram	Complete state	NA	NIL
Nagaland	Complete state	NA	NIL
Sikkim	Complete state	NA	NIL
Tripura	Complete state	NA	NIL

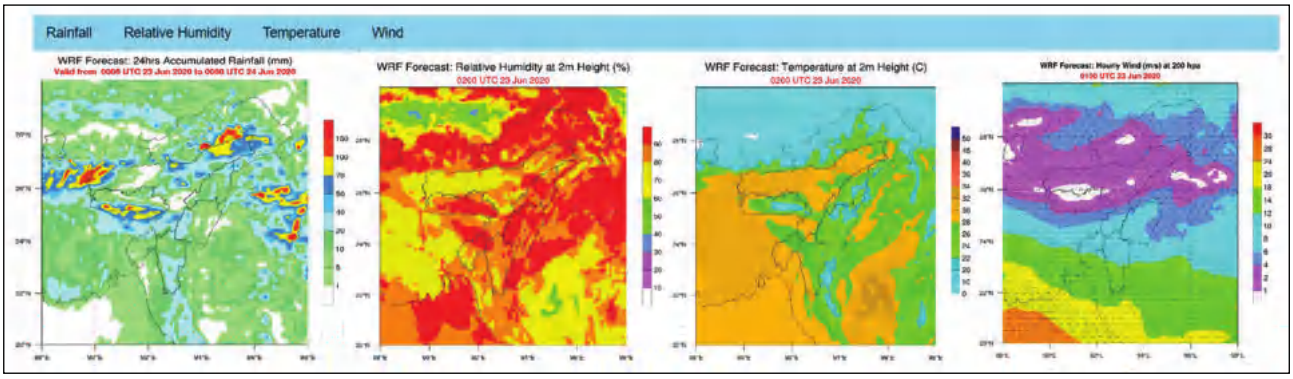
NIL | LOW | MODERATE | HIGH | SEVERE

Note: The nowcast is issued with the approval of Director, NESAC
Disclaimer: This is a research and development effort by NESAC and data cannot be used for any legal purpose.

Thunderstorm Bulletin issued for the day

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.



NER-DRR portal showing different WRF daily data products

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 trainings, 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 three training programs on 'Applications of Geographic Information System in Disaster Risk Management' sponsored by 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 17–18 October 2019, the second training was held during 9–13 December 2019, and the third training was held during 06–07 February 2020. A total of 62 participants have been trained during these three training programs. The first training program was inaugurated by Shri T Dkhar, IAS, Commissioner and Secretary, Social Welfare Department, Government of Meghalaya.

The training was mainly focused on different topics including Basics of Remote Sensing (RS) and Geographical Information System (GIS), Global Navigation Satellite System (GNSS) and their applications to various disasters like flood, forest fire, landslide, earthquake, thunderstorm, cyclone, lightning, weather forecasting, Web-GIS, satellite communication, and UAV technology. These courses include some invited lectures by resource persons from NRSC & GSI on the topics related to earthquake seismic risk seismotectonic domains, landslide hazard zonation & early warning, and National Database for Emergency Management (NDEM). The two-day training program was mainly focused on theoretical lectures, whereas the

Participants and faculties of NESAC along with Chief Guest Shri T Dkhar, IAS during the first training program

five-day training program consisted of various hands on exercises on flood forecasting, landslide susceptibility mapping, GNSS, etc. During the five-day training program, one full day field visit was conducted to demonstrate Doppler Weather Radar (DWR), Unmanned Aerial Vehicle (UAV), Indian Navigation Satellite System (NaVIC) - Global Navigation Satellite System (GNSS) systems to the participants.

PHOTOGRAMMETRY & UAV APPLICATIONS

Unmanned Aerial Vehicle (UAV) Systems at NESAC

Unmanned Aerial Vehicle (UAV) popularly known as drone, is an airborne system or an aircraft operated remotely by a human operator or autonomously by an onboard computer. UAVs can be assembled as per the applications. UAV remote sensing technology has been widely used to acquire geospatial data on land resources and the environment. The imagery obtained from UAVs can immensely support in many applications ranging from large-scale mapping, urban modeling to vegetation structure mapping. North Eastern Space Applications Centre (NESAC) has expanded its activities in the field of UAV remote sensing (UAV-RS) and applications. With the advancement of 3D printing technology, in-house mini UAVs for the experimental purpose have been developed. NESAC has demonstrated some unique applications such as tethered UAV for continuous surveillance, drop mechanism for dropping of medicine, food and relief material at the time of disaster. NESAC has also integrated NAVIC based VTS (vehicle tracking system) for monitoring of UAVs. The following new UAV systems such as Quadcopter, Hexacopter and fixed wing UAVs have been added as shown in the figure below.

(a) 3D printed small Quadcopter

(b) Assembled Quadcopter

(c) Quadcopter with thermal and Multispectral Camera as payload

(d) Lightweight and portable Quadcopter with 20 MP Hasselblad camera

Aerial Survey using UAV Platforms

NESAC has been effectively providing operational UAV services in the NER region. NESAC has conducted more than 14 UAV surveys in the year 2019-20 for different users departments in NER, as shown in the list below:

List of survey conducted

Sl. No	Survey Area/ Location	User
01.	Nongkhra village survey (near Nongpoh, Meghalaya)	NESAC & District statistical office, Nongpoh
02.	Landslide mapping near NEPA, Barapani, Meghalaya	NESAC
03.	Project Monitoring at ISBT Shillong, Meghalaya	North Eastern Council (NEC)
04.	Sericulture farm mapping at Tura, Meghalaya	Central Silk Board (CSB) and NESAC
05.	Mapping Nongsder football ground and nearby area, Umiam, Ri Bhoi, Meghalaya	Village Headman Nongsder
06.	Water pipeline leakage detection and damage assessment due to the disaster at Kopili	North Eastern Electric Power Corporation (NEEPCO)

07.	Ukhrul (Manipur) to Pfutsero (Nagaland) road mapping	Border Roads Organization (BRO) and NEC
08.	Wetland mapping at Umiam lake, Ri-Bhoi, Meghalaya	Forest Department, Meghalaya
09.	UAV survey of diseased tree at Umiam lake using Multispectral camera, Ri-Bhoi	NESAC and Forest Department Meghalaya
10.	Village mapping at Nongkhrah, Nongpoh, Meghalaya	NESAC & District statistical office, Nongpoh
11.	Mapping of Girar ridge, Lalitpur, UP	Remote Sensing Application Centre, UP
12.	Community forest and Wetland mapping, West Jaintia Hills, Meghalaya	Divisional Forest Officer, Jowai
13.	Agricultural Crop mapping, Ahmedabad (Gujarat) and Vidisha (M.P.)	SAC Ahmedabad and NESAC
14.	Mapping of Nonstoin town for urban planning, Meghalaya	NESAC

Research and Development of UAVs

In addition to aerial survey using UAV platforms and various UAV based applications provided by NESAC as service to various user departments, NESAC also works on various research and development areas. Some of the research and development works currently going on in collaboration with educational institutions are briefly given below:

1. IISc: UAV team at NESAC has collaborated with IISc, Bengaluru to develop an amphibious UAV to collect multiple water samples from multiple locations in a single flight. The water sample collected can then be tested for its contaminants and also for its dissolved nutrients.
2. K.J. Somaiya College of Engineering: UAV team at NESAC has also collaborated with K.J. Somaiya College of Engineering to develop a network of swarm drones to accomplish a common target. The drones shall work in coordination with each other keeping a common objective.

UAV based Capacity Building Programme at NESAC

Under the Capacity Building Programme of NESAC, every year, two weeks residential training programme on the advancement and various applications using UAV platform in the area of Remote Sensing Technology is being carried out. During 16–27 September 2019, the two weeks UAV Remote Sensing (UAV-RS) training programme has been conducted successfully. About 34 participants from various parts of the country had participated in the programme. The major focus of the training was to elaborate on the importance of UAV platforms in Remote Sensing technology and applications for various planning and developmental activities, which will help in making a better society. The lectures include UAV technology and recent advancements, UAV Photogrammetry and data processing techniques, UAV data analysis for different applications in the field of Agriculture, Disaster management, Forestry, Infrastructure planning, construction monitoring, etc. The course also includes intensive hands-on practical training for UAV data processing. The course/ training programme also focuses on certain mini-project works in different themes of UAV applications such as Forestry, Agriculture, Disaster management, urban planning, etc. Participants were also introduced to 3D printing technology.

UAV training programme, September 2019 batch

RS and GIS based inputs for suitable route alignment planning of construction of Mahadev-Toloi-Pfutsero road

Roads are the key to the development of economic activities for both commercial and residential. Road connectivity is the factor determining the speed of growth and development of a place. Infrastructure and connectivity in north eastern region (NER) of India are poorer being in the most remote corner of the country and due to its geographical location. Inadequate infrastructure and poor connectivity in NER because of geographic conditions and other reasons lead to the inaction of the socio-economic conditions of the villagers. NER being hilly terrain region, disruption of communication links during rainy season due to landslides and mudslides has become a major difficulty. Planning for development of a new or alternate route to connect between two endpoints is based on the various factors such as the socio-economic, administrative as well as strategic importance of the area, region or the country.

This work has been initiated 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. This work involves the generation of landslides susceptibility map using various geo-environmental parameters with the aid of remote sensing and GIS techniques in conjunction with existing collateral data with limited field survey and to suggest a new aligned/ realigned route using the defined gradient criteria. Along the proposed aligned route, an aerial survey using Unmanned Aerial Vehicle (UAV) will be conducted for the generation of very high resolution Digital Elevation Model and to perform the volumetric/ cut & fill analysis for earthwork estimation.

Reconnaissance/preliminary survey for the proposed align/realign route was carried out in the state of Nagaland and Manipur to understand the terrain structures, landforms, land use land cover, etc. Based on the recent satellite data available in NESAC and along with the existing collateral and in-situ data, SOI topo maps, etc., the thematic layers such as base maps, LULC, drainage, geomorphology, Lithology, Lineament, Soil texture, slope, aspect, etc. are generated. There are various methods or approaches for the preparation of landslide susceptibility zonation adopted by many experts. Using the thematic information and using spatial association analysis for categorical spatial factors with the help of Yule's Coefficient, the susceptibility zonation maps were generated. The susceptibility zonation maps are categorized into the following five classes – very low, low, moderate, high and very high using natural cut-off ranges as shown in figure.

Using the landslide susceptibility map and with the gradient criteria, i.e., 1:20, the road alignments were performed to connect Dungrei, Manipur and Pfutsero, Nagaland. A total of 12 alternate road alignments were generated from the start point to the destination of the study area. Considering the future scope of development and spatial distribution of the existing villages along the aligned route, the proposed aligned route of 122.74 km (approx.) length, is finalized.

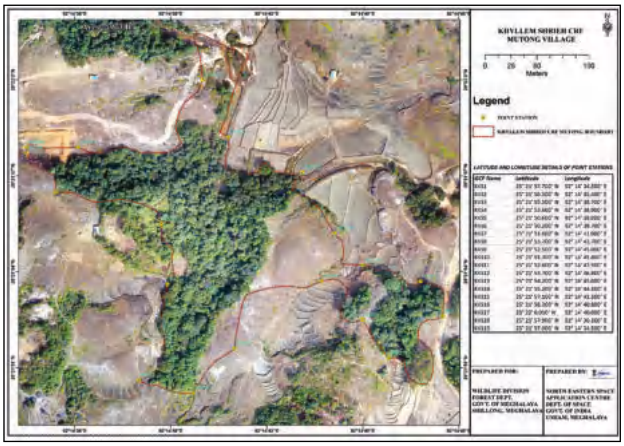
To perform the aerial survey using UAV along the final proposed road alignment, around 80 nos. of Ground Control Points (GCPs) were identified.

The DGPS and aerial survey using the UAV platform will be conducted as per the objective of the work and accordingly, the volumetric analysis and cross-section profile generation will be generated for earthwork estimation.

Large Scale Survey and Mapping of Community Reserves in Meghalaya

Surveying technique like DGPS and the total station has been widely used for mapping in the recent past. In addition, with the development of UAV based surveying approach, time and manpower requirement has been reduced drastically for any kind of land surveys. The objectives of this work are to surveys and map the community reserve forests using a multi geophysical approach (DGPS/ Total Station/UAV). DGPS surveying is carried out to establish the base points and collect the ground control points (GCPs) in and around the study area. Depending on the thickness of the forest/ tree canopy of the study area where the boundary mapping is not possible from the aerial image, the total station survey method is deployed along with the DGPS survey. In such cases, the points (GCPs) collected using the DGPS survey are used to establish the initial point/ location for the total station survey to continue the data acquisition process of the study area. UAV is deployed to acquire aerial photographs with predefined flight plans of the study areas. Using photogrammetric techniques, UAV data/ images are processed to generate point clouds, digital surface model (DSM), digital terrain model (DTM) and orthophotos. The integration of GCPs improves the accuracy in centimetres (0.002m) of the resultant outputs. The average point density generated for the photogrammetric based point cloud is 92 per m^3. Based on this, the DSM of 3.14cm posting and orthomosaic of 3.14cm/pixel ground sampling distance (GSD) were generated. Using the field surveyed data (DGPS/Total Station/UAV) and also as per the inputs from the user department, boundaries of each community reserves are delineated in the GIS platform. The deliverables of the project include boundaries of each community reserve forests and the maps defining areas in a GIS platform.

This work has been carried out for four community reserve forests in West Jaintia Hills Districts as proposed by the Chief Wildlife Warden, Government of Meghalaya. Out of the four community reserve forests, two nos. of community reserve forests are completed and the other 2 nos. of community reserve forests are in progress. The figure below shows the maps of the community reserve forests.



Community reserve forest boundary map

Wetland Survey and Mapping using UAV for Umiam Lake, Meghalaya

UAV Photogrammetry imaging applications are increasing rapidly in large scale mapping of Wetland areas for better management. Moreover, GPS enabled UAVs for aerial surveying is very cost effective in comparison to hiring an aircraft with Photogrammetry equipment. UAV platform with the type of camera used is also more efficient in providing near real-time images with ultra high spatial resolution. The Large Scale Wetland Survey and Mapping using UAV for Umiam Lake, Meghalaya was requested by State Forest and Environment Department, Govt. of Meghalaya. For this work, a multi-rotor UAV (M100) was used

to carry out the aerial survey. The multi rotor enables vertical takeoff and landing, which are often needed in mountain sites, where there are few wide open spaces without obstacles and complex in nature. It is also more reliable to perform an irregular, linear, and low flight. A Zenmuse X3 RGB camera has been used to perform the aerial survey of the community reserve forests. The specification of Zenmuse X3 is given in the table given below.

Table: Specification of Zenmuse X3 RGB camera

Camera Dimensions	6.17 x 4.55 mm
Optics	20mm (F/2.8)
Sensor	CMOS
Image dimensions	12.4 MP
Max Field of View	94° (diagonal)
Operating Temperature	-10 to 40°C
Shutter Speed	8 - 1/8000s

As required and requested by the user department, the extent of the survey area has been designed with a 500m buffer from the periphery of the reservoir with a total area of 25 sq. km. Due to the limitation of the flying time of multirotor, multiple aerial surveys have been planned. The average flying heights above the ground were determined based on the complexness of the terrain. The aerial data/ geotagged photographs are then transformed into any of the following types of products using UAV data processing software.

- ***Point clouds:*** sets of data points in a 3D coordinate system that represent the external surface of terrain or object. The average point density generated for the point cloud is about 85 per m^3
- ***Digital surface models (DSMs):*** files containing elevations that include buildings, vegetation, power lines and other above-ground objects. The ground can be seen only when there is nothing on it. A posting of 13.5 cm DSM is generated using the point cloud data.
- ***Orthomosaics/orthophotos/images:*** files containing aerial photographs geometrically corrected so that the scale is uniform with ground sampling distance (GSD). Using the DSM, orthomosaic of 13.5 cm/pixel ground sampling distance (GSD) is generated.

Survey and Mapping of Girar Ridge at Lalitpur, Uttar Pradesh using Unmanned Aerial Vehicle

Drones in mining improve the overall efficiency of the large mine site and quarry management by providing accurate and comprehensive data detailing site conditions in a very short time. Drone aerial images are used to generate point clouds, digital surface models, digital terrain models and 3D reconstruction of a mining site, including its stockpiles. As the point cloud contains several thousand data points, very accurate volume calculations can be performed easily. This enables high-accuracy calculation of stockpile value. When compared with traditional manned aviation surveys, the use of drones is cost effective.

This work has been carried out in collaboration with Remote Sensing Application Centre, UP. The main objective of this work is to generate very high resolution DSM and orthomosaic of Girar ridge, Lalitpur in UP. The outcomes will be used by the user department to understand and support mining exploration projects where it is difficult to navigate on foot. The total area covered was 7 sq. km. The specification of the camera sensor used for the aerial survey is given in the table below and the figure shows the orthomosaic image (GSD 3.95 cm/pixel) of the study area.

RGB camera sensor specifications

Camera sensors	CMOS, 1" Effective pixels: 20MP
Lens	F/2.8-11, 8.8mm (35mm Equivalent: 24mm)
Field of View (FOV)	77 degree HFOV
Photo resolutions	3:2, 5472 x 3648

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, NESAC 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 also has facilities like SATCOM studio for content generation, transportable WLL-VSAT for emergency communication, primary node under ISRO-DMS VPN network, Satellite Interactive Terminals under Tele-education network, Spacenet connectivity for secure communication among other ISRO centres, Ka-Band propagation experiment facility, mobile satellite services terminals developed by ISRO, etc.

Tele-Education project in north eastern states during 2019-20

All the seven HUBs cum Teaching end and 329 Satellite Interactive Terminal (SIT) are operational in all the NE states. Nagaland Tele-Education network is ready with 25 nodes and is managed by SCERT, Nagaland, as the nodal agency. The state wise 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 Manipur

Hundreds of live and recorded programs were telecasted by these networks in 2019-20 and more than 50000 students/other groups were benefitted by these networks.

Communication support for disaster management

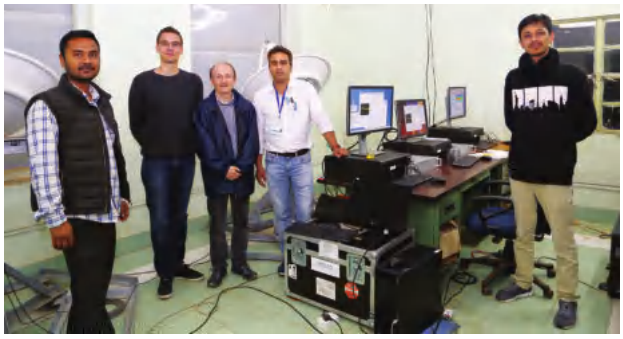
NESAC is equipped with a number of Satellite Mobile Radio (SMR) and SatSleeve terminals under GSAT-6 satellite for emergency communication. NESAC has a transportable VSAT system and a node under the ISRO DMS network to communicate with NDMA, New Delhi and SDMAs of all NER states at the time of emergency. These systems are 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 on the propagation of the Ka-Band signal for use in Satellite to earth communication. These signals are expected to suffer higher attenuation than conventional C or Ku-band satellite signals, especially in high rainfall regions like tropics. CNES, ONERA and ISRO has jointly collaborated to do Ka-Band propagation Experiment in tropical regions of India. Beacon signals at Ka-Band transmitted from GSAT satellite are received at ground stations at various parts of India.

The Ka-Band Experiment facility at NESAC has a ground station with a set up for measuring the attenuation of the above-mentioned signals due to rain. 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.

With the setup, it has been possible to analyze Rainfall and Signal Attenuation Statistics at Umiam from February 2016 onwards. Various parameters like Rain Drop Size Distribution, Cumulative Probability of Rain Rate, etc. have been deduced from the equipment.



ONERA team at NESAC during April 2019

Demonstration of internet connectivity using 1.2 m VSAT through High Throughput Satellite (HTS) GSAT-11

ISRO has launched 03 High Throughput Satellites (HTS) till now, namely GSAT-19, GSAT-11 and GSAT-29. These satellites use novel techniques like spot beams having higher power, frequency reuse and use of Higher Frequencies (Ka-Band which enable narrower beams to generate satellite communication throughputs which are much higher (in the range of 10-20 Gbps) in comparison to traditional single beam or multi beam communication satellites (300-400 Mbps).

These HTSs will be mostly used to introduce satellite-based internet services in India, which is already prevalent in many other regions of the world. The high throughput means that very high-speed internet connectivity can be provided on the ground and remote areas also may be connected with such high bandwidth digital connectivity without the need to extensively set up ground infrastructure like optical fiber cables etc.

GSAT-11, India's heaviest (~6 tons) communication satellite was launched in December 2018 and is an HTS with 40 Ku/Ka-Band transponders. To utilize the high capacity provided by the satellite, ISRO coordinated with many stakeholders to take the benefits of the satellite to every corner of the country. Once in orbit, the Geostationary satellite would cover regions of the country with multiple high-power spot beams. These beams can be intercepted by small sized receiving VSATs and a local Hub can be made from where high-speed internet connectivity can be extended to nearby areas via WiFi connectivity. This means people can use the satellite-based connectivity to browse internet through known wireless modes. This alleviates the need for extensive last mile arrangements at user premises.

VSAT near the school, where the service point was set up in Arunachal Pradesh

The concept for easily accessing the all-weather high bandwidth internet was planned to be demonstrated in selected locations of the country by ISRO. For this, a Hub was set up at Ranchi, Jharkhand and two locations were selected in Arunachal Pradesh and Meghalaya in North East India where traditional internet coverage and in general electronic communication is poor. It was planned to establish one service point at each of these two locations to provide internet in nearby locations. NESAC was given the responsibility of coordinating the whole activity in coordination with other stakeholders in February 2019 for a demonstration to PMO.

Two teams from NESAC left for the two locations with people from other stakeholders. The teams coordinated with the local authorities of the village to set up the service points there. The teams set up the necessary logistics, coordinated with the Hub at Ranchi and ISRO Hq at Bangalore and demonstrated high-speed internet access to the villagers. The two locations selected by ISRO for the demonstration were Gunapati village in Jirang area of Meghalaya and Kokila village in Arunachal Pradesh.

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:

Vertical profiling of absorbing aerosol over a mountainous terrain

Aerosol interacts strongly with the meteorological variables within the Atmospheric Boundary Layer (ABL). Aerosol-ABL interaction has a significant effect on air quality, weather, and climate. Very few studies have been conducted on the vertical distribution of aerosols using in-situ measurements, especially over the North Eastern Region (NER) of India. To make such measurements for the first time over NER, a campaign was conducted using a tethered balloon along with Microaethalometer and Dr. Pisharoty Radiosonde. The balloon was launched up to 1 km altitude for characterization of absorbing aerosols and meteorological parameters over Umiam covering different seasons during the year 2019.

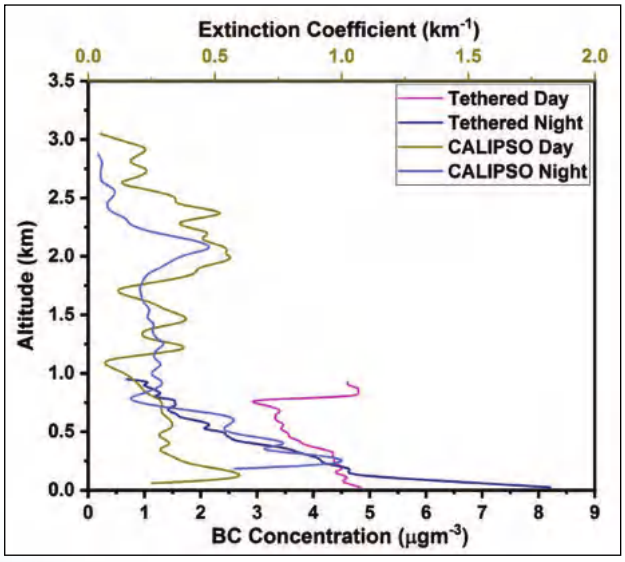
Kytoon/tethered balloon (volume: 9.9 cum) manufactured by TIFR (Tata Institute of Fundamental Research) was used as an instrument platform for the lifting of Dr. Pisharoty Radiosonde and Microaethalometer for vertical profiling of meteorological parameters (Temperature, Pressure, and Relative Humidity) and black carbon (BC) aerosol respectively. The launches were carried out 4 times per day at 6 hourly intervals. The derived parameters like virtual potential temperature (θv) and specific humidity (q) obtained from the raw data of radiosonde helped in assessing the mixed layer height (h) of the ABL.

Hydrogen gas filled tethered balloon

The vertical profile of BC and meteorological parameters showed diurnal variability throughout the day. Vertical profiles of temperature, pressure, relative humidity, specific humidity and virtual potential temperature were also observed to be in good agreement with the profiles of BC, indicating the impact of ABL on BC variability. The maximum average concentration of BC was found during night time near the surface. AAE at every 25 m altitude suggests the dominance of BC from fossil fuel burning over the study region. The BC concentration decreases gradually with an increase in altitude, however the pattern changes throughout the day. During noontime, the BC concentration was observed to remain almost unchanged throughout the vertical column. During morning time, enhancement of approx. 50% was seen around 250 m altitude, which probably

occurs due to capping inversion during January winter morning. The BC concentration above 400 m height was lowest during morning hours and highest during noontime, while below 400 m height, the concentration was highest during night time and lowest during evening, suggesting a strong influence of ABL evolution and convection.

Smoke extinction coefficient measured by CALIOP payload onboard CALIPSO satellite for the winter season (January and February) of 2019 has also been validated with the help of in-situ measured vertical profile of BC mass concentration. It is seen that their patterns, when observed individually, appear to be the same from both CALIPSO and Microaethalometer. While the night time profile had a very good match between the CALIPSO and Microaethalometer barring the surface level concentration, the day time profile by CALIPSO was heavily underestimated. It has been documented that CALIPSO is unable to differentiate the smoke from polluted continental aerosols within 2.5 km height (assumed planetary boundary layer height) and also it may not be possible to conclude anything from a single profile comparison. Studies are being conducted to validate the same using multiple profiles covering different seasons.



Comparison of vertical profiles of BC concentration (as measured using Microaethalometer) and extinction coefficient of Smoke (from CALIPSO) during winter season (January-February, 2019).

These findings suggest the requirement of more follow-up studies on the impacts of aerosol - ABL interaction and comparison studies with satellite and model data. A campaign covering other stations of North East India for the next cycle of seasons during the year 2020-2021 has been planned for better spatio-temporal resolution of vertical profiles along with the launch of the meteorological balloon 8 times per day at 3 hourly intervals synchronized with a tethered balloon launch. Furthermore, evaluations of mountain valley circulation, heating effect, etc. are also planned from the experiments.

Aerosol characterization over eastern Himalayan region

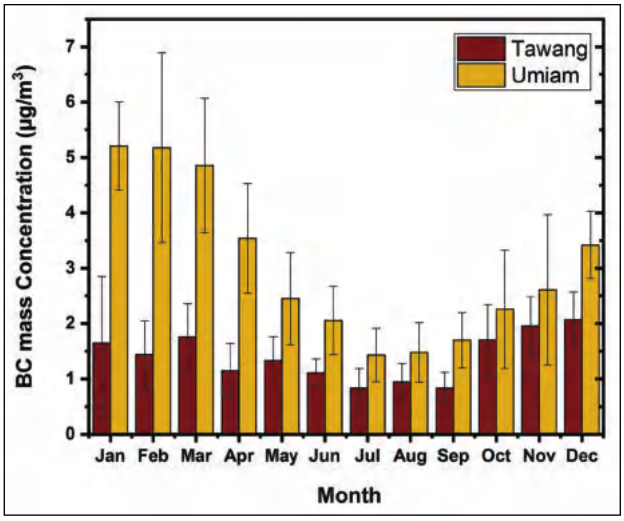
A high-altitude aerosol observatory was established at Lachung, Sikkim (27.4° N, 88.4° E; 2650 m) in the eastern part of Himalayas during the year 2018, under the joint effort of Space Physics Laboratory, VSSC, Thiruvananthapuram and NESAC, to study the physicochemical and optical properties of aerosols using a suite of instruments. The parameters measured are spectral scattering, absorption coefficients using multi-wavelength Aethaolometer and Nephelometer, columnar AOD (Aerosol Optical Depth) by Microtops Sunphotometer, aerosol number size distribution by an Aerodynamic Particle Sizer, composite aerosol mass concentration by PM10 and HVS samplers and mass size distribution by Quartz Crystal Microbalance (QCM) impactor.

The preliminary results indicate that the average values of AOD at 500 nm during pre-monsoon season is 0.09 ± 0.01, which is comparable to those observed over several other high-altitude sites in the Himalayas. On the other hand, near surface PM10 mass concentration shows a large day to day variability (3.0 μgm^{-3} to as high as 55 μgm^{-3}). Similarly daily mean BC mass concentration also found to vary between 0.5 μgm^{-3} to 3.7 μgm^{-3} (annual mean of 1.5±0.6 μgm^{-3}), with lowest values

occurring during monsoon and the highest during winter and pre-monsoon seasons. Biomass burning aerosols significantly influence the spectral absorption properties over the site, especially during winter. Investigation using air-mass pathways shows the transport of aerosols from the Indo-Gangetic plains contributing to the aerosol load over this eastern Himalayan region. Further investigations on the chemical composition of aerosols are going on for better evaluation of the anthropogenic and natural processes on air quality and radiative forcing at this unique geographic region. In the near future, the deposition of major light-absorbing aerosols on the highly reflecting surfaces of snow/glaciers will be investigated to understand the role of absorbing aerosols on changing snow albedo as well as accelerated melting of the snow/glaciers causing far-reaching consequences on the climate of the region.

Regional characteristics of aerosols over Umiam and Tawang

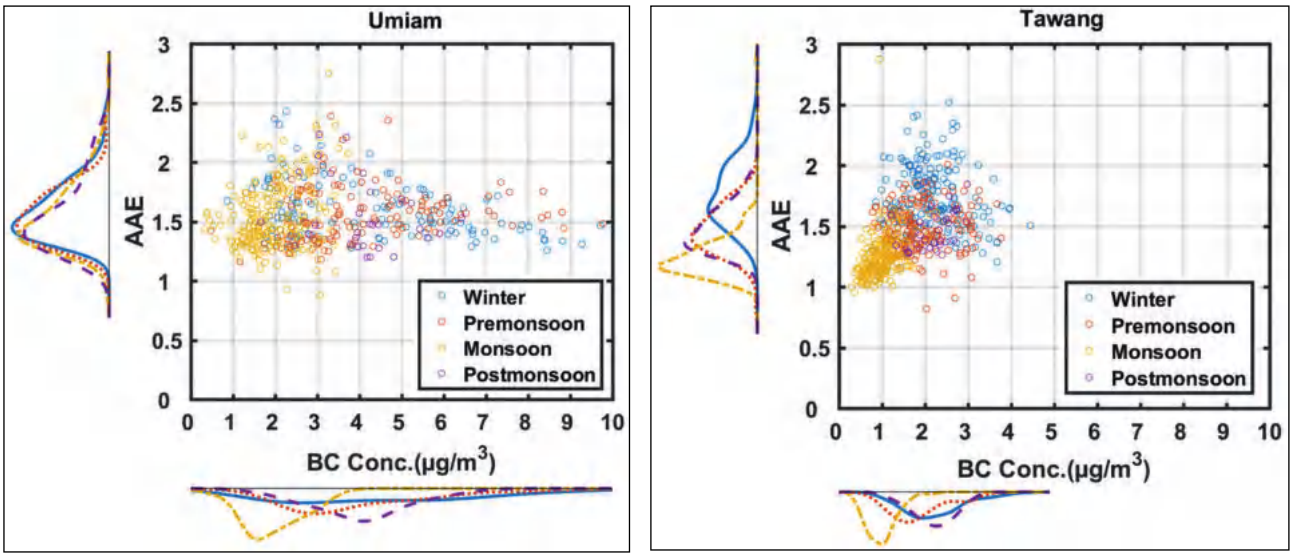
Physical and optical characterization of aerosol under the Aerosol Radiative Forcing over India (ARFI) project have been going on at NESAC, Umiam and Tawang (27.59° N, 91.87° E, 2886 m) with an objective to understand the temporal change in aerosol over high altitude stations of North East India. BC mass concentration at 880 nm measured using a seven channel Aethalometer (AE33, Magee Scientific) exhibited a significant annual variation during the measurement period with drier months (winter season) having maximum concentration. Annual average BC concentration over Umaim was 3.02±1.41 µg/m^3 (from Jan 2019 to Dec 2019) while for the same period over Tawang it was 1.4±0.43 µg/m^3. January 2019 showed maximum concentration with 5.2±0.79 µg/m^3 over Umiam whereas over Tawang, the maximum BC loading of 2.07±0.5 µg/m^3 was observed during December 2019. There is a marked distinction between the BC concentration over these two sites with Umiam dominated by large local sources of aerosols while Tawang dominated by transported aerosols from Brahmaputra valley.



Monthly mean BC mass concentration (measured at 880 nm) over Umiam and Tawang from January 2019 to December 2019

To get further information about the spectral dependence of light absorption over the study locations, Absorption Ångström exponent (AAE) has been calculated by using absorption coefficients at 370-880 nm wavelengths. Previous studies say that AAE of aerosols emitted from vehicular emission, particularly diesel burning vehicles are about 0.8-1.1, whereas aerosols from biomass burning show higher spectral dependency due to the higher light absorption near 370 nm (UV) or 450 nm (Blue) wavelengths, with AAE lying in the range of 0.9-3.5. Over Umiam, scatter histogram of BC with AAE shows the existence of both fossil fuel and biomass burning BC in the atmosphere; but over Tawang, an increase of BC coincides with an increase in AAE, which shows the dominance of biomass burning over the region. The AAE values over both the locations are more than unity throughout the year, which indicates probable sources are of fine mode origin.

Columnar Aerosol properties are also studied simultaneously over Umiam for years. AOD at all five channels over Umiam measured with MICROTOPS Sunphotometer showed notable annual variation during the year (from Jan 2019 to Dec 2019). AOD

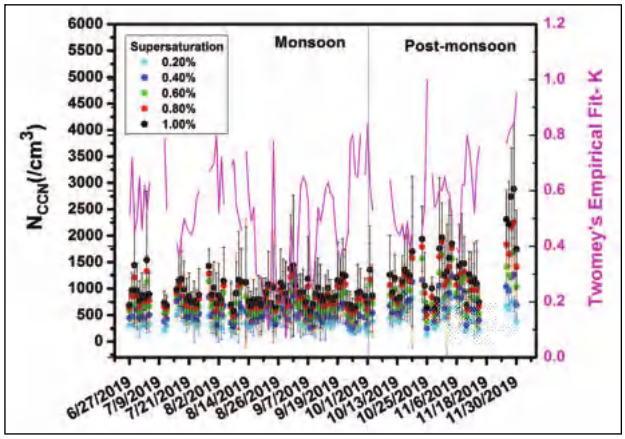


Scatter plot of BC mass concentration against AAE along with their seasonal distributions as kernel density on the horizontal and vertical axes over Umiam & Tawang

at 500 nm was maximum at 0.75±0.15 in April 2019 and minimum at 0.15±0.05 in August 2019. AOD was very high during winter and pre-monsoon, indicating significant regional loading. It was less in monsoon, although high AOD at all channels appeared in July 2019, which could be due to the prolonged dry spell observed at that time. Also, a significant variation of AOD with wavelength was observed over Umiam, which indicates changes in particle size and origin with the season.

Study on cloud microphysical properties over a hilly station

Cloud Condensation Nuclei (CCN) Counter has been installed over Umiam for measuring the concentration of aerosol particles that can act as cloud condensation nuclei. The instrument was operated every week for at least 3 days continuously at five selected supersaturation levels (0.2%, 0.4%, 0.6%, 0.8%, and 1.0%). Brief results of the study carried out this year showed the mean CCN number concentration at 1% of supersaturation was 927±245/cm^3, 1369±356/cm^3, and 3922±1087/cm^3 during monsoon (June-Sept), post-monsoon (Oct-Nov), and winter (Dec) season respectively. CCN concentration is found maximum at night and minimum at daytime, which is similar to the typical diurnal pattern of aerosol concentration following boundary layer evolution. The average value of the single hygroscopicity parameter (k), estimated from Twomey's empirical fit, is found as 0.51±0.20 and 0.61±0.16 during monsoon and post-monsoon season respectively indicating an abundance of hygroscopic particles during the post-monsoon season than monsoon. Efforts are being made to understand the aerosol activation efficiency and quantify cloud-aerosol interactions and its impacts on precipitation over this region.



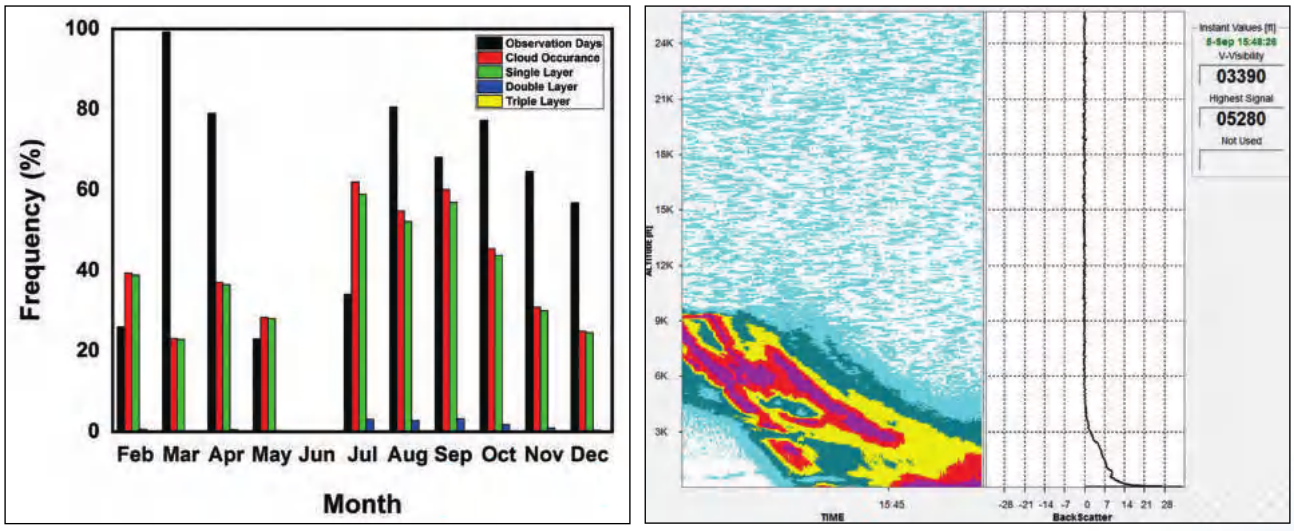
Temporal variations of CCN number concentrations at five different super-saturation and single hygroscopicity parameter (k) from 27th July 2019 to 30th November 2019

An observational study of cloud base height over a complex topography

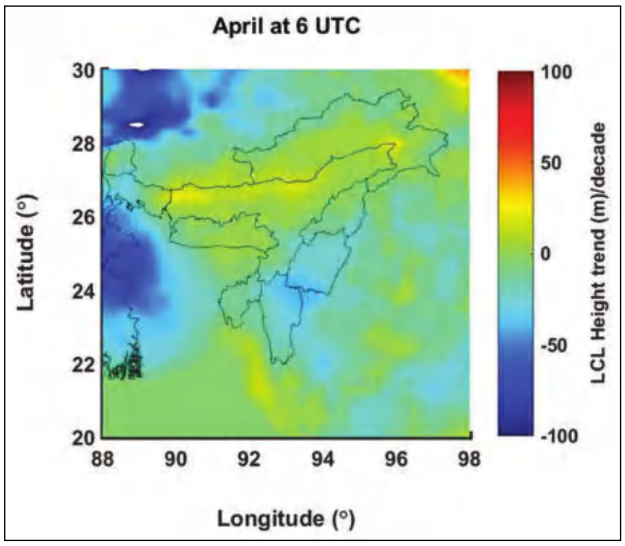
To investigate the characteristic features of clouds over a hilly region, a Ceilometer, a ground-based instrument that provides continuous data on cloud base height (CBH), has been deployed over Umiam since February 2019 by Physical Research Laboratory (PRL), Ahmedabad. Clouds are found to be present over Umiam throughout the year, with a frequency of about 40.08% out of approximately 61.09% of the time when Ceilometer observations were made during the year 2019. There is a noticeable seasonal variation found in cloud occurrence frequency with respect to observation days, which is maximum during July with a frequency of 61.95%. Clouds are less observed during December and March. Interestingly, most of the clouds observed over Umiam by Ceilometer are of a single layer. However, the presence of double-layer clouds is noticed from July to Oct. The cloud structures are mostly multilayered during monsoon and post-monsoon season. In contrast, they are single layered during pre-monsoon, which might be related to its convective origin. Otherwise, it could be because of the thickness of the cloud layer, which is hiding the other layers that the ceilometer LASER is not being able to penetrate. On the whole, it reflects possible contributions of different cloud types during the above mentioned seasons. Further study is going on to explore the vertical distribution of CBH in detail and to find its implications over the local weather.

Investigation on change in cloud base height over North East India

A study on cloud base dynamics has been initiated to understand long term temporal change in cloud characteristics over NER of India, especially during pre-monsoon season. The lifting condensation level (LCL) over any place has been taken as a proxy for cloud base height. Spatial distribution of LCL height computed using Reanalysis data showed a decreasing trend in the western part of Brahmaputra river valley and southern states of North East India, namely Tripura and Mizoram during March, whereas Barak valley showed an increase in the LCL height. In April, the northern part of the Brahmaputra river valley has shown a considerable rise in the LCL level. Further investigation is going on to correlate LCL height with Cloud-base height obtained from CALIPSO data and by in-situ measurements over the study region.



Frequency of observation over a month, cloud occurrences with respect to observation days and occurrences of single, double and triple layered clouds (left) and Precipitation from a mid-level cloud as observed by Ceilometer (right).



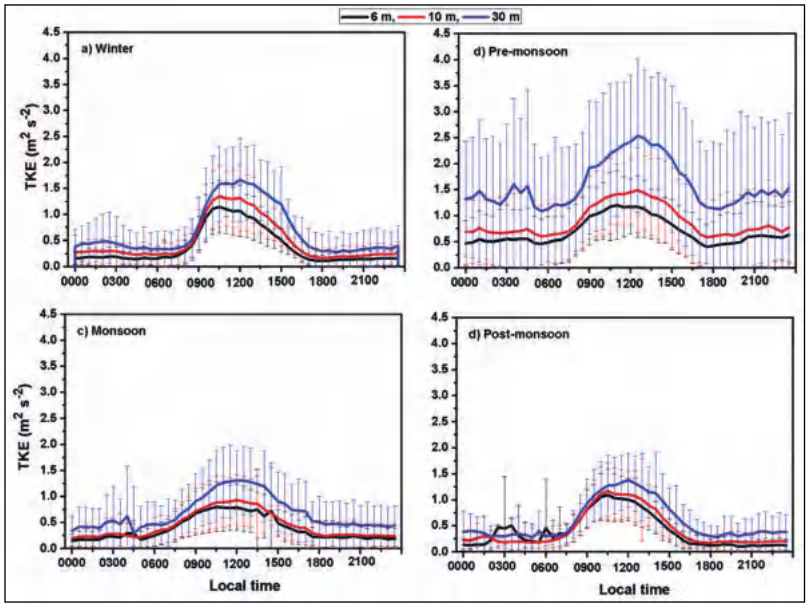
Decadal trend of monthly average LCL height over NE India during April

Study on influence of solar elevation angle (φ) on mountain-valley wind circulation and surface layer parameters over the NER of India

Solar elevation angle (φ) has a great impact on the wind-circulation and energy exchange over mountainous terrain, which controls the mountain valley wind circulation. The circulation dominates in winter, pre-monsoon and post-monsoon season, while synoptic flow dominates the wind direction over such a complex terrain in monsoon season. The hourly variation of φ for the different seasons has been calculated during the daytime (07:00-19:00 Hrs IST). In all the seasons, φ value reached the maximum at the midday (1300 Hrs), while the higher difference (31°, 42° and 12°) in the elevation angle observed in the pre-monsoon, monsoon and post-monsoon season respectively than in winter season.

Sensible Heat Flux (H) and Turbulent Kinetic Energy (TKE) at 6 m, 10 m and 30 m above surface level during winter, pre-monsoon, monsoon, and post-monsoon season has been estimated using the fast response sonic anemometer data installed at NESAC, Umiam. The water vapor exchange between the land and the atmosphere influences the sensible heat flux, which predominantly controls the air temperature in the lowest layers. Moreover, heat is supplied into the air during the daytime, which comes back to the ground during the nighttime. The daytime variation of H is significant in the winter and post-monsoon seasons. The time of occurrence of the maximum H value was 1-2 hours before the largest solar elevation angle over the station. The peak values of H were 219 ± 61 Wm^{-2}, 278 ± 120 Wm^{-2},152 ± 127 Wm^{-2} and 166 ± 68 Wm^{-2} in winter (1000-1100Hrs), pre-monsoon (1000-1100Hrs), monsoon (1100-1200Hrs), and post-monsoon (1000-1100Hrs) respectively at 30 m height. Such high values of H over the complex terrain during pre-monsoon are contributed by the higher solar insolation due to the larger solar elevation angle and the intense convective vertical motions that dominated during the daytime.

The seasonal mean daytime variation of TKE showed a distinct pattern in winter, pre-monsoon, monsoon and post-monsoon seasons at 6m, 10 m, and 30 m levels at the station. In the daytime,



Seasonal mean diurnal variation (line) and standard deviation (bar) of turbulence kinetic energy at 6 m (in black), 10 m (in red) and 30 m (in blue) heights.

TKE values at higher height (30 m level) was higher (59%, 71%, 51%, and 41%) than at the lower height (6 m level) in winter, pre-monsoon, monsoon, and post-monsoon seasons respectively. The higher TKE value in the pre-monsoon season was mainly due to the higher wind speed at the higher level (30 m). In pre-monsoon, the synoptic flow has an impact over the station, which has been visualized in the TKE values. The daytime TKE values are higher (99%, 56%, 72%, and 93%) than the night time value in winter, pre-monsoon, monsoon, and post-monsoon seasons. In the pre-monsoon season, the lower difference in day-night values of TKE indicates the influence of synoptic flow at a higher level.

Observation and analysis of Pre-monsoon weather system using polarimetric Doppler Weather Radar

The dual polarimetric S-band Doppler Weather Radar (DWR) installed at Sohra (erstwhile Cherrapunjee), Meghalaya is used for real-time weather monitoring and for research in meteorology. From radar data, the structure of thunderstorms, cyclones and other precipitating cloud systems can be analyzed. Radar observations are very much effective in tracking and monitoring the growth of weather systems as well as decay and movement of the systems. In this way, reliable forecasts and warnings for severe weather events can be done, saving life and property.

The DWR was made fully operational on 21st June 2019 after replacement of the slewing ring bearing (SRB) and replacement of azimuth motor. The DWR was calibrated using Sun calibration and bore sight calibration before the commencement of the 24X7 operation. The data was uploaded in real-time to the IMD and MOSDAC (Meteorology and Oceanographic Scientific Data Archival System) websites for utilization by various users. NESAC also utilizes the data for thunderstorm nowcasting and flood forecasting over the Barak basin.

Several weather systems in the monsoon season of 2019 and 2020 pre-monsoon season have been analyzed. One such pre-monsoon season weather system which occurred in the afternoon of 23rd April 2020 is elaborated here. The storm had maximum reflectivity at 54.50 dBZ and crossed parts of Meghalaya and Assam. To study the vertical distribution of the cloud system, a sector analysis between 140 degree to 150 degree azimuth was done. Corresponding to this azimuthal Sector, Max(Z), Max(V), PPI(Zdr), VCUT(Z) and hydrometric classification (HCA) is done. The differential reflectivity and maximum Doppler velocity observed for the system were 2.89 dB and 30.68 m/s, respectively. Corresponding VCUT (Z) and hydrometric classification analysis are also done. The in-built products and analysis available with the DWR RT product software enable detail physical and micro-physical analysis of cloud that could be effectively used for nowcasting of severe weather events. More use of polarimetric products has been the focus of such study to unleash the full potential of the DWR.

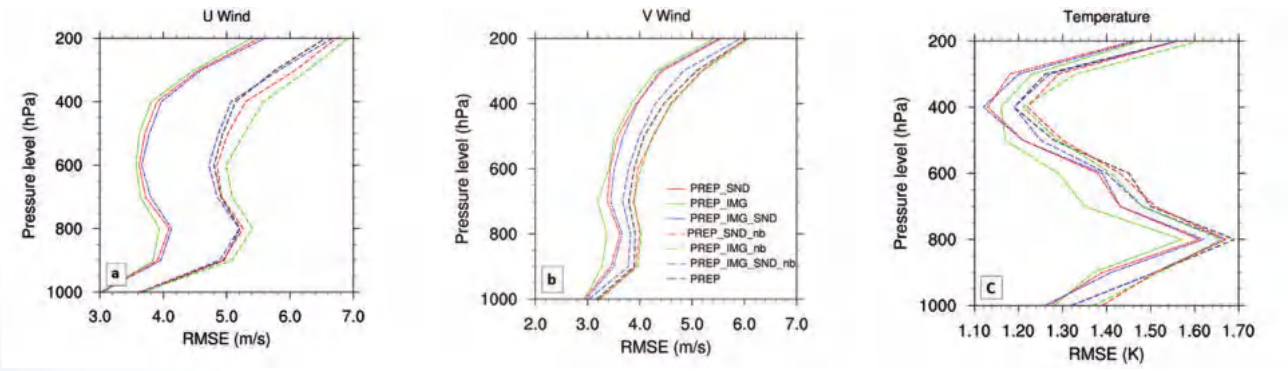
Impact of INSAT 3D radiances assimilation in monsoon simulation using WRF model

This study was carried out under technology development projects (TDP) of NESAC in collaboration with IIST (Indian Institute of Space science and Technology), Thiruvananthapuram. This study describes the impact of assimilation of INSAT-3D radiances from both Imager and Sounder in Indian summer monsoon simulations using the Weather Research and Forecasting (WRF) model. In this study, WRF-3DVAR (Three dimensional variational) is used for data assimilation and RTTOV (Radiative Transfer for TOVS) version 10 is used to simulate clear sky radiances. Data assimilation is conducted at every 6 hourly cycle in ±90 minutes assimilation window for the entire July month of

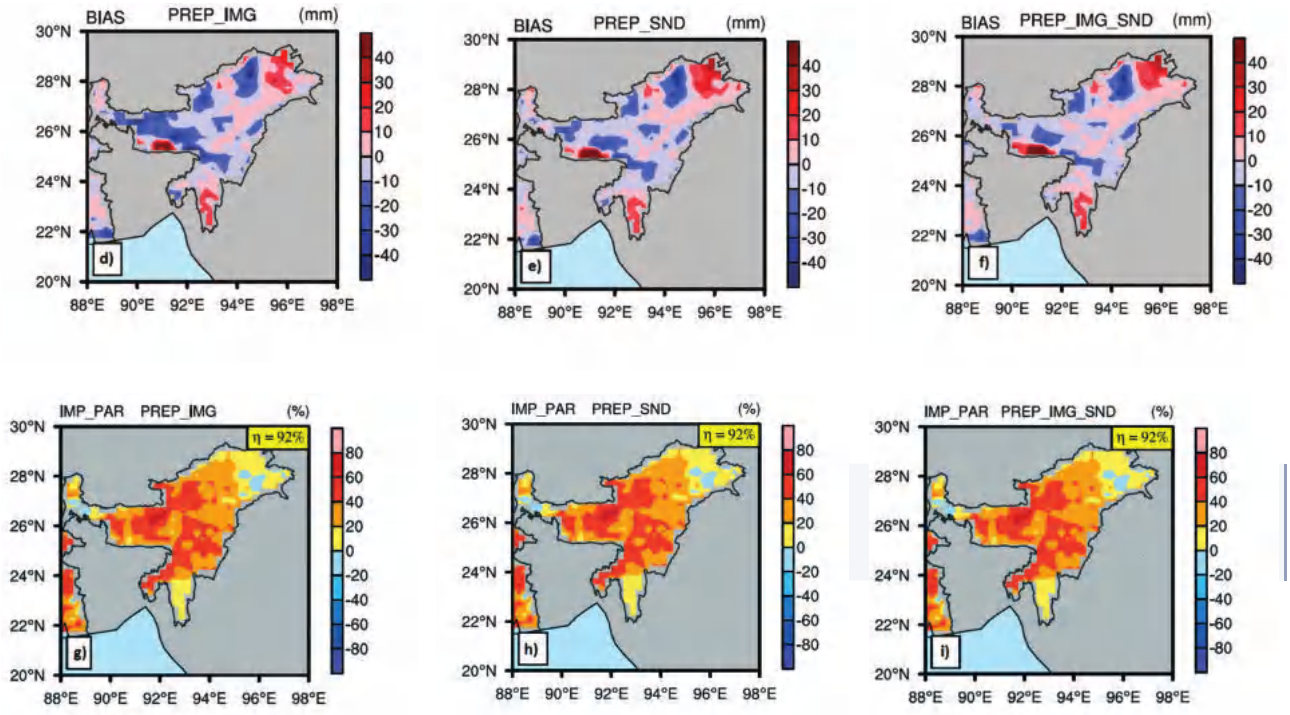
2016 through four unique experiments (control run, imager data assimilation, sounder data assimilation, and both imager and sounder data assimilation).

As a quality control measure, the INSAT 3D sounder channels were chosen in such a way that surface sensitive channels cannot be assimilated into the model for land. Cloud removal is also incorporated so that only clear sky radiances can be assimilated. The systematic errors of satellite radiances are treated using variational bias correction (VarBC) technique, which is already embedded in the WRF-3DVAR system. The vertical profile of the averaged RMSE (root mean square error) of the 24-hour forecast generated from each day's 0000 UTC analysis time for the month of July 2016 is shown in the figure. Large improvements in the wind field have been observed, with significant reductions of RMSE in the zonal wind for all the three bias-corrected data assimilation experiments throughout the troposphere with the maximum improvement shown for the assimilation of imager data experiments. Similar improvements have been observed in the temperature field where RMSE of temperature showed a drastic reduction with imager data assimilation from 950 hPa to 450 hPa while a large fall in RMSE for temperature was seen with sounder data assimilation and also when both sounder and imager data were assimilated at the surface as well as at levels between 450 hPa to 200 hPa. However, the improvement in the moisture field is not so marked, but nonetheless, bias-corrected experiments have performed better than the conventional data assimilation experiment. The assimilation of only sounder data reduces the RMSE of moisture at the surface, while the assimilation of only the imager data reduces the RMSE of moisture between levels 750 hPa to 600 hPa in the mid-troposphere.

The main signatures of monsoon systems such as low level jet, Tibetan anticyclone, vertical wind shear are better simulated in the experiments with radiance data assimilation than the experiments with conventional data only. Although both imager and sounder channels contributed towards the improvement, the largest improvement is seen with imager data. In the case of rainfall simulations, the effect of radiance data assimilation has been observed only over the West Bengal region, where the overestimation observed from the control experiment has been reduced with the INSAT data assimilation (DA) experiments. Some improvements from the RMSE plots are also observed over NER of India with all three DA experiments performed equally. Rainfall over NER of India is further investigated by comparing the results at 9 km resolution with IMD gridded rainfall data. It is observed that the impact of INSAT 3D radiances is immensely significant over the NER region. Large improvement is observed over the Meghalaya region, which is also the highest rainfall region of India. Apart from a small area of Arunachal Pradesh and Sikkim, almost entire NER is positively influenced by INSAT 3D radiance data assimilation in comparison to only conventional data assimilation.



Vertical profiles of root mean square error for 24 h forecasts against radiosonde observations



Bias of monthly average rainfall (mm) with respect to IMD gridded rainfall for assimilation of imager data (top left), sounder data (top centre), and both (top right) and Impact parameter (%) for assimilation of imager data (bottom left), sounder data (bottom centre), and both (bottom right)

Simulation of thunderstorm over NER of India by WRF model with direct and indirect assimilation of DWR data

The effort to assimilate the polarimetric DWR data in numerical models to improve severe weather nowcasting over the NER of India was continued and few more severe events were simulated. The DWR reflectivity data that gives information about the intensity of a cloud system, whereas radial velocity provides information on vertical atmospheric motions, were assimilated in the WRF model for the simulations. Experiments were also conducted by indirect assimilation of DWR data in the WRF model.

A case study on simulation of thunderstorm over the southern part of NER of India is discussed here and the experiments are named CNTL for the control simulation without data assimilation, DWR_RF for direct DWR reflectivity assimilation with radial velocity and DWR_Q for indirect reflectivity assimilation with radial velocity. In the indirect method, instead of directly assimilating radar reflectivity, the retrieved rainwater and water vapor derived from radar reflectivity are assimilated. The thunderstorm considered here initiated at 12 UTC of 30th March 2018, however, the model was initialized at 0000 UTC to spin up the convective process.

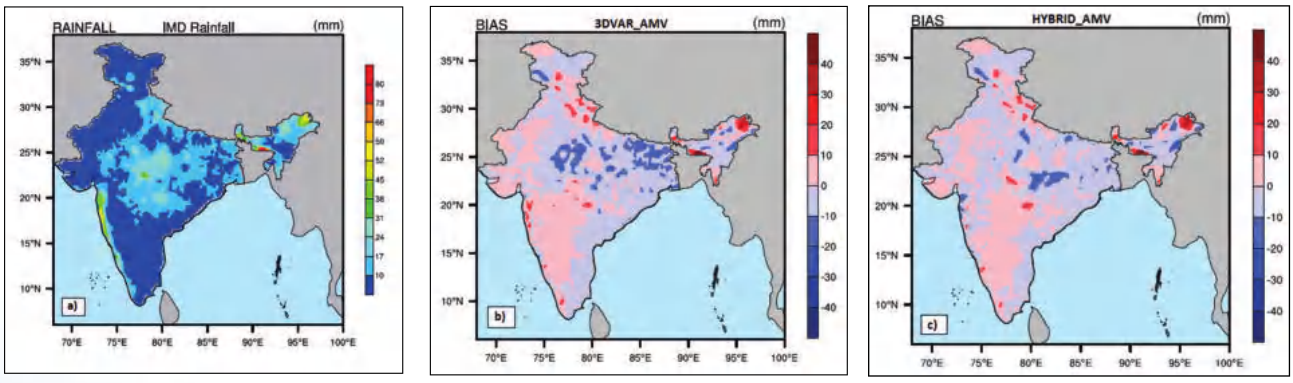
The simulated thermodynamic indices and the meteorological field such as equivalent potential temperature, reflectivity, and vertical velocity, are compared between CNTL, DWR_RF, and DWR_Q experiments. Vertical cross-sections are taken through the thunderstorm core area at 24° N and 93° E for the analysis. It is observed that the DWR experiment reveals the presence of moist warm core corresponding to a strong updraft that further enhances the instability to build up the thunderstorm. The study revealed that tall clouds favorable for severe thunderstorms were missing in the CTRL experiment. However, the severity of the thunderstorm is better simulated by DWR_Q

where reflectivity is assimilated indirectly. One of the problems with the direct reflectivity data assimilation is that reflectivity data from DWR gives information about the existence of precipitation only, but no information about water vapor, temperature and other fields. Therefore, warm-rain processes cannot be activated in the minimization of the cost function by DWR data only, until and unless prior instability exists, which is required for convection. However, in the indirect method, the assimilation of the estimated water vapor is expected to provide a favorable environment that supports convection. Few more cases over different geographical locations and time periods are being simulated. These assimilation systems are expected to be part of the operational nowcasting process soon.

Impact of INSAT 3D wind data assimilation in monsoon simulation using WRF model

The main objective of this study is to explore the impact of assimilation of INSAT-3D atmospheric motion vectors (AMVs) for the simulation of monsoon circulations over the Indian region during July 2016 using the WRF model. Two data assimilation (DA) techniques are used such as 3DVAR for variational assimilation and HYBRID (ETKF-3DVAR) for incorporating flow dependent error covariances in a variational framework. Variation DA system inherits limitations such as it allows only linearized physical and dynamical processes to be incorporated whereas the errors in the NWP system may be highly nonlinear; it uses a background error covariance (BEC) matrix that is either completely static or only weakly coupled to the dynamics of the forecast model. The error induced by static BEC can be treated by using ensemble based data assimilation system such as Ensemble Kalman Filter (EnKF), which provides flow-dependent BEC information estimated from the ensemble of nonlinear model forecasts. However, EnKF also is subject to sampling error due to the use of a finite number of ensemble size to overcome computational constraints. Another method has been proposed as an alternate solution that combines the strength of variational as well as ensemble DA system in a common framework known as hybrid ensemble - 3DVAR DA method (hereafter HYBRID).

Every 12 hourly DA cycles are performed for the entire month of July 2016 and everyday analysis at 0000 UTC is used for 48 hour model forecast. The results of the rainfall forecast reveal that HYBRID DA outperformed 3DVAR in 24 hour rainfall forecast. It is found that the wet biases observed in 3DVAR experiments in central India and NE Indian region and dry biases observed in the Western Ghats region are reduced in HYBRID experiments. The dry bias in the Western Ghats is significantly improved by HYBRID with AMV DA. In terms of model simulated monsoon circulation, it is observed that 3DVAR alone is not sufficient to improve the circulations in



Observed spatial distribution of accumulated rainfall (mm/day) for July 2016 (left) and bias in forecasted rainfall with AMV data assimilation (centre) and HYBRID data assimilation (right).

upper as well as lower levels. With the inclusion of AMVs, 3DVAR gains some skill, which is ascertained by calculating RMSE of 3DVAR experiments with respect to ERA (ECMRWF Reanalysis) interim data. It is evident from the result that 3DVAR with AMVs improves the lower level wind flow over the equatorial Indian oceanic region. When the same comparison is made for the HYBRID experiments, the results suggest that although HYBRID RMSE is smaller than 3DVAR experiments, the improvement is more when AMV data is included for the LLJ. The zonal vertical wind shear (ZVWS) that reflects the strength of the monsoon circulation has been better presented by HYBRID with AMVs, which may be the reason for the decrease in bias in HYBRID_AMV on the Indian landmass observed in 3DVAR.

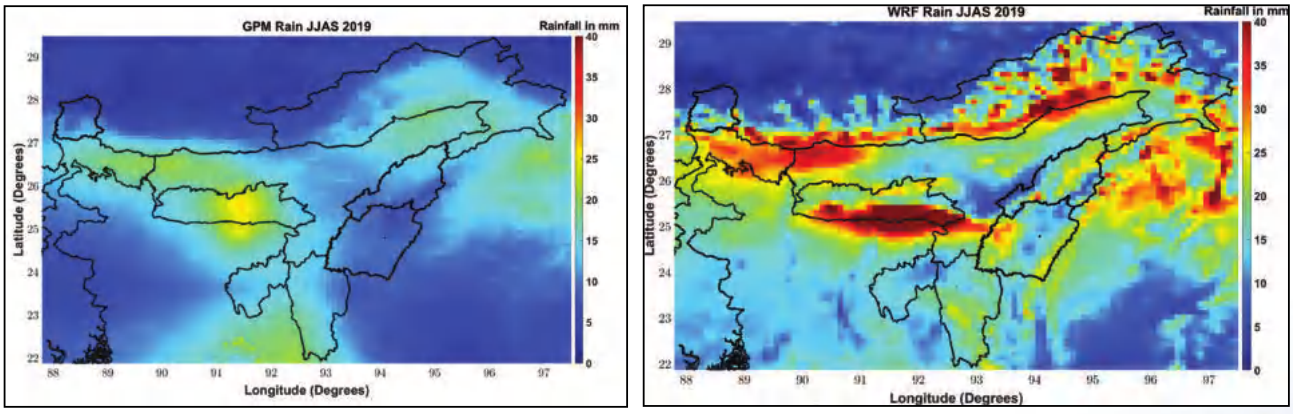
Validation of seasonal rainfall forecast provided using WRF model

NESAC has been providing the short and medium range weather forecast over the NER of India using the WRF model. The forecast is provided for 48 hours for rainfall, temperature, and humidity at 9 km spatial resolution. The rainfall forecast is used by several users including for the Flood Early Warning System (FLEWS) project covering a large part of NER of India. The forecast, particularly the rainfall forecast is continuously validated and efforts are made to improve the forecast further. For the year 2019, the monsoon seasonal (June-July-Aug-Sept, JJAS) forecast has been validated using the GPM rainfall estimates.

The spatial distribution of mean daily rainfall for the full monsoon season suggests that the WRF model based rainfall forecast systematically overestimates for the most part of NER of India when compared with GPM-MS (GPM-multi satellite) rainfall estimates. The statistically significant Pearson correlation coefficient over NER was also estimated and it shows a strong correlation of more than 0.6 over a large part of NER. Most of the places of North East India show a positive bias of WRF rainfall with respect to GPM rainfall. Based on the mean negative bias days and positive bias days, a bias corrected WRF rainfall map was generated. The correction partially rectified the bias, but more analyses are required for better correction. Such bias corrected rainfall forecast is expected to be used for different applications, including flood forecasting in the near future.

Improving location based lightning nowcasting over NER of India

North Eastern region of India is one of the most lightning prone areas in the world, as evidenced from the Lightning Imaging sensor data onboard Tropical Rainfall Measuring Mission (TRMM) satellite. NESAC has been working to provide location based lightning early warning services



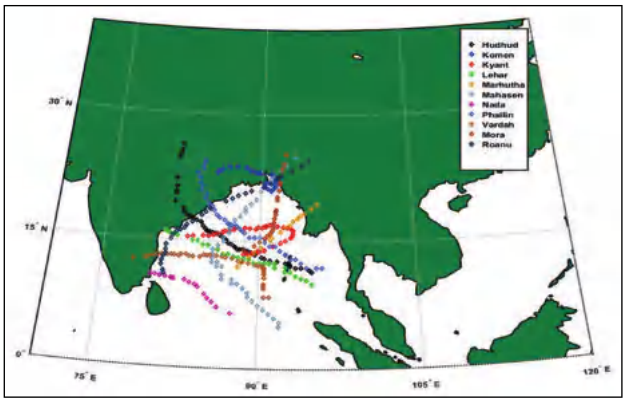
JJAS 2019 seasonal mean of daily rainfall as per GPM-MS (left) and WRF forecast (right)

for the NER of India with actionable lead time. Probable lightning location maps are generated on an hourly basis for two/three times a day using numerical models and the same is communicated with the concerned stakeholders. The forecast is compared with the Earth Networks detected lightning count and good agreement has been observed for lightning warning up to two hours lead time. The model generated vertical reflectivity of several severe storm cases were also validated with the reflectivity derived from CloudSat satellite data. The forecast well simulated the storm height and extension for most of the cases.

Experiments have been conducted in control run condition using three different models viz, WRF-Electrification generated flash origin density (FOD), Lightning potential Index (LPI), and PR92 scheme derived total lightning flashes (TLF), to investigate the effectiveness of these models in simulating the lightning scenario over the NER of India. The forecast was validated using the Earth Networks detected lightning flash count for a few severe lightning events. Compared plots for 15th April 2017 are presented here. The colour bar shown in the figure depicts the time of lightning. This validates the accuracy of the total lightning forecast in terms of both spatial and temporal distribution. The comparison shows that LPI and PR92 schemes over-predicted the actual scenario while the WRF electrification scheme under predicted the same. This is very clear that WRF electrification schemes better represented the observed scenario compared to the other two WRF schemes in the control run condition.

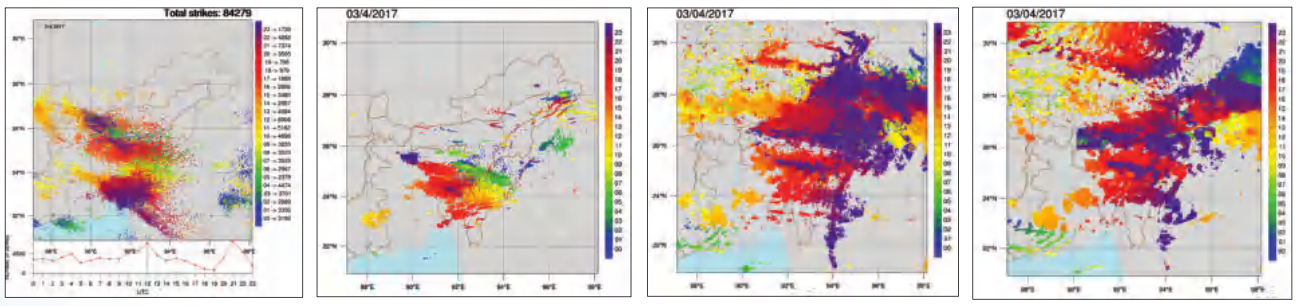
A study on lightning potential of Tropical Cyclones over Bay of Bengal

The cyclone induced lightning was studied to assess the interrelationship between cyclonic intensity change and variation of the lightning flash count. Eleven tropical cyclones (TC) occurring during 2013-2017 over the Bay of Bengal have been analyzed from various aspects. The cyclones are Mahasen, Phailin, Lehar, Hudhud, Komen, Nada, Roanu, Vardah, Kyant, Marutha, and Mora. Each TC has been divided into two regions, i.e., eye, and the rain band region to study the lightning characteristics within the TC. Taking TC eye centre latitude and longitude as the reference, we selected a 20 km X 20 km grid as the eye region. The total TC area is considered in a 5° X 5° grid.



Track of all the TCs (from 2013 to 2017) over the Bay of Bengal

The variation of MSWS (mean sustained wind speed) with TC evolution and the associated WWLLN detected LSC (lightning stroke count) within each hundred kilometer radius from the TC centre for four weak TCs are studied and the same



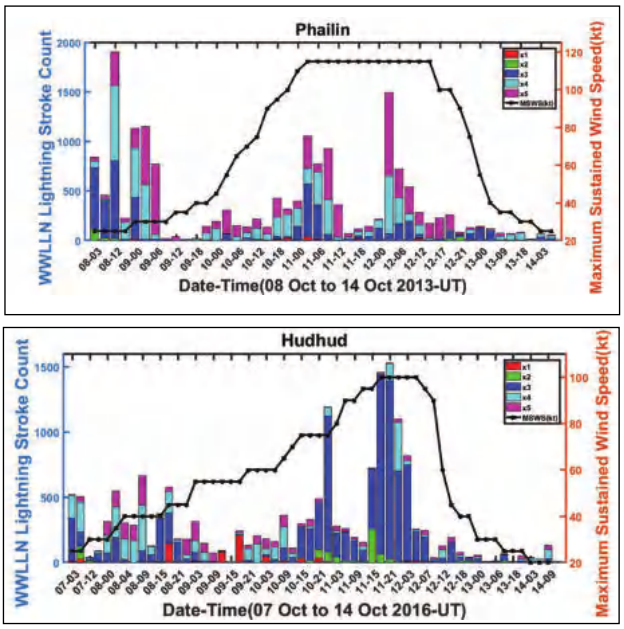
Comparison of observed lightning flash count (left) with WRF electrification generated lightning FOD (2nd from left), LPI (3rd from left), and PR92 TLF (right) for severe storm on 15 April 2017.

is depicted for two weak cyclones in the figure. Each color in the bar diagram represents the LSC for a 100 km radius denoted by X1 to X5 in which X1, X2, X3, X4 and X5 correspond to 100 km from the centre, 100-200 km, 200-300 km, 300-400 km and 400-500 km radius, respectively.

The pre-monsoon TCs show four different MSWS variations including initial stepwise MSWS enhancement followed by a steady trend with sudden peak intensification before final sharp weakening. Such a pattern was clearly visible for Mahasen and Roanu. A gradual intensification of MSWS followed by stepwise weakening has been noticed in the weak TCs like Kyant and Komen during monsoon or post-monsoon seasons. In addition to the initial phase, TCs during pre-monsoon season also have high LSC during steady MSWS state. LSC contribution during steady MSWS state is primly from X1 and X2 bands. A prolonged steady state of MSWS triggered high lightning from outer bands (X3, X4 and X5) in Mahasen and Komen, which is a rare phenomenon. The observed sharp intensification rate in Mahasen is associated with high LSC in X1 and X2 bands. Steady state of TCs during pre-monsoon followed by the sudden enhancement of MSWS is associated with a sharp rise in LSC in X1 and X2 bands.

The variation of LSC and MSWS for moderate intensity TCs like, Lehar and Vardah was also studied. Both the TCs occur during the fall season. The variation of MSWS for both the TCs is coupled with LSC increase during the initial intensification phase. The outer bands show higher LSC for both the TCs during initial intensification. LSC increase in the inner regions (X1 and X2) is often associated with high MSWS.

A prime parameter that made Phailin and Hudhud most severe among the other TCs is the range of MSWS. The entire dynamic scope of the MSWS



Variation of WWLLN detected LSC in each 100 km radius from TC centre along with the variation of MSWS in the TC evolution for Phailin and Hudhud.

of Phailin and Hudhud begins from 10 kt and goes beyond 100 kt. TCs in post-monsoon season intensifies vigorously with single step MSWS intensification and demonstrate no multi step increment of MSWS as in the case of Mahasen. The time-series variations of LSC over the five different bands of TC starting from its centre along with the MSWS evolution are shown. One of the salient features of severe TCs is low LSC in the inner bands (X1 and X2) or eye regions and high LSC at the outer bands (X3, X4 and X5) or rain bands.

The SST (sea surface temperature) variability during the TC advancement along with the LSC over the various cyclonic regions (eye, rain band & full region) is also studied. Sustained SST from 10th to 13th May 2013 provided a favorable condition for the TC intensification and lightning activity enhancement over both the regions of Mahasen. The variation of SST for Phailin and Lehar is in good agreement with the variation of MSWS and LSC. The average SST maximum for Mahasen is around 31.2°C during 11th May 2013 and a minimum of around 29.5°C on 16th May 2013.

Spatio-temporal evaluation of a land surface model

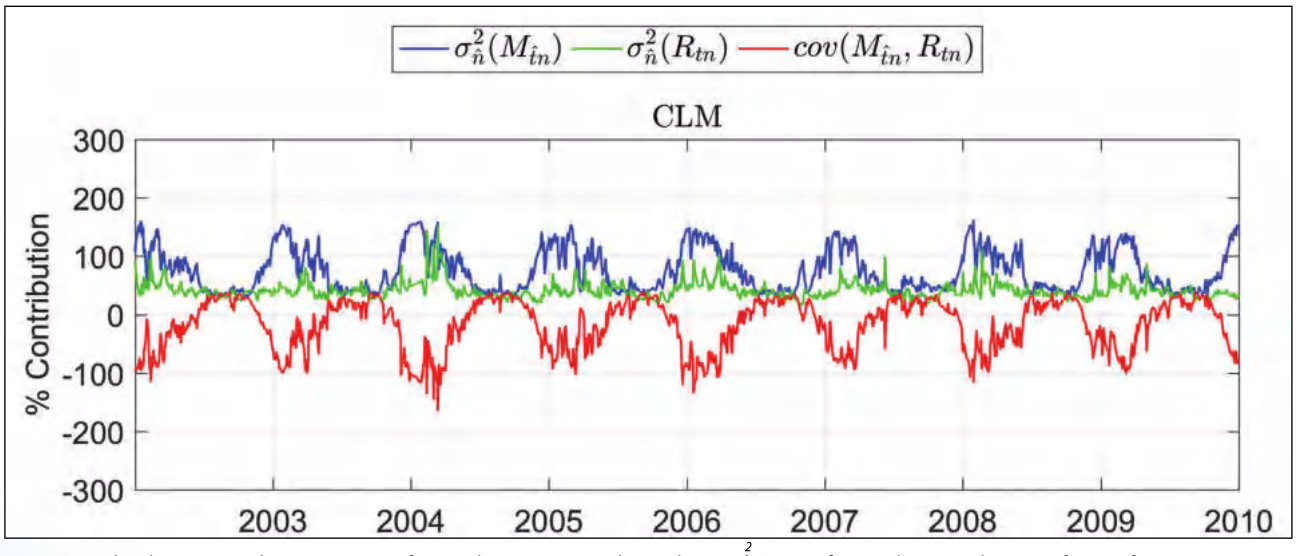
Soil moisture controls hydrological, meteorological and ecological processes as well as interactions between the land surface and atmosphere by distributing precipitation to infiltration, runoff and surface storage. Above all, soil moisture plays an important role in climate change prediction and meteorological feedback at local, regional and global scales. This has prompted many studies of the spatial and temporal variability of soil moisture. These studies have suggested two broad categories of factors affecting the variability of soil moisture: static factors (soil texture, topography, etc.) and dynamic factors (precipitation, wind, temperature, vegetation dynamics, etc.).

This study intended to observe the contribution of these factors to the soil moisture variability in a land surface modeling framework. This is achieved by decomposing the spatial variance time series of soil moisture into three components: time-invariant component (representing the contribution of static factors), time-variant component and covariance of time-invariant component and time-variant component. Together the time-variant component and the covariance term represent the contribution of dynamic factors. The analysis was conducted over all the grid of India and then over the various climatic zones.

The analysis revealed that modeled soil moisture is dominated by the contribution of static factor, however, a seasonal oscillation was observed in the contributions from the different factors. This behavior is not constant for all climate zones of India, with some showing a strong influence of dynamic factors on the spatial variability of soil moisture. This behavior is being correlated with satellite SM to evaluate the limitations and gaps in the modeling framework.

Spectral decomposition of simulated soil moisture and precipitation time series over Indian region

Soil moisture affects the earth system by interacting with both the water and energy cycle. Thus, it is important to understand its behavior under the influence of various control variables. One of the ways to do it is to analyze soil moisture from a land surface model (LSM) forced by meteorological variables. Since an LSM is forced by meteorological

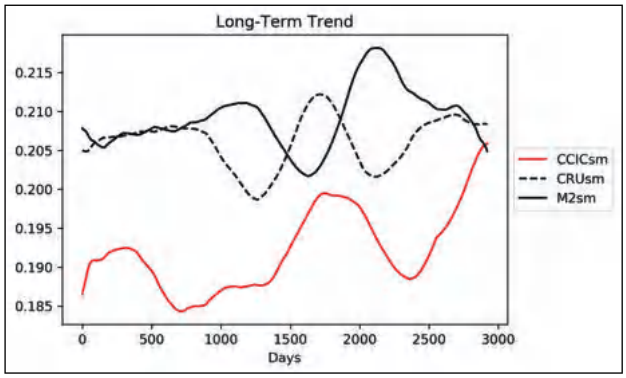


The decomposed components of spatial variance are shown here. $\sigma^2_{\hat{n}}(M_{\hat{t}n})$ refers to the contribution of static factors, $\sigma^2_{\hat{n}}(R_{tn})$ refers to the contribution of dynamic factors and the $cov(M_{\hat{t}n}, R_{tn})$ refers to effect of the interaction between static & dynamic factors to the spatial variance.

variables, it is important to investigate their influence on the model performance.

This study was conducted to investigate the impact of two gauge-corrected rainfall products (CRU-NCEP and MERRA2) on CLM4.5 simulated soil moisture: CRUsm and M2sm, respectively. CLM4.5 was simulated for a period of 8 years from 2003 to 2010 at a resolution of 0.96° × 1.25° over India. A spectrum decomposition approach, called Singular Spectrum Analysis, was used to decompose the soil moisture time-series into a long-term trend, slow-moving, fast-moving, and noise components. The analysis was conducted over the all-India average time-series. The simulated soil moisture was also compared with satellite observed soil moisture. The rainfall time-series was also decomposed to understand its contribution to the soil moisture time-series.

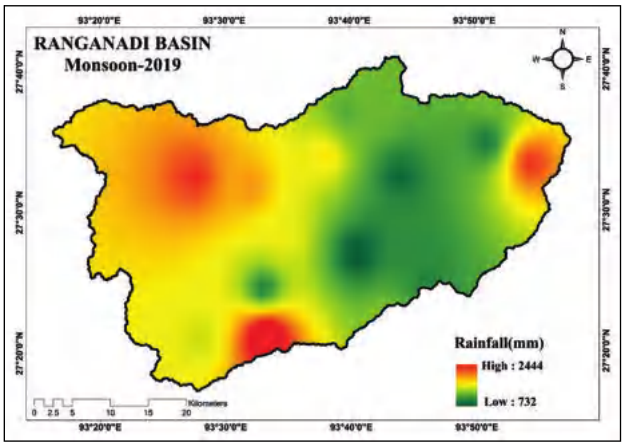
The decomposition of the all-India average time-series showed that the deviation between CRUsm and M2sm is mainly due to the deviation in their long-term trend. No significant deviation was observed in the slow-moving and fast-moving components. Similar behavior of different long-term trends and no significant deviation in slow-moving and fast-moving components in rainfall was observed. It can be concluded that the effect of rainfall on the soil moisture components depends on the component of rainfall with the most deviation. The analysis is being extended to the different climate zones of India.



The long term trend of simulated soil moisture (CRUsm and M2sm) is compared with the satellite soil moisture (CCICsm).

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 of 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. The 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.



Map showing spatial distribution of rainfall (mm) in Ranganadi basin during Monsoon season

All the AWS in the network was serviced and maintenance activity was carried out and the AWSs were calibrated during January-March, 2020 time period to ensure the smooth operation of the AWS during the monsoon season in 2020. A web-based

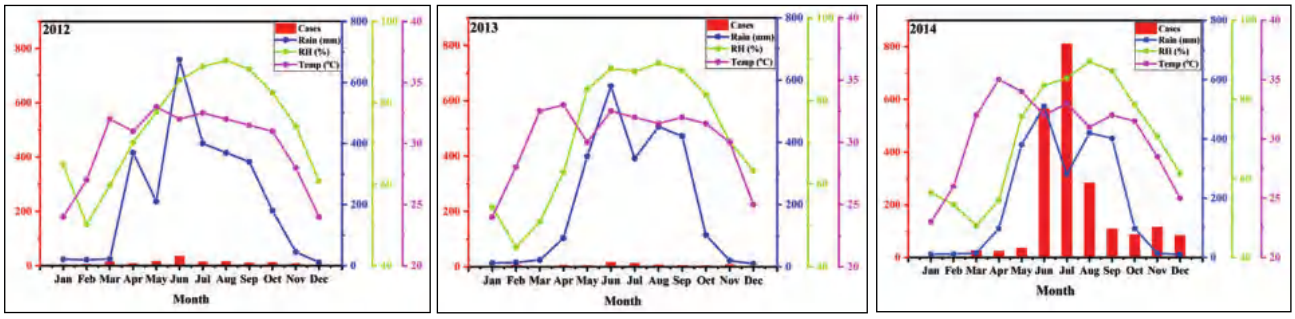
dashboard is also being developed for real-time visualization of AWS data, AWS health, rainfall pattern, heavy rainfall warning, and a host of several other advisories. The dashboard will be web-hosted with limited access for real-time monitoring of the network and proposed management of the RHEP dam.

Impact of meteorological parameters on Malaria epidemic in Ambassa region of Tripura

A study has been carried out to understand the relationship between malaria and meteorological parameters in the Ambassa region, Dhalai district of Tripura, in collaboration with RMRC (Regional Medical Research Centre), Dibrugarh. The district has a tropical climate with hot and humid summers, a prolonged rainy season and relatively warmer winters. Rains in Dhalai are frequent in March and April. Maximum temperatures in summers and winters are 36° and 28° Celsius, respectively.

The meteorological data (rainfall, ambient temperature, and relative humidity) used for the present study was obtained from NCEP (National Centre for Environment Prediction) reanalysis and GPM (Global Precipitation Mission) rainfall data. Malaria case density data was provided by RMRC. The data was collected from four health centres of the district viz. Karnamoni, Maldapara, Gurudhanpara, and Sikaribari, which come under the Ambassa primary health centre. Statistical analysis was made between the occurrence of malaria cases and meteorological parameters over the study area. The variation of rainfall, relative humidity, and temperature against monthly malaria cases for three years period (2012, 2013, and 2014) was studied and it has been observed that the highest malaria cases are seen in the months of May to September which is the pre-monsoon and monsoon season of the years.

This shows that malaria is a disease related to seasonal variations. In order to better understand the relations, a two-tailed test for significance was done for each of the three parameters against malaria cases. The highest r-values of monthly averages of rainfall, relative humidity and temperature against case were found to be 0.79, 0.62 and 0.70 respectively, which shows that all three parameters play an important role in the growth of mosquitoes over the area. Vector-parasite relation with meteorological parameters will be studied on a daily basis over the region in the future under this study.



Correlation between rainfall, Maximum temperature, and relative humidity with malaria cases

IMPORTANT EVENTS

Training & Workshops

NESAC conducted 2 weeks online Distance Learning course on Remote Sensing and GIS-Technological Advances and Applications

Inauguration of the course at NESAC Outreach Smart Class Room by Director NESAC

NESAC conducted a distance learning program jointly with IIRS, Dehradun on "Remote Sensing and GIS-Technological Advances and Applications". The course was designed to provide sufficient knowledge and advanced training in the field of Geospatial domain and Earth Observation applications. One of the objectives of such course was to reach a large number of Professionals of user Departments, Students & Researchers engaged in Urban & Regional Planning, Geography, Environmental Studies, Civil Engineering, Architecture, Agriculture, Horticulture, Hydrology, etc.

The course was scheduled from 29th April-10th May 2019. The first week of the course was designed to provide basic knowledge on Remote Sensing, Digital Image Processing, Geographic Information System, Global Navigation Satellite System and Web & Mobile GIS– Technology & Applications. The second week of the course was designed to focus on various application areas using Space Technology. The application areas that were designed to address during the course are Geo-Web services and Governance Applications, Remote Sensing for Agriculture and Forestry Applications, Remote Sensing Applications in Earth Science and Water Resources, Applications of UAV Remote Sensing and Remote Sensing of Urban and Societal Applications. The resource persons were identified from IIRS and NESAC. This was the first time that NESAC conducted a joint course in collaboration with IIRS, Dehradun. IIRS, Dehradun has a long experience of conducting such online training programs in various thematic areas of Remote Sensing & GIS. The course announcement letters addressed by Director, NESAC were circulated to Line Departments of all the North Eastern State Governments as well as Academic Institutions of the region. The Online mode of the course allowed participants to complete the registration process online and they could receive the lecture online through Virtual Classroom from his own location and need not travel to NESAC or IIRS. More than 200 candidates had registered from all over the NE Region as well as from the other part of the country.

The course was inaugurated on 29th April 2019 in

Participants attending a lecture through the virtual classroom for the DLP course

a brief ceremony. Shri P.L.N. Raju, Director, NESAC, Shri Victor Saikhom, Course Coordinator, NESAC, Shri Anjan Debnath & Shri Nilay Nishant, Course Officer, NESAC were present along with student participants at NESAC Outreach Facility whereas from IIRS, Dehradun, Dr. Prakash Chauhan, Director, IIRS, Dr. Harish Karnatak, Head, GIT&DL Dept., IIRS, Mrs. Shefali Agrawal, GH, GTOPG, IIRS were present in Online Video Conferencing Mode.

ISRO YUva VIgyani KAryakram (YUVIKA) or Young Scientist Program conducted at NESAC

Inauguration of the YUVIKA Program at NESAC by Chairman, ISRO through Video Conferencing

The ISRO "Young Scientist Programme YuViKA" (YUva VIgyani KAryakram) was conducted from 13th to 25th May 2019. Three students each from the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and West Bengal attended the programme. The programme was inaugurated by Chairman, ISRO via video-conference. Prof. BK Dutta, Hon'ble Member, North Eastern Council was the Chief Guest of the inaugural function at NESAC. The two weeks programme included a plethora of lectures, practicals, lab visits and other activities. The students interacted with several eminent scientists such as Shri PLN Raju, Director of NESAC, Shri KC Bhattacharyya, Former Director of NESAC, Dr. Asis Bhattacharya, Former Deputy Director of NRSC, Dr. S Ramakrishnan, Former Director of Vikram Sarabhai Space Centre, Dr. George Joseph, Former Director of Space Applications Centre, Dr. JN Goswami, Former Director of Physical Research Laboratory, Dr. Mudit Srivastava, Physical Research Laboratory, Dr. Shyama Narendranath, UR Rao Satellite Centre, Dr. PC Joshi, Space Applications Centre and other scientists. The students also had the opportunity to visit the Satish Dhawan Space Centre at Sriharikota and witness the launch of the RH200 rocket. The valedictory function was held on 25th May 2019, where Prof. B.C. Goswami, Vice-Chancellor of Cotton University, Guwahati graced the occasion as the Chief Guest.

Valedictory function of the YUVIKA Program

NESAC conducted two weeks customized course for ONGC officials

NESAC conducted a two weeks customized course for officials from ONGC, Jorhat from May 27–June 08, 2019 at newly constructed NESAC Outreach Facility. The main objective of the course was to understand Remote Sensing technology and its applications for surface geomorphological study for oil exploration. The course was coordinated by Dr. Gopal Sharma, Scientist/Engineer-SC under the guidance of Shri PLN Raju, Director NESAC. A total of 10 participants consisting of two Superintending Geologists, four senior Geologists, two Geologists and two Geophysicists attended the training at NESAC. The course consisted of basics of remote sensing followed by topic on image interpretation for geomorphological/geological/structural study with special emphasis to oil exploration. The training started with a basic lecture on Introduction to Remote Sensing followed by introduction to GIS, Spatial & Non-Spatial data Models in GIS, Geomorphic anomaly identifications and advanced lectures on image interpretation. Each theory class

was followed by a practical session. The practical included familiarization and hands on training with open & commercial software, geometric and radiometric corrections of images and image interpretation for geological applications such as lithology, geomorphology and structural analysis. The training course also included a half day field trip to Barapani shear zone areas in Ri Bhoi District of Meghalaya to enable the participants to differentiate and identify signatures in the field vis-a-vis in the satellite images. The participants were also taken to different facilities of NESAC. Apart from lectures by NESAC Scientists, three invited talks were also arranged for the participants. Two of the invited lectures were delivered by Dr. D S Mitra, Former GGM (Geology), ONGC Dehradun on topics- 1. Remote sensing in Basin Analysis and 2. Remote sensing in Oil exploration. The third invited talk was delivered by Shri. Suresh Kannaujiya, Scientist IIRS-ISRO, Dehradun through Skype on topic GRACE data applications on Geosciences". The valedictory program of the course was held on 8th June 2019 at Conference Hall, NESAC Outreach Facility and was attended by Shri P L N Raju, Director, NESAC, Dr. Firoze Dotiwala, Basin Manager, ONGC, Jorhat and the scientists and staff of NESAC. The participants have given positive feedbacks and thanked NESAC for conducting the course. Dr. Firoze Dotiwala, Basin Manager, ONGC, Jorhat congratulated participants for the successful completion of the training course.

Participants with Director & Staff of NESAC at NESAC Outreach Facility

He has also requested NESAC to conduct more number of such courses to ONGC in the future. The course ended with the certificate distributions by Director, NESAC and a formal vote of thanks by the course coordinator.

4th Basic Course on Remote Sensing and GIS conducted at NESAC

Participants with Director, NESAC and staff at NESAC Outreach Facility

The three week Basic Course on Remote Sensing and GIS was organized at NESAC during June 03-21, 2019. 39 Participants from Govt. Departments, Academia and students were enrolled for the course. The programme saw the participation of the Soil and Water Conservation Dept of Shillong and Nongstoin, PHE Shillong, Irrigation Dept of Assam, NIC Kolhapur as well as several students, researchers and faculty members from the academia from across the country. The program was inaugurated on 3rd June 2019 by Director NESAC in the presence of all the participants. The course covered all the aspects of remote sensing and GIS. It was segregated into 5 modules: the basic Remote Sensing Module, the GIS module, Navigation Module, Advanced Techniques Module and the Application Module. The Basic Remote Sensing, GIS and Navigation modules covered all the essential topics necessary for embarking upon a journey in remote sensing and GIS. The advanced techniques covered the topics pertaining to Microwave Remote Sensing, Hyperspectral Remote Sensing, UAV Remote Sensing, Web-Based Serviced for Remote Sensing and GIS, Machine

Learning and AI for Remote Sensing and Cloud Computing for Remote Sensing using Google Earth Engine. The application module entailed a set of classes followed by project work in the following application domains: (1) Forestry, Ecology and Biodiversity, (2) Land and Water Resources, (3) Space and Atmospheric Physics, (4) Disaster Risk Reduction, (5) IT and Geoinformatics, (6) Geosciences and (7) Urban Studies. A field visit and visit to facilities at NESAC and the Doppler Weather Radar at Cherrapunjee was also conducted.

The valedictory function was held on 20th June 2019, where Shri James Sangma, Minister of District Council Affairs, Food, Civil Supplies & Consumers Affairs, Home (Passport & Police), Law, Power and Prisons Departments, Govt. of Meghalaya graced the occasion as the Chief Guest in the presence of Director, NESAC and all the participants & faculty members.

Hon'ble Chief Guest handing over memento and course certificate to a participant

One Day workshop cum interaction meeting on Lightning Resilient India Campaign and Agromet Advisory Services in NER conducted at NESAC

A one day Workshop cum interaction meeting on Lightning Resilient India Campaign and Agromet Advisory Services in NER of India was conducted on 22nd June 2019 at NESAC Outreach Facility. More than 100 participants from different government departments, NGOs, and private organizations participated in the workshop. The workshop was divided into two halves; the first half covered the

Participants of the workshop at NESAC Outreach Facility

Lightning Resilient India Campaign while the second half was focused on interaction meeting on agro-meteorological services over the NE region of India. The Lightning Resilient India campaign, spearheaded by Climate Resilient Observing Systems Promotion Council (CROPC) and is supported by India Meteorological Department (IMD) and Indian Meteorological Society (IMS) has the objective of making a lightning safe India. The program was organized jointly by NESAC and IMS-Shillong Chapter. Eminent speakers during the campaign were Dr. K J Ramesh, Director General, IMD; Shri P P Shrivastava, Member, NDMA Advisory Board, Prof. S K Srivastava, VC, NEHU; Shri P L N Raju, Director, NESAC and Col. Sanjay Srivastava, Chairperson, CROPC. Scientists and Professionals from National Remote Sensing Centre, National Disaster Management Authority, Indian Air Force, IMD, NESAC, NEHU, Assam State Disaster Management Authority, Nagaland State Disaster Management Authority, Meghalaya Revenue & Disaster Management Department, Mizoram State Remote Sensing Centre, Earth Networks, Indian Red Cross Society, World Vision India, All India Radio, different NGOs, Print and Electronic media, etc. attended the workshop. The interaction meeting to address various issues on implementation of Block level Agromet Advisory Services (AAS) in Northeast Region was presided by Dr. K J Ramesh. Dr. K K Singh, Head, Agromet Advisory Service Division, IMD briefed about the purpose of conducting the workshop focusing on strategies and implementing GKMS at block level for NE region.

Dr. Sanjay O'Neil Shaw, DDGM, RMC-Guwahati; Dr. A K Tripathi, Director, ICAR-ATARI, Guwahati; Dr. B C Deka, Director, ICAR-ATARI, Umaim and Nodal officers, Technical officers of all concerned KVK's and State Universities of NE Region participated in the workshop.

Three days training organized at NESAC on Applications of Remote Sensing and GIS in Agriculture

Agriculture and Soils Group of NESAC organized a 3 days training on "Applications of Remote Sensing & GIS in Agriculture" for 20 officers (Deputy Project Directors) of Agricultural Technology Management Agency (ATMA), Department of Agriculture, Govt. of Meghalaya at NESAC Outreach Facility during July 03-05, 2019. The programme was sponsored by Meghalaya Agricultural Management & Extension Training Institute (MAMETI). The programme was inaugurated by Shri P.L.N. Raju, Director, NESAC. The programme covered a wide range of topics starting from Basics of Remote Sensing & GIS to Advanced Remote Sensing Techniques for agricultural applications in 9 theory lectures and 7 practical sessions. The valedictory session of the programme was graced by Smt. Aroma M. Lyngdoh, Director (i/C), MAMETI as the Chief Guest and distributed certificates to the Trainees.

Participants of the training with Sr. Scientific staff of NESAC at NESAC Outreach Facility

Hindi Technical Seminar organized at NESAC

A Hindi Technical Seminar was organized in North Eastern Space Applications Centre (NESAC), Umiam, Meghalaya on 12th July 2019. The theme was "Reaching the Unreached through Space Science and Technology". The Chief Guest of the Seminar was Mrs. Kala Ramchandran, I.P.S., Director, North Eastern Police Academy (NEPA) and the Guests of Honor were Mrs. Sarla, Joint Director (O.L.), DOS and Shri Badari Yadav, Research Officer, Regional Implementation Office (O.L.), Guwahati.

The seminar was chaired by Shri P.L.N. Raju, Director, NESAC. He welcomed Scientists and officials who participated from different centres of ISRO (DOS) and said Hindi Language strengthens the unity of India and NESAC is committed to implement the official language policy of the Government of India.

Scientists, Officers and Employees from Semi Conductor Laboratory, Chandigarh; IIRS Dehradun; Branch secretariat, (DOS) New Delhi; ISTRAC Port Blair and NESAC, Umiam participated in the Seminar. The seminar was conducted in two sessions (i) Official language session and (ii) Technical session.

There were 4 articles received for official language session and 16 for Technical session. Out of which 3 writers presented in the Official language session and 11 in Technical session.

Ms. Anaculate Fernandez, Junior Hindi Translator, Branch secretariat, (DOS) New Delhi won the 1st Prize in the Official Language Session and Smt. Rekha Bharali Gogoi, Sci/Eng. 'SE', NESAC won the 1st Prize in the Technical Session. Winners and

Participants of the Technical Seminar with Director, NESAC at NESAC Outreach Facility

the participants were given certificates by Shri P.L.N. Raju, Director, NESAC. The seminar was concluded with the vote of thanks by Shri Avaneesh Shukla, Sr. Administrative Officer, NESAC, Umiam.

IRADE NESAC GBPANT joint project stakeholder meeting

An "Experts' Consultation on Developing Disaster Resilience Action Plan through GIS and Prioritizing Actions for natural Disaster Risk Reduction in Urban Agglomerations of Shillong and Gangtok" was organized at North Eastern Space Applications Centre (NESAC), Shillong, Meghalaya on 30th July 2019. The project is supported by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India under the NMHS Programme.

The primary objective of the consultation was to bring together various sectoral experts and discuss the work done so far in the project. The meeting was attended by experts from Geological Survey of India (GSI), Indian Meteorological Department (IMD), State Disaster Management Authority, North Eastern Space Applications Centre (NESAC) and North Eastern Hill University (NEHU).

Participants and faculties with Director, NESAC at NESAC Outreach Facility

NESAC conducted Research Collaborators' Meeting; Benefit Sharing Strategy for the Meghna Basin for Bangladesh & India

A two-day research collaborators meeting was held at NESAC during June 11-12, 2019 to discuss, define and identify priority areas for collaborative research initiatives that can support the sustainable and cooperative management of the Meghna basin. From India, the meeting was attended by Institute of Economic Growth (IEG), Gauhati University, North-Eastern Hill University (NEHU), Meghalaya Basin Development Authority (MBDA) and Asian Confluence. From Bangladesh, organizations such as the Centre for Environmental and Geographic Information Services (CEGIS), Dhaka, East West University, Dhaka and Oxfam Bangladesh attended the meeting.

The meeting was facilitated under the project, Building River Dialogue and Governance (BRIDGE) in the Ganga-Brahmaputra-Meghna (GBM) basin, or BRIDGE GBM by IUCN and funded by Transboundary Rivers of South Asia (TROSA) programme under Oxfam. The goal of the initiative is to create an enabling environment for the cooperative governance of shared rivers in the GBM region for poverty alleviation, as well as conservation of the ecological integrity of the river basins.

During the meeting, it was proposed to bring out Landuse Landcover Atlas for the Meghna basin at 1:50,000 scale. The atlas covers full basin and takes a catchment area approach thus will include thematic maps of sub-basins in the Meghna basin without any administrative demarcation. Land use change analysis for six different time durations, starting from the year 2005 to 2019 and LULC hotspots are also proposed to carry out. The drivers

Participants with Director, NESAC at NESAC Outreach Facility

for the land use changes in the Meghna basin are to be identified/quantified with ground data collected through socio–economic survey.

Considering the sensitivity of data sharing between two countries, Meghna Basin Atlas has been recommended to create without physical data sharing. The outcome of this study will be useful in preparing regional level development programme, including transboundary resource assessment and management. It will also support the development and implementation of a benefit-sharing strategy for the Meghna basin, thereby improving poverty through the sustainable planning process.

Participants with Director, NESAC at NESAC Outreach Facility

One Day Orientation Program on Jal Shakti Abhiyan (JSA)

As a part of Jal Shakti Abhiyan (JSA), a mission-mode time-bound water conservation campaign by the Ministry of Jal Shakti, NESAC has imparted a one-day training program on JSA to Block Development Officers of Umsning and Bhoirymbong blocks of RiBhoi district, Meghalaya on 9th August 2019. A total of 26 participants from both the blocks attended the training program. The training was mainly focused on using remote sensing and GIS techniques for water resources applications.

Participants and faculties with Director, NESAC at NESAC Outreach Facility

Short Course on "Microwave Remote Sensing with Special Emphasis on North East India"

NESAC has successfully organized a short course on "Microwave remote sensing with special emphasis on North East India" from 19th to 23rd August 2019. The course aimed to develop the expertise of NESAC scientists, research scientists and JRF in the field of microwave remote sensing applications. A total of 28 participants attended the course. During the course, expert lectures and practical demonstrations were provided by Shri C Patnaik,

Dr. Shashi Kumar, IIRS taking a class of participants during the course

Participants with Shri C Patnaik and Dr. Anup Kumar during the training program

Scientist, SAC, Ahmedabad, Dr. Anup Kumar Das, Scientist, SAC, Ahmedabad and Dr. Sashi Kumar, Scientist, IIRS. The various topics covered during the course include microwave remote sensing and thematic applications of SAR data, SAR Image Interpretation and basic processing, basics of SAR, polarimetric SAR, basics of interferometric SAR (InSAR) & differential InSAR (DInSAR), polarimetric InSAR (PolInSAR), etc.

Tier II: Training Course for Middle Level Officers under AMRUT Sub-scheme

NESAC conducted 3rd Tier II: Training Course for Middle Level Officers under AMRUT Sub-scheme on Formulation of GIS-based Master Plans at NESAC, Shillong during September 02-13, 2019. The training course was attended by a total of 24 participants and included government officials from 5 state town planning departments, i.e., Manipur (2), Madhya Pradesh (4), Uttar Pradesh (2), Telangana (7) & West Bengal (9) having varying designations ranging from Draughtsman, Statistical officer, Town planning officer, Assistant Engineer, Town planning assistant, Associate district town planner, Urban planner, Urban infrastructure expert, Assistant Director & Deputy Director.

The course content emphasized on Government Initiatives in Geospatial Technology based Planning, URDPFI and E-governance, Map projections and Mobile Applications, Remote Sensing, Image Processing and Basics of GIS, Spatial Analysis and Modeling, Formulation of GIS-based Master Plans under AMRUT Sub-scheme, GIS and RS Applications in Urban Planning, Project Work on Formulation of Master Plans & Advances in Geospatial Technologies and Data Policies.

The course had 32 hours of lectures & 26 hours of practical work for the participants, one day of field visit to conduct surveys related to urban land use planning. The last three days of the second week were dedicated towards mini-projects, which were executed in groups with different components of master plan preparation utilizing the data collected during the field visit for each group.

Participants of the course with staff & Director of NESAC at NESAC Outreach Facility

Two weeks training course on UAV Remote Sensing

The fourth 2-weeks training course on UAV Remote Sensing – Possible Applications & Future Advances was conducted by NESAC during September 16-27, 2019. The training course was attended by a total of 36 participants, including students, research scholars and teachers from different colleges and universities and officials from various public/ private sectors of the different parts of the country. The course covered understanding of the UAVs and its components, flight planning for data acquisitions for various remote sensing applications, 3D printing & its application in UAV. It also covered different data processing techniques such as the generation of Orthomosaic, digital surface model (DEM), digital terrain model (DTM), contour maps, volumetric analysis etc. for high-resolution UAV data processing using open source software, Pix4D mapper pro and Agisoft photoscan pro software. The course had 14 hours of lectures, 26 hours of practical work for the participants, one industry interface session and one day of field visit to capture UAV data with GCPs. The third and fourth day of the second week was dedicated towards mini-projects, which were executed in groups with different application based topics for each group. The valedictory function was graced by Shri Atanu Saha, Director S&T, North Eastern Council as the Chief Guest and Shri Manish Kumar Agrawal, Airport Director, Umroi Airport as the Guest of Honour.

Participants of the course with staff & Director of NESAC at NESAC

Short Course on RS & GIS Applications in Forestry and Ecology

A short course on RS and GIS applications in forestry and ecology was conducted at NESAC from 21st to 25th October 2019. A total of 21 participants joined the training from various parts of Northeast India and West Bengal. The themes covered during the course are basics of remote sensing and GIS, image interpretation, enhancement techniques, vegetation indices, concepts of GPS & map projection, wildlife habitat evaluation, species distribution modelling, concepts of microwave remote sensing, UAV remote sensing, hyperspectral remote sensing, etc. The course focused more on practical sessions demonstrating image geo-referencing, satellite image interpretation, layer stacking, familiarisation with QGIS software, forest mapping etc. The various thematic topics and practical exercises were conducted by NESAC scientists and researchers.

Participants of the course with staff of NESAC at NESAC Outreach Facility

NESAC participated in State level "National Children's Science Congress", Assam

NESAC participated at the 27th State level "National Children's Science Congress (NCSC)" held at Doom Dooma, Assam during November 01-04, 2019. A state of the art space museum build in a bus developed by ISRO as a part of the Dr. Vikram A. Sarabhai centenary celebration program was also displayed in the NCSC. The mobile space exhibition bus was on display for the first time in the North Eastern part of India. The "Space Museum on Wheels" has models of the launch vehicle (SLV, ASLV, PSLV, GSLV), satellites (polar and geostationary), Vikash engines, cryo stage, RLV-TD-NAVV, ISRO extra-planetary missions, etc. The bus was also exhibited in CSIR-NEIST, Jorhat and Sivasagar College, Sivasagar. Around 2500 participants from various groups of people like students, teachers, and the general public visited the bus and experienced Indian space technology. A team of NESAC led by Dr. Arup Borgohain, Scientist demonstrated the features of the exhibition to the participants.

Students and Parents flocking in to see the Space On Wheels Exhibition Bus

Short Course on Drone Data Acquisition, Processing and Analysis Using Open Source Tools

A short course on Drone Data Acquisition, Processing and Analysis Using Open Source Tools was successfully organized by NESAC during November 04-08, 2019. The course was focused on how available tools and libraries could be used for processing of Drone derived imagery and generate valuable high-resolution data products such as Orthomosaics, Digital Surface/Terrain Models, 3D Textured Models, etc. which can then be used

for various planning and R&D purposes. Further, advanced lectures on Computer Vision techniques for 3D scene reconstructions and the use of ML/DL for UAV data analysis were also delivered during the course. Extensive Hands-On tutorials were prepared and used by the participants to equip themselves with the major tools and libraries for drone data processing. Each Hand-Out has clearly defined learning goals to keep track of what they would be doing/learning during the practical sessions. Different UAV datasets were provided to the participants for use during the lab sessions. The weeklong course was attended by 32 participants coming from various government departments, institutes and public/private sectors. A short quiz was also taken to assess the understanding of their learnings during the course. Shri PS Singh (Sci/Engr. 'SE'), NESAC was the Course Coordinator and Shri Avinash Chouhan (Sci/Engr. 'SD') was the Course Officer for the 5-days training program.

Participants of the course at NESAC with Staff & Director, NESAC

National Symposium on Innovations in Geospatial Technology for Sustainable Development with special emphasis on NER

The National Symposium on "Innovations in Geospatial Technology for Sustainable Development with special emphasis on NER" and annual conventions of Indian Society of Geomatics (ISG) & Indian Society of Remote Sensing (ISRS) was organized jointly by Indian Society of Geomatics & Indian Society of Remote Sensing during November 20-22, 2019 in Shillong. The event was hosted by the Indian Society of Geomatics, Shillong Chapter (ISG-SC) Indian Society of Remote Sensing, Shillong Chapter (ISRS-SC) North Eastern Space Applications Centre (NESAC), Umiam & North Eastern Hill University (NEHU), Shillong. The symposium focused on recent advancements made in the satellite payloads, data processing techniques, Web GIS, Mobile App., Geospatial Technology and applications in various key areas defined under different key programs of the Government of India. The symposium was attended by a large number of researchers, academia, students and professionals from the geospatial industry from different parts of the country. More than 350 delegates from various states and representing on different themes have attended the symposium and participated in the deliberations.

Release of Proceedings of the symposium by Hon'ble Governor of Meghalaya and other dignitaries

The symposium was preceded by 2 days pre-symposium tutorials during November 18-19, 2019 under the four broad themes,1) UAV Remote Sensing, 2) SAR data Processing and Applications, 3) Artificial Intelligence (AI) and Machine Learning (ML) for Remote Sensing Data Analysis, and 4) Hyperspectral Remote Sensing.

The national symposium was formally inaugurated on 20th November 2019 at NEHU by Shri Tathagata Roy, Hon'ble Governor of Meghalaya. The Abstract Volume cum Souvenir of the symposium was also inaugurated by Hon'ble Governor during the inaugural function of the symposium. This was followed by the award distribution ceremony of ISG

and ISRS. Dr. Dibyajyoti Chutia, Scientist-SF, NESAC was awarded National Geomatics Award 2019 on Technology for his significant contribution in the applications of Geomatics. There were two plenary sessions after the inaugural session. In the afternoon, Vikram Sarabhai Memorial Lecture was delivered by Padmasree Kiran Karnik and ISG Millennium lecture was delivered by Prof. Henry Lamin, Pro-Vice Chancellor of NEHU. The daylong technical program was followed by a cultural program in the evening.

Dr Dibyajyoti Chutia receiving the award from Hon'ble Governor, Meghalaya

On November 21-22, 2019 technical program was held at NESAC Outreach Facility. On 21st November 2019, Shri Tapan Misra, President, ISG and ISRS inaugurated the exhibition at NESAC Outreach premises. There were exhibition stalls from various state government departments and vendors displaying their activities and products. One poster session was also there, in which

Technical session at NESAC Outreach Facility

posters from different themes were presented. There were 18 technical sessions spread across the two days and divided into different themes, each hosting multiple paper presentations. A special session on 'Jal Shakti– Sustainable Water Resources Management in India' was organized on 22nd November 2019. The session was chaired by Dr. V.V. Rao, NRSC, Hyderabad. It was followed by the concluding session/panel discussion and distribution of awards for best performance in both oral presentation and poster presentation categories. The programme ended with a vote of thanks offered by Dr. Bijoy K. Handique, Organising Secretary of the symposium.

NESAC conducted one week course on applications of Remote Sensing & GIS in Water Resources

NESAC has conducted a one week short course on 'Applications of Remote Sensing & GIS in Water Resources' during November 25–29, 2019. This

Participants of the Inaugural Program on 20 November 2019 at NEHU, Shillong

Participants of the one week course at NESAC Outreach Facility with Staff & Director, NESAC

course mainly focused on the understanding of remote sensing and GIS techniques to study the recent advances in water resources. The course consisted of a series of lectures and practical on remote sensing, GIS and water resources. The course was designed with a view to provide an understanding of the scientific concepts associated with remote sensing and its applications to various water resources problems. A total of 15 participants for different parts of North East attended the training program.

NESAC conducted one week course on applications of Remote Sensing & GIS in Agriculture

A one week short course on 'Applications of remote sensing & GIS in agriculture and allied areas' was conducted at NESAC during November 25-29, 2019. This course focused primarily on providing basic working knowledge in the field of the geospatial domain for professionals related to agriculture and allied areas. The course consists of the series of lectures and hands-on exercises which emphasizing the overall understanding of basic concepts, applications and the utilization of geospatial technology for crop acreage and production estimation, cropping system analysis and crop damage assessment, Land and Soil Resources Assessment Site suitability analysis for expansion of crop, applications of geospatial technology in allied agriculture activities like animal husbandry, sericulture etc. The trainees were also introduced to the recent developments

Participants of the one week course at NESAC Outreach Facility with Staff & Director, NESAC

in the areas of mobile applications and services and UAV remote sensing. A total of 19 participants for different parts of NER attended the training program. In addition to lectures by Scientists of NESAC, Dr. P. P. Nageswara Rao, Former Director, NESAC and Dr. J. S. Parihar, Former Director, NESAC and former Deputy Director, SAC, Ahmedabad delivered talks as invited speakers.

NESAC conducted training on "Application of Geographical Information System in Disaster Risk Management" NDMA officials during December 9-13, 2019

North Eastern Space Applications Centre (NESAC) conducted 5 Days Training Course on "Geographical Information System (GIS) in Disaster Risk Management" for the officials sponsored by National Disaster Management Authority (NDMA), Govt. of India, at NESAC Outreach Facility, Umiam, Meghalaya during December 9-13, 2019. Total 18 officials from both Central and State organizations like, DoT, SDMA, DDMA, IMD etc. from Eastern and North Eastern parts of India participated in this training.

Total 18 theory classes were taken on diverse topics including Basics of Remote Sensing (RS), Geographical Information System (GIS), Global Navigation Satellite System (GNSS) and their applications to various disasters like flood, forest fire, landslide, earthquake, thunderstorm, cyclone, lightening etc. apart from weather forecasting, web-GIS, satellite communication and UAV technology. The course includes 4 invited lectures by resource persons from NRSC, GSI on the topics related to the course like Earthquake-seismic risk-Seismotectonic domains, Landslide Hazard zonation & early warning and National Database for Emergency Management (NDEM) in addition to 3 Practical sessions for hands-on training on flood forecasting, landslide susceptibility mapping and GNSS. On full-day field visit conducted to demonstrate Doppler Weather Radar (DWR), Unmanned Aerial Vehicle (UAV),

Indian Navigation Satellite System (NaVIC) - Global Navigation Satellite System (GNSS) systems to the participants.

Participants of the course at NESAC Outreach Facility with Staff & Director, NESAC

NESAC organized Vikram Sarabhai Centenary Program at Agartala, Tripura during January 02-04, 2020

As part of the ISRO's nationwide Vikram Sarabhai Centenary Program to mark the birth centenary of Dr Vikram Sarabhai, the first such program in NE region of India was organized at Maharani Tulsibati Girls Higher Secondary School at Agartala, Tripura during January 02-04, 2020. The program was conducted in collaboration with State Council of Educational Research and Training (SCERT) of Government of Tripura and coincided with the Annual state level fair on Science, Mathematics, and Environment conducted by the Government of Tripura. NESAC set up an exhibition stall with a complete set of material received for this program, displayed the Space on wheels, arranged different competitions like painting, quiz, extempore speech, essay writing, etc. in addition to special lectures by eminent space scientists. The program was inaugurated by Hon'ble Chief Minister of Tripura, Shri Biplab Kumar Deb in the presence of Hon'ble Education Minister of Tripura Shri Ratan Lal Nath. Hon'ble Chief Minister visited the Space on wheels and took keen interest on the displays. Two lectures were organized during the program. The first lecture was by Padmashree Dr V Adimurthy, ISRO Honorary Distinguished Professor on "Indian Space Program with focus on Planetary Missions, Exploration, and Science and the second lecture was on "Benefits of Space Technology with special emphasis on Societal Development", which was delivered by Shri P L N Raju, Director, NESAC. More

Hon'ble Chief Minister, Tripura during the inaugural address of the exhibition

Hon'ble Chief Minister, Tripura inaugurating the Space on Wheels Bus

Prize distribution by Director, NESAC for various competitions held during the exhibition

than 2000 students visited the Space on wheels and exhibition area each day during the program. The students enthusiastically participated in different competitions and interacted with scientists. Different posters, stickers, T-shirts, caps, pens, etc. specially designed for the centenary celebration program were gifted to the students. The students were also shown by flying Unmanned Aerial Vehicles, different Science activities, video shows, etc. The program was concluded on 4th January 2020 where Hon'ble Minister of Forest and Tribal Welfare of Tripura, Shri Mevar K. Jamatia was the Chief Guest. During the valedictory program, students were given prizes and certificates for their exceptional performance in different competitions.

NESAC conducted 2 weeks training course for BIMSTEC countries during January 06-17, 2020

A two weeks training programme on "Capacity Building on the Earth Observation Applications and Research: Fundamentals, Emerging Technological Tools and Services for BIMSTEC Counties Professionals" was conducted at NESAC during January 06-17, 2020. Total 24 participants from Bangladesh, Myanmar, Sri Lanka, Thailand, Nepal and Bhutan have attended this two weeks programme organized by NESAC and sponsored by the Ministry of External Affairs, BIMSTEC Division, Government of India. Shri DK Das, Distinguished Scientist, Director, Space Applications Centre, ISRO, Ahmadabad graced the occasion as a Chief Guest during the inaugural programme held on 6th January 2020. Dr. R R Navalgund, Former Director, Space Applications Centre, ISRO, Ahmedabad delivered a talk on the Principle of Remote Sensing and Sensors as an invited speaker as well as Guest of Honour in the inaugural programme. Shri Moses K Chalai, IAS, Secretary, North Eastern Council (NEC) graced the occasion as the Chief Guest during the valedictory programme of the course held on 17th January 2020.

BIMSTEC participants with NESAC Staff at NESAC Outreach Facility

NESAC conducted Vikram Sarabhai Centenary Program for Meghalaya at NESAC Outreach Facility during February 25-26, 2020

A two-day program on Vikram Sarabhai Centenary Program was conducted for the students of Meghalaya at NESAC Outreach Facility. More than 500 students attended the program. Twelve schools were selected and participated in the program. On the first day, various competitions – drawing, extempore speech, painting and quiz were arranged- both for the junior and senior groups. The inauguration program had taken off with the welcome speech by Shri P. L. N. Raju, Director NESAC, the inaugural speech was delivered by Shri A. S. Suting, Officer on Special Duty, State Council of Science, Technology & Environment (SCSTE), Meghalaya. The Vikram Sarabhai Memorial Lecture was delivered by Shri. K. C. Bhattacharyya, Former Director, NESAC at NESAC Outreach Facility. The program ended with good feedback from the students, with more liking to the illustrative interaction with the space models in the Space on Wheel.

Vikram Sarabhai Memorial Lecture by Dr. K.C.Bhattacharyya, Former Director, NESAC at NESAC Outreach Facility

Students gathered for the 'Space On Wheels Exhibition Bus' at NESAC Outreach Facility

Students participating in various Space Club Activities

NESAC conducted Vikram Sarabhai Centenary Program for Sikkim jointly with Sikkim Manipal Institute of Technology during March 04-06, 2020

Vikram Sarabhai Centenary Program was conducted in Sikkim with a 3 days program from March 04–06, 2020 in collaboration with Sikkim Manipal Institute of Technology (SMIT) at their campus at Majitar, Rangpo, Sikkim. The program was inaugurated on 4th March 2020 by Prof. Ashis Sharma, Director, SMIT followed by an invited talk on 'Life of Dr. Vikram Sarabhai and applications of space technology for society' by Dr. V. Jayaraman, Former Director, NRSC. The inauguration program was attended by faculties & students of SMIT, teachers and students from various secondary schools, ITI etc. from different parts of Sikkim state. Prof. Utpal Deka, Head, Dept. of Physics, SMIT had coordinated the program and Shri R.K. Das, Scientist from NESAC and the state coordinator for Sikkim, offered the vote of thanks at the end of the inaugural program.

As part of the program, an exhibition stall was set up in the institute premise. The exhibition bus, i.e. 'Space on Wheels' was also put for demonstration among students, teachers, faculties, parents and all interested visitors. More than 3000 people had witnessed the exhibitions. Various educational aids & awareness materials on space science and technology were distributed among students. Several competitions like painting, essay writing, extempore speech, quiz, etc. were conducted among different levels of school's students, and very good participation was observed. Prizes were distributed to winners in the concluding ceremony conducted on 6th March 2020.

Vikram Sarabhai Memorial Lecture by Dr. V. Jayaraman, Ex. Director, NRSC, ISRO at SMIT

Students gathered for the 'Space On Wheels Exhibition Bus' at SMIT

Various Office Events & Celebrations

Awareness Lecture delivered on Cyber Security for CISF Personnel

A lecture on Cyber Security was delivered on 5th April 2019 by Shri PS Singh under his role as Information Security Officer, NESAC for the benefit of CISF personnel stationed at NESAC. As part of the lecture, PS Singh has explained the need for a proper understanding of various forms of Cyber threats and essential security tips and tricks to prevent these threats. Further, He also briefly talked on cyber security and social media and explained ways to keep media accounts safe and secure.

Scientist NESAC with NESAC CISF Unit

Observance of Anti-Terrorism Day

Anti-Terrorism Day was observed on 21st May 2019 at NESAC. The objective behind 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 as to how it is prejudicial to the national interest. As part of the observance, a pledge taking ceremony was administered by Shri P.L.N. Raju, Director, NESAC.

Director, NESAC administering of Anti Terrorism Day Pledge to all staff

World Environment Day 2019 observed at NESAC

The World Environment Day 2019 was observed at NESAC during June 04-06, 2019. Tree plantations were done in the residential area of NESAC on 4th June 2019. As a part of the celebration, invited talks were organized in the NESAC auditorium for NESAC staff and students. Dr. A Balusamy, Scientist, ICAR RC NEH, Umiam delivered a talk on '*Beat Air Pollution*' and Smt. H. Lato, DFO (Wildlife), Jaintia Hills Division delivered a talk on '*Wildlife conservation and its importance*'. The talks were followed by mass tree plantation inside the NESAC main campus on 6th June 2019.

A tree plantation drive on the occasion by Director & Staff of NESAC

Bomb Threat & Evacuation Mock Drill Conducted at NESAC

A multi-party bomb threat Mock Drill was conducted at NESAC in collaboration with CISF Unit, NESAC, Meghalaya Fire & Emergency Services, Shillong Bomb Squad Officials and Meghalaya Home Guard Officials. The Officials instructed

Officials during the mock drill

NESAC Staff on general procedures at the situation of a bomb threat and also demonstrated a mock bomb identification and defusal. Evacuation of stuck people was also done. The whole program was conducted by Safety Officer, NESAC, Assistant Commandant, CISF Unit and Sr. Administrative Officer, NESAC.

5th International Yoga Day Celebration at NESAC

The International Day of Yoga is celebrated annually on June 21 to raise global awareness about the benefits of the ancient Indian practice. It comes with a different theme every year and the theme for 5th International Yoga Day is 'Climate Action'. Like every year, NESAC celebrated 5th International Day of Yoga (IDY) on 21st June 2019. As a part of the program, common Yoga protocol was performed from 6:30 AM onwards at NESAC Community hall. Director NESAC, Shri. P L N Raju on his opening remarks told that the practice of yoga may be practised on a daily basis to get its maximum benefits.

Dr. Himangshu Barua, Lecturer, North Eastern Institute of Ayurveda and Homeopathy (NEIAH) delivered a lecture on "Role of Yoga and Ayurveda for better health" for the benefit of the NESAC staff and students from nearby schools. The lecture included basic Yoga practices as well as the role of Ayurveda in improving overall human health. NESAC staff and students interacted with the invited guest and discussed various aspects of Yoga and Ayurveda.

A lecture by Dr. Himangshu Barua

NESAC Staff celebrating Yoga Day by attending Special Yoga Session

The celebration also included quiz completion for NESAC staff and students. The program ended with the remarks and observations by Dr. K K. Sarma, Senior Scientist, NESAC and a formal vote of thanks by Dr. Gopal Sharma, Coordinator of the program.

NESAC Conducted One Day Free Eye Camp at NESAC Community Hall

A "One day free Eye Check up Camp" was organized by NESAC, in association with Bansara Eye Care Centre, Laitumkhrah, Shillong on 12th July 2019 at Community Hall, NESAC Residential Complex. The programme was inaugurated by Shri P L N Raju, Director, NESAC, In his inaugural address, he mentioned that the Eye Camp has been conducted on demand from the staff and the people of the nearby localities. Residents of Nongsder & Umiam village had also participated in the Eye Camp. He further informed that last year in collaboration with North Eastern Institute of Ayurveda & Homeopathy, Ministry of Ayush, Shillong, a free Health camp was organized. A team of doctors and staff from

Eye Check up camp at NESAC Community Hall

Bansara Hospital led by Doctor Wakaru Shullai (Eye Specialist), conducted the Eye Camp. The response to the Eye camp was overwhelming and a total of 158 people were benefited from the eye camp.

Inauguration of new CISF Quarters at NESAC Residential Complex

The CISF quarters was inaugurated on 9th August 2019 by Dr. D.P. Sharma (Director CEPO) in the presence of Shri P.L.N. Raju (Director NESAC) and Assistant. Commandant CISF NESAC. The foundation stone for this was laid by the Former ISRO Chairman Shri. A.S. Kiran Kumar on 5th October 2017. The facility consists of 19 nos of B-type Quarters, 2nos of C-type and one D-type Quarters. The building is 4 stories with separate D-type Quarter for Assistant commandant. The Building is equipped with proper fire hydrant system, lightning protection systems, earthings etc as per the norms. Besides solar powered water heaters and solar street lights is installed as green features.

CISF Quarters being inaugurated by Director, NESAC & Assistant Commandant, CISF Unit, NESAC

NESAC celebrated 73rd Independence Day

73rd Independence Day of the nation was celebrated at NESAC with a colourful programme. Shri P. L. N. Raju, Director, NESAC hoisted the tricolor amidst singing of national anthem by the staff of NESAC at 9 AM. The CISF unit of NESAC offered a guard of honour to Director, NESAC and performed Independence Day parade. Director, NESAC addressed the staff of the Centre with an informative speech, where he highlighted the significance of Independence Day celebration and briefed about the activities and achievements of NESAC vis-a-vis the Department of Space. The CISF unit demonstrated various skills in front of the staff of NESAC. This was followed by a cultural program organized by Recreation Committee of NESAC, in which the staff of NESAC and their family members participated in various interactive games, quiz and other activities at the auditorium.

Hoisting of National Flag by Director, NESAC on Independence Day

Sadbhavana Pledge taken by Staff of NESAC

Sadbhavana Diwas was observed in NESAC on 20th August 2019 where Shri PLN Raju, Director, NESAC administered the Sadbhavana Diwas Pledge.

Sadbhavana pledge for the staff of NESAC being administered by Director, NESAC

NESAC celebrated its 19th Foundation Day

19th Foundation Day of NESAC was celebrated with a day-long programme on 5th September 2019. The program was started with a welcome speech by Director, NESAC, followed by tree plantation

program inside NESAC Campus. After tree plantation, the staff of NESAC proceeded towards Umiam Market for the inauguration of a Community Toilet newly constructed for the market area under CSR activity of Antrix Corporation. Shri George B. Lyngdoh, Hon'ble MLA, Umroi constituency, Meghalaya graced the occasion as the Chief Guest. Tree plantation was also undertaken in and around the market area. This was followed by the remaining part of the program at NESAC Auditorium where a technical session was organised from 11 AM till 1 PM. Shri Uddhab Bharali, a renowned innovator from Assam and Shri D. Majaw, Secretary, Ri Bhoi Farmers' Union and graced the session as the Chief Guest and the Guest of Honour respectively. The session was started with the lighting of lamp and chanting of Saraswati Vandana followed by releasing of the September edition of NESAC Newsletter by Shri PLN Raju, Director NESAC. Later, Mr. Majaw presented a popular talk on his experience of integrated farming in the Ri Bhoi District of Meghalaya. Shri Uddhab Bharali delivered the NESAC Foundation Day lecture, where he provided glimpses of some of his numerous innovations

Release of NESAC Newsletter by Director, NESAC and Dr. K.K. Sarma, Sr. Scientist, NESAC

which has changed many lives in distress. The second session saw the participation of NESAC Staff in various programs like Open Quiz followed by an array of cultural programs like Singing, Dancing, Recitation, Skit, etc. organized by NESAC

Cultural program performance at NESAC on Foundation Day

Recreation Committee. This was followed by a Prize Distribution Ceremony for various sporting and recreational events organized as part of the Foundation Day celebration. Several Contractual Staff working at NESAC were also recognized in the form of different awards for their dedicated services.

Community Toilet inaugurated at Umiam market

The community toilet at Umiam market area was constructed by M/s Sulabh International Social Service Organization under Corporate Social Responsibility (CSR) activity of Antrix Corporation, Bangalore with the support from Construction and Maintenance Division (CMD), NESAC. The land for this project was given by Meghalaya Energy Corporation Limited (MeECL) on lease basis for 30 years. This toilet complex is located close to Umiam market and Orchid Hotel Junction. This toilet facility will be operational on 'pay and use' basis. This facility is expected to fulfil a much-needed requirement of the local residents, shop keepers, tourists, and students of the Umiam locality. NESAC has initiated this project as part of Swachh Bharat Mission and also to serve the local people residing near and around NESAC campus. The construction work was started on 31st January 2019 and completed in August 2019 at cost of Rs 15.00 lakhs. This facility was opened for public on 5th September 2019 by Shri George B. Lyngdoh, Hon'ble MLA, Umroi constituency in the presence of Shri P. L. N. Raju, Director NESAC,

Shri D. Warjri, Additional Secretary, MeECL, officials from M/s Sulabh International Social Service Organization and representatives from the office of Deputy Commissioner, Ri Bhoi District. On this occasion, tree planting was also carried out by the dignitaries. Hon'ble MLA, Director NESAC and other dignitaries addressed the gathering and sought the support of the local people in maintaining the cleanliness of the Umiam market area. A large number of NESAC officials and public participated in the program.

Inauguration of community toilet at Umiam market by Director, NESAC

NESAC celebrated Hindi Fortnight

Hindi fortnight was organized in NESAC from 2nd to 16th September 2019. 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. A short presentation related to provisions of official language 'Hindi' presented by Shri Avaneesh Shukla, Sr. Admin Officer. During the fortnight, several activities were organized such as display of Banner, planting of trees, competitions, etc. A Hindi workshop was organized on the topic "Elementary Knowledge of Hindi and Hindi Translation" at NESAC Auditorium on 3rd September 2019 by Shri K. C. Basfor, Manager (O.L.), SBI, Guwahati, in which employees from all sections have participated. On 11th September 2019, various Hindi competitions were organized, in which NESAC staff participated with full zeal. Competitions like Hindi newspaper reading, translation of administrative terminology, extempore speech, dictation writing and group debate competition etc. were organized. During the fortnight all employees were encouraged to sign in Hindi, to do their official work in Hindi, and to converse in Hindi. On 16th September 2019 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. It was followed by the distribution of certificates to the winners of the competition by Dr. Diganta Barman, Sci/Eng. 'SF', NESAC. The Hindi fortnight celebration concluded with the vote of thanks offered by Dr. Kasturi Chakraborty, Sci/Eng. 'SF' & Member, NESAC Official Language Implementation Committee.

Staff of NESAC participating in Hindi competition

Earthquake Evacuation Mock Drill conducted at NESAC

A joint Mock Drill was conducted at NESAC on 17th September 2019 on Earthquake Evacuation for the staff of NESAC. Personnel from NESAC CISF Unit, Ri Bhoi District Disaster Management Authority, Local Police from Umiam Police Station, Meghalaya Fire & Emergency Services personnel from Umiam Station, personnel of Meghalaya Home Guard stationed at NESAC, NESAC Safety Team & Administration along with staff of NESAC participated in the Mock Drill exercise. Smt. K. Wanniang, District Disaster Management Officer, Ri Bhoi District gave an informative lecture on the best practices during earthquake event and

need for earthquake preparedness. Shri K Ramdas, Asst. Commandant, NESAC CISF Unit briefed the staff regarding their roles during the mock drill. After the briefing, staff were sent to their respective sitting places and sometime later, the mock drill was initiated by sounding a surprise siren symbolizing the earthquake event. On hearing the siren, staff of NESAC came out of the building and gathered at the pre-decided assembly point. Then personnel of the CISF Unit, acting as the first responders, carried out a search and rescue operation in the office building to take out the people acting as injured. The Mock Drill was concluded with the sharing of experience by the participants.

Staff of CISF Unit coordinating the Evacuation Mock Drill

Swachhata Hi Seva (SHS) celebrated at NESAC

Swachhata Hi Seva (SHS) Campaign with a Motto 'Plastic waste free India', was organized by NESAC from 3rd to 27th October 2019. The programme was inaugurated by a Swachhata Pledge which was administered by Shri P L N Raju, Director NESAC followed by a Cleanliness drive at NESAC Campus. During this period, various activities took place like cleanliness drive outside NESAC Office, NESAC Residential Complex, NESAC Outreach Facility & Hostel Block, nearby villages, Umiam market, etc. In order to create awareness on cleanliness, hygiene & sanitation and to create awareness regarding segregation of plastic waste, Flyers, stickers, pamphlets were distributed to nearby areas. Awareness talks on segregation of waste to all residents and nearby villages as well as the

NESAC Staff participating in Swachhata Hi Seva by cleaning the NESAC Outreach Facility

arrangement of blue and green bins for waste segregation was also given to the residents and nearby villages. Sloganeering on sustaining toilet usage and taking up waste management work in the area and sensitize the local community to stop wasting of water resources was also done for nearby villages.

Observance of Vigilance Awareness Week

The Vigilance Awareness Week-2019 was observed in the Centre from October 28–November 02, 2019. The Integrity Pledge as an Organization was administered by Director, NESAC at the NESAC Auditorium. Banners and Posters were displayed in the Centre. Quiz and Essay Writing for school students were also conducted on 1st November 2019.

Conducting Quiz Competition for Students of nearby schools

Observance of Rashtriya Ekta Diwas

'Rashtriya Ekta Diwas' (National Unity Day), was observed in the Centre on 31st October 2019. Director, NESAC administered the Rashtriya Ekta Diwas pledge to all employees of the NESAC. As part

of the observance, a "Run for Unity" is organised on 31st October 2019 at 6 AM from NESAC main gate to Nongsder Football ground and back (approx 5 km).

Run for Unity

NESAC celebrated the Constitution Day

NESAC celebrated the Constitution Day on 26th November 2019. Dr. K K Sarma, Sci/Engr 'SG', NESAC read out the 'Preamble' to the Constitution (as it exists today).

Reading of the Preamble to the Constitution

Observance of Swachhta Pakhwada 2020 at NESAC

NESAC also observed the Swachhta Pakhwada 2020 under the title – 'Dioxin to Oxygen' during the period from 1st to 15th February 2020. On this occasion, All NESAC Employees, Research Scientists, Junior Research Fellows and all outsourced workers were requested to participate enthusiastically in the event and tried to make our workplace and surroundings more clean and plastic free. The observance included Plogging run by Officers and Staff, lead by senior officials of NESAC to pick up plastic litters in and around campus, cleaning of NESAC Campus, Hostel, Residential Complex and nearby areas, Procurement and distribution of steel/ copper water bottles to all NESAC staff for office use (so as to curb the use of SUPs), Swachhata procession at nearby villages to spread awareness on plastic harmfulness and the necessity to avoid/ reuse the same, etc.

Plogging run by Officers and Staff

NESAC celebrated 71st Republic Day of the Nation

71st Republic Day of the nation was celebrated at NESAC on 26th January 2020 with a colorful program. Director, NESAC hoisted the tricolor amidst singing of national anthem by the staff of NESAC at 9 AM. The CISF unit of NESAC offered a guard of honor to Director, NESAC and performed Republic Day parade. Director, NESAC addressed the staff of the Centre with an informative speech, where he highlighted the significance of Republic Day celebration and briefed about the activities and achievements of NESAC vis-a-vis the Department of Space. This was followed by the distribution of sweets and snacks to the gathering by NESAC Canteen.

NESAC Staff celebrating 71st Republic Day

Student Visits

Students from Saint Mary's college visited NESAC on 25th April 2019

Students from St. Anthony's College, Shillong visited NESAC on 3rd May 2019

MSc Students from DM College, Imphal visited NESAC on 8th May 2019

Students from Sanskriti-The Gurukul visited NESAC on 21st June 2019

Students from RIST, Meghalaya visited NESAC on 28th August 2019

Visit of Distinguished Guests

Padma Bhushan Dr. K. Radhakrishnan, Former Chairman, ISRO visited NESAC

Padma Bhushan Dr. K. Radhakrishnan, Honorary Distinguished Advisor, DOS/ISRO & Former Chairman, Space Commission/Chairman, ISRO/ Secretary, DOS/ Former, Chairman, NESAC Governing Council visited NESAC during 14th-15th October 2019.

Interaction of Staff of NESAC with Dr. K. Radhakrishnan & presentation of NESAC activities by Director, NESAC

Dr. Radhakrishnan visited the NESAC facility on 15th October 2019. During the facility visit, Director, NESAC had given a comprehensive presentation on the activities of NESAC along with a demonstration of UAV flying to Dr. Radhakrishnan. This was followed by an interaction meeting with all NESAC staff and Research Scholars. Dr. Radhakrishnan appreciated the activities being carried out by NESAC and expressed his happiness on the progress made by NESAC in fulfilling the need of applying the geospatial technology for the betterment of NER.

Staff of, NESAC with Dr. K. Radhakrishnan in front of the 'Space on Wheels' Exhibition Bus

Before proceeding to IIM, Shillong, Padma Bhushan Dr. Radhakrishnan flagged off the "Space on Wheels" – the exhibition bus provided by ISRO under Vikram Sarabhai Centenary Celebration program to NESAC.

Important Visitors

08.04.2019	Prof. M Temjit Singh Vice-Chancellor, CAU, Imphal
15.10.2019	Dr. K Radhakrishnan Former Chairman ISRO/Secretary, DOS / Chairman, Space Commission
17.01.2020	Shri K Moses Chalai, IAS Secretary, NEC
06.03.2020	Dr. Ashok Dalwai, IAS CEO, National Rainfed Area Authority, New Delhi
06.03.2020	Dr. Shobhana K Pattanayak, IAS Director-General, ASCI, Hyderabad

Official Language Implementation

One day Hindi Technical Seminar on the theme "Reaching the Unreached through Space Science and Technology" was conducted at NESAC on 12th July 2019 where fourteen participants from other ISRO/DOS Centres/Units participated.

Hindi fortnight was organized in NESAC from 2nd to 16th September 2019. As part of the Celebration, a Hindi workshop was organized on the topic "Elementary Knowledge of Hindi and Hindi Translation" at NESAC Auditorium on 3rd September 2019 by Shri K C Basfor, Manager (O.L.), SBI, Guwahati, in which employees from all sections have participated.

Hindi Technical Seminar

Hindi Workshop Programme

World Hindi Day was organized in North Eastern Space Applications Centre this year on 10th January 2020 at NESAC Auditorium from 11 AM onwards and banners were displayed at various places in the NESAC campus.

Displaying of Banner during World Hindi Day

Welfare of SC & ST

i) The welfare of SC & ST is being taken care in this Centre. This Centre has been observing the guidelines for recruitment, promotion and welfare of Scheduled Caste and Scheduled Tribes. The following table indicates the status of representations of persons belonging to Scheduled Caste and Scheduled Tribe.

Sl No	Centre / Unit	Total strength of employees 2019-2020	Strength of SC employees 2019-2020	Strength of ST employees 2019-2020
01	NESAC	44	02	04

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) 60% 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.

Right to Information: NESAC receives RTI Applications through online and offline mode. The following table showing the number of RTI Applications received and disposed off.

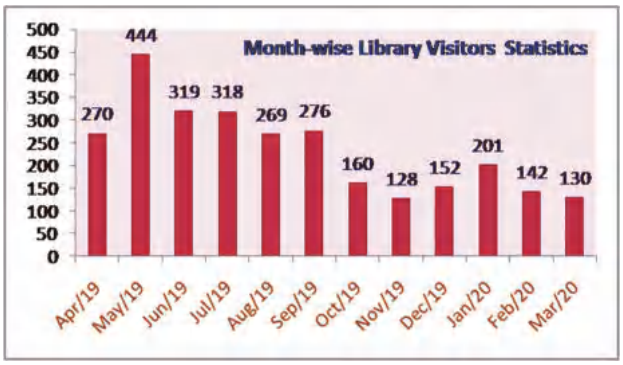
Details of RTI Officials:

Particulars	Name and designation
First Appellate Authority (FAA)	Dr. K K Sarma Sci/Engr 'SG', NESAC
Central Public Information Officer (CPIO)	Shri Avaneesh Shukla Sr. Admn. Officer NESAC

Library Activities

During the period, total physical footfalls to the library were approx. 2800. The library had registered 18 new members, and a total number of 2290 circulation transactions were carried out during the period. The Library homepage continued to be the gateway to all kinds of information resources.

Remote access facility was implemented by the library using RemoteXS during this period, which enables the users anytime and anywhere access to all the subscribed e-resources from a single portal.



NESAC Library organized a one-day book exhibition on 31st January 2020 for scientists and other researchers to suggest books for collection development of the library. More than ten booksellers had participated in the exhibition. There was active and enthusiastic participation of scientists and other staff to view/browse the latest books in their subjects. Around 580 titles were suggested for addition to the library collection.

Staffs browsing books in the exhibition

Year	Information		Replied		No. of applications transferred to other Public Authority	No. of applications rejected
	No. of applications received	No. of appeals	No. of applications disposed off	No. of appeals disposed off		
2019-2020	102	01	82	01	20	01

PUBLICATIONS

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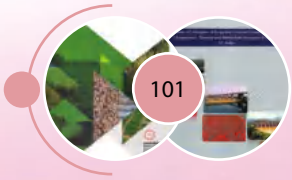

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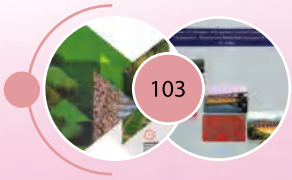

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Wangmo, D., 2019: River dynamics and erosional study of Manas-Beki river, Assam, India. B.Tech. (6th Semester), *Summer internship report* submitted to University of Petroleum and Energy Studies, Dehradun, Uttarakhand, India.

DETAILS OF INTERNSHIP AND PROJECT TRAINEES DURING 2019-20

In order to attract and nurture motivated and dedicated undergraduate and graduate students towards a world of space science and research, NESAC provides limited research internship opportunities. NESAC received over 300 applications for the 2019-2020 period. Of these, 115 were shortlisted and undertook research internships at NESAC. All the interns were stationed at the Outreach Facilities, where a system with open source software and internet connection was provided to all. The projects have been undertaken across all research domains. Masters in Geoinformatics, GIS and Remote Sensing students have taken up projects in the space based services provided in the domains of agriculture, sericulture and horticulture, forestry, geosciences, disaster risk reduction, land and water resources, space and atmospheric science, climate studies, etc. Engineering students have worked largely on UAV related projects, satellite communications and information technology to develop unique and innovative solutions to the pressing challenges in the field. The detailed list of parent organizations of students undertaking their internship at NESAC is given below.

Sl. No	University/Institute	Degree	No of Interns	Project Domain
1.	SRM University	B.Tech. (Aerospace)	3	UAV Design and assembly
2.	IIT Madras	Dual Degree (Aerospace)	6	• UAV Design • UAV data processing using deep learning and artificial intelligence • Mobile app design and development
3.	GH Raisoni College of Engineering	B.Tech. (Electronics)	1	Satellite Communication
4.	Central University of Karnataka	M.Sc. (Applied Geography)	4	• Remote Sensing applications in Geosciences • Active plate tectonics • Landslide Mapping and Susceptibility Studies
5.	Assam Engineering College	B.Tech. (Electronics, Computer Science)	4	Mobile app development UAV Communications Protocols
6.	Jorhat Engineering College	B.Tech. (Electronics)	2	UAV Communications Protocols
7.	North Orissa University	M.Sc. (Remote Sensing)	4	Urban Studies
8.	TERI School of Urban Studies	M.Tech. (Urban Studies Remote Sensing)	2	• Urban Studies • Atmospheric science data assimilation
9.	Kumaun University	M.Sc. (Remote Sensing)	4	Remote Sensing Applications in Forestry

10.	KUFOS	M.Sc. (Remote Sensing	1	Remote Sensing Applications in Forestry
11.	CEPT University	M. Tech. (Remote Sensing)	2	• Remote Sensing for Urban Studies • 3D city modelling
12.	Vidyasagar University	M.Sc. (Remote Sensing)	1	Remote Sensing for Urban Studies
13.	Pune University	M.Sc. (Geoinformatics)	1	Climate data decomposition
14.	Pondichery University	M.Sc. (Remote Sensing)	1	Remote Sensing for Urban Studies
15.	Jamia Milia Islamia	M.Sc. (Disaster Mitigation)	1	Remote Sensing for Urban Studies
16.	SPA	Architecture	1	Remote Sensing for Urban Studies
17.	ICFAI	B.Tech. (Computer Science)	2	WebGIS and Geoportal Development
18.	NERIST	B.Tech. (Electronics, Computer Science)	8	• Satellite Communication • WebGIS and Geoportal Development • WebGIS for Geosciences
19.	IIST	Dual Degree	1	Planetary Remote Sensing
20.	Anna University	B.Tech. (Geoinformatics)	4	• LiDAR Altimetry • WebGIS and geoportal creation
21.	Sikkim Manipal Institute of Technology	M.Tech. (Computer Science)	5	• 3D modelling using UAV data • WebGIS and Geoportal Development • Machine Learning applications in remote sensing
22.	NIT Silchar	B.Tech. (Computer Science, Mechanical Engg., Electronics)	5	• UAV Design and Development • Deep Learning Applications on UAV Data
23.	NIT Sikkim	B.Tech. (Computer Science, Mechanical Engg., Electronics)	8	• UAV Design and Development • Deep Learning Applications on UAV Data
24.	Central University of Jharkhand	Dual Degree Geoinformatics	14	• Glacier identification and mapping • Glacial lake identification and mapping using Google Earth Engine • Landslide susceptibility mapping
25.	IIT Gandhinagar	B.Tech. (Computer Science, Electronics)	15	• UAV Design and Development • Deep Learning Applications on UAV Data • Big Data Platforms for Remote Sensing and GIS
26.	BITS Pilani	B.Tech. (Dual Degree: Electronics, Computer Science)	15	• UAV Design and Development • Deep Learning Applications on UAV Data • Big Data Platforms for Remote Sensing and GIS • Open Data Cube platform for in-house data

AUDITOR'S REPORT AND STATEMENT OF ACCOUNTS FOR THE FINANCIAL YEAR 2019-2020

R.Pal & Co.
Chartered Accountants

Membership No – 54234
Firm Registration No: 322343E

C.P.I Office Campus, Quinton Road, Shillong, Pin-793001 Office: (☎) 0364-2224371,
E-mail: ranadhirpal@gmail.com

AUDITOR'S REPORT

Report on the Financial Statements

Opinion

We have audited the accompanying financial statement of the **North Eastern Space Applications Centre** which comprise of the Balance Sheet, Income & Expenditure & Receipt & Payments Account for the year ending 31st March 2020.

In our opinion and to the best of our information and according to the explanation given to us, the aforesaid financial statement of the Centre give the information in accordance with the generally accepted accounting principles and the applicable Accounting Standards issued by the Institute of Chartered Accountants of India.

Basis for Opinion

We conducted our audit of the financial statements in accordance with the Standards on Auditing (SA) issued by the Institute of Chartered Accountants of India. 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 our other ethical responsibilities in accordance with these requirements and the ICAI's Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion on the financial statement.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with the aforesaid Accounting Standards, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

The management of the Centre is also responsible for overseeing the Institution's financial reporting process.

Auditor's Responsibility

Our objectives are to obtain reasonable assurance about whether the financial statements as whole are free from material misstatement whether 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 materials if, individually or in the aggregate, they could reasonably be

expected to influence the economic decisions of uses taken on the basis of this financial statement.

Emphasis of matter

Without qualifying our report, we draw attention to the following matters:

1. Fixed Assets which have been found damaged and obsolete during physically verification have not been written off.
2. Advance to National Remote Sensing Centre (NRSC) as the books of account of NESAC is Rs 3175687/- as on 31/03/20 whereas as per the statement of account furnished by NRSC the closing balance is Rs 364362/-. The difference of Rs 2811325/- is due to non accounting of data purchased by NESAC for various projects. Thus advance to NRSC is overstated by Rs 2811325/- and Project expenses is understated by 2811325/-.
3. TDS under Section 194C is being deducted only on the service charge portion of the bill paid to outsourced employees service providers viz Shishupal Security & Consultancy Services and ALF Human Resource Placement and Consultancy Services and not on the gross bill value excluding GST.
4. TA advance to Shri Deepank Saxena of Rs 20000/- who is no more in service is outstanding from 20th June 2019 onwards.

Subject to the above observations, we further report that:

(a) We have obtained all the information and explanations which to the best of our knowledge and belief, were necessary for the purpose of our audit.

(b) In our opinion, proper books of accounts as required by law have been maintained by the Centre, so far as appears from our examination of those books.

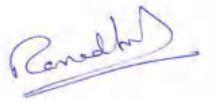
(c) The Balance Sheet, the Income & Expenditure Account, and the Receipts & Payments Account dealt with by this report are in the agreement with the books of accounts maintained.

(d) In our opinion, and to the best of our information and according to the explanations given to us, the said Balance Sheet, the Income & Expenditure Account, read together with the schedule and notes annexed to and forming part of the accounts, give a true and fair view:

  (a) In case of the Balance Sheet, of the state of affairs of the Centre as at 31st March, 2020 and

  (b) In case of the Income & Expenditure Account, of the deficit of income over expenditure for the period ended on that date.

For R.Pal & Co.
Chartered Accountant



(RANADHIR PAL)
Proprietor
Membership No: 54234
FRN:- 322343E
UDIN: 19054234AAAADY8897

Place: Shillong
Date: 19th August 2020

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-2020

(Amount - ₹)

CAPITAL FUND AND LIABILITIES	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Capital Fund	1	79,07,81,827.32	69,73,34,231.46
Current Liabilities & Provisions	2	31,63,44,600.00	31,03,43,444.00
Pension Fund as per contra*		1,08,73,182.00	1,10,18,442.00
TOTAL		**1,11,79,99,609.32**	**1,01,86,96,117.46**
ASSETS			
Fixed Assets	3	69,34,46,876.96	62,14,25,640.00
Current Assets, Loans & Advances etc.	4	41,36,79,550.36	38,62,52,035.46
Pension Fund as per contra*		1,08,73,182.00	1,10,18,442.00
TOTAL		**1,11,79,99,609.32**	**1,01,86,96,117.46**
Significant Accounting Policies	10		
Contingent Liabilities & Notes on Accounts	11		

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

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

Sd/-
(Sk J ABDUL AZEEZ)
HEAD, P & GA

Sd/-
(P. L. N. RAJU)
DIRECTOR

Date: 19.08.2020

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-2020

(Amount - ₹)

INCOME	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Grants	5	23,78,00,000.00	19,98,00,000.00
Other Incomes	6	1,61,14,949.01	1,25,73,734.23
Incomes from services	7	1,99,84,532.00	12,89,738.00
TOTAL		**27,38,99,481.01**	**21,36,63,472.23**
EXPENDITURE	**SCHEDULE**	**CURRENT YEAR**	**PREVIOUS YEAR**
Establishment Expenses	8	15,57,67,936.00	13,19,70,075.00
Other Administrative Expenses & etc.	9	4,68,17,516.15	4,39,13,433.23
Depreciation *(Net total at the year-end – corresponding to schedule 3) (Column 7)		7,70,73,945.00	6,35,66,232.00
TOTAL		**27,96,59,397.15**	**23,94,49,740.23**
BALANCE BEING SURPLUS (+)/ DEFICIT (-)		**(57,59,916.14)**	**(2,57,86,268.00)**
Less: Prior period expenses - Establishment Expenses		-	-
Less: Prior period expenses - Other Administrative Expenses		17,48,968.00	2,97,433.00
Less: Provision for Pension, Gratuity & Leave Encashment		3,90,43,520.00	2,53,53,206.00
NET SURPLUS (+)/ DEFICIT (-) CARRIED TO CAPITAL FUND		**(4,65,52,404.14)**	**(5,14,36,907.00)**

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

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

Sd/-
(Sk J ABDUL AZEEZ)
HEAD, P & GA

Sd/-
(P. L. N. RAJU)
DIRECTOR

Date: 19.08.2020

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-2020

	RECEIPTS	CURRENT YEAR	PREVIOUS YEAR		PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I.	**Opening Balances**			**I.**	**Expenses**		
	a) Cash in Hand	-	-		a) Establishment Expenses	13,45,58,579.00	11,63,26,594.00
	b) Bank Balances:				b) Other Administrative Expenses	4,63,74,637.15	4,40,52,602.00
	i) In Current Accounts, SBI Shillong	10,44,52,852.41	11,50,55,456.41	**II**	**Investments and Deposits**		
	ii) In Current Accounts, SBI Umiam	12,87,37,589.05	13,94,77,429.05		a) Deposit with MeSEB/ NRSC/ BSNL	-	3,97,300.00
	iii) In Current Accounts, Canara Bank	50,83,093.00	11,88,55,868.00				
	iv) MOD With Canara Bank	12,98,46,190.00	-	**III**	**Fixed Assets & Capital Work-In-Progress**		
II	**Grants Received**				a) Purchase of Fixed Assets	14,42,88,180.96	20,06,85,427.00
	From Government of India:			**IV**	**Other Payments**		
	a) Department of Space, Bangalore				a) ISRO Projects	6,31,28,845.00	3,50,31,782.00
	i) For Salaries	9,00,00,000.00	8,98,00,000.00		b) USER Projects	4,50,76,791.00	5,73,80,065.00
	ii) For General	14,78,00,000.00	11,00,00,000.00		c) In-House Projects	24,23,009.00	9,06,274.00
	iii) For Creation of Capital Assets	14,00,00,000.00	20,00,00,000.00		d) Advances to Staffs	44,73,190.00	49,74,256.00
	b) Ministry of DONER, NEC Shillong	-	-		e) Advances to Projects	22,60,526.00	12,03,126.00
					f) Training	73,48,381.00	3,12,253.00
III	**Interest Received**				g) Payment of Recoveries	1,98,34,570.00	1,93,24,244.00
	a) On Fixed Deposits & Other Interests	91,32,918.00	6,60,137.00		h) Prior Period Expenses	17,11,376.00	2,39,402.00
					i) Security Deposits	39,84,692.00	1,31,17,778.00
IV	**Other Incomes**				j) ISTRAC Expenses	24,17,501.00	24,94,339.00
	a) Others Income	20,81,219.01	12,98,128.23		k) DWR Cheerapunji	-	59,12,199.00
					l) Assam ISRO Centre	4,20,603.00	12,79,171.00
V	**Other Receipts**			**V**	**Closing Balances**	-	-
	a) Miscelleneous Recoveries	12,72,351.00	22,55,819.77		a) Cash in Hand (Imprest)	-	15,000.00
	b) Recovery of Advances and Deposits from:				b) Bank Balances:		
	i) Staffs (Cont., Imprest, TA/ DA & LTC Advances)	15,52,870.00	4,27,629.00		i) In Current Accounts, SBI Shillong	12,48,07,803.45	10,44,52,852.41
	ii) Others Receipts from ISTRAC/ NRSC/ DWR	1,83,19,733.00	49,00,000.00		ii) In Current Accounts, SBI Umiam	-1,14,15,280.60	12,87,37,589.05
	c) Receipts on ISRO Projects	2,97,85,000.00	4,24,96,687.00		iii) In Current Accounts, Canara Bank	99,48,912.00	50,83,093.00
	d) Receipts on USER Projects	5,91,03,272.00	3,76,76,882.00		iv) MOD with SBI Umiam	15,99,16,593.51	-
	e) Security Deposits	43,56,452.00	88,67,500.00		v) MOD with SBI Umiam	15,99,16,593.51	-
	TOTAL	**87,15,23,539.47**	**87,17,71,536.46**		**TOTAL**	**87,15,23,539.47**	**87,17,71,536.46**

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

for **R PAL & Co**
Chartered Accountants

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897
Date: 19.08.2020

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(Sk J ABDUL AZEEZ)
HEAD, P & GA

Sd/-
(P. L. N. RAJU)
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

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2020

(Amount - ₹)

SCHEDULE 1 - CAPITAL FUND	CURRENT YEAR		PREVIOUS YEAR	
Balance as at the beginning of the year	69,73,34,231.46		54,87,71,138.46	
Add: Balance of Surplus (+)/ Deficit (-) transferred from the **"Income & Expenditure Account"**	(4,65,52,404.14)		(5,14,36,907.00)	
Add: Grant-In-Aid for Creation for Capital Assets	14,00,00,000.00	79,07,81,827.32	20,00,00,000.00	69,73,34,231.46
BALANCE AS AT THE YEAR END		**79,07,81,827.32**		**69,73,34,231.46**
SCHEDULE 2-CURRENT LIABILITIES AND PROVISIONS	**CURRENT YEAR**		**PREVIOUS YEAR**	
CURRENT LIABILITIES:				
1 Other Current Liabilities				
a) Establishment Expenses	1,03,09,794.00		1,20,20,242.00	
b) Other Administrative Expenses	22,38,167.00		15,39,564.00	
c) Others	1,64,02,894.00		88,82,065.00	
d) Audit Fee	70,200.00	2,90,21,055.00	70,200.00	2,25,12,071.00
2 Deposit from Contractors	59,02,828.00	59,02,828.00	38,62,663.00	38,62,663.00
3 Project Accounts: USER Project				
Balance as at the begining of the year	7,89,62,938.00		10,30,94,704.00	
Add: Received during the year	6,25,12,376.00		4,27,62,496.00	
Less: Utilised during the year	6,96,61,228.00	7,18,14,086.00	6,68,94,262.00	7,89,62,938.00
4 Project Accounts: ISRO Project				
Balance as at the begining of the year	5,44,34,614.00		4,71,29,906.00	
Add: Received during the year	3,17,21,381.00		4,32,14,887.00	
Less: Utilised during the year	6,61,64,042.00	1,99,91,953.00	3,59,10,179.00	5,44,34,614.00
5 PROVISIONS:				
Pension, Gratuity & Leave Encashment	18,96,14,678.00	18,96,14,678.00	15,05,71,158.00	15,05,71,158.00
TOTAL		**31,63,44,600.00**		**31,03,43,444.00**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

Sd/-
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DIRECTOR

Date: 19.08.2020

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उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2020

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 ded-uction 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 Development	1,77,53,045.00	3,25,09,094.00	-	5,02,62,139.00	0%	-	-	-	-	5,02,62,139.00	1,77,53,045.00
2	Boundry of New Land	36,43,529.00	-	-	36,43,529.00	10%	8,29,714.00	2,81,382.00	-	11,11,096.00	25,32,433.00	28,13,815.00
3	Renovation of lease Buildings	52,40,087.00	-	-	52,40,087.00	10%	41,94,437.00	1,04,565.00	-	42,99,002.00	9,41,085.00	10,45,650.00
4	Machinery & Equipment	95,40,622.00	-	-	95,40,622.00	15%	81,74,977.00	2,04,847.00	-	83,79,824.00	11,60,798.00	13,65,645.00
5	Furniture & Fixtures	2,87,31,770.76	14,14,206.00	-	3,01,45,976.76	10%	98,31,242.76	20,04,059.00	-	1,18,35,301.76	1,83,10,675.00	1,89,00,528.00
6	Office Equipments	75,43,850.00	11,85,833.00	-	87,29,683.00	15%	41,92,579.00	6,56,950.00	-	48,49,529.00	38,80,154.00	33,51,271.00
7	Computer & Peripherals	6,60,75,993.60	43,03,791.00	-	7,03,79,784.60	40%	6,19,16,051.60	26,63,142.00	-	6,45,79,193.60	58,00,591.00	41,59,942.00
8	Library Books	5,34,31,699.93	72,01,581.00	-	6,06,33,280.93	40%	4,56,09,329.93	60,09,580.00	-	5,16,18,909.93	90,14,371.00	78,22,370.00
9	Telephones Installation	19,02,230.00	-	-	19,02,230.00	15%	9,51,265.00	1,42,645.00	-	10,93,910.00	8,08,320.00	9,50,965.00
10	Other Equipments	8,22,93,502.00	1,94,90,785.96	-	10,17,84,287.96	15%	3,26,47,491.00	96,43,046.00	-	4,22,90,537.00	5,94,93,750.96	4,96,46,011.00
11	NE-SAC Complex	17,54,07,882.00	30,72,805.00	-	17,84,80,687.00	10%	8,57,02,034.00	91,82,729.00	-	9,48,84,763.00	8,35,95,924.00	8,97,05,848.00
12	Vehicles	43,91,216.00	1,47,116.00	-	45,38,332.00	15%	15,90,604.00	4,42,159.00	-	20,32,763.00	25,05,569.00	28,00,612.00
13	Air Conditioner (Heating & Cooling)	27,28,835.00	-	-	27,28,835.00	15%	8,18,985.00	2,86,478.00	-	11,05,463.00	16,23,372.00	19,09,850.00
14	Apple I-Pad	71,250.00	-	-	71,250.00	15%	46,393.00	3,729.00	-	50,122.00	21,128.00	24,857.00
15	Aquarium	35,630.00	-	-	35,630.00	15%	23,200.00	1,865.00	-	25,065.00	10,565.00	12,430.00
16	CISF Barrack	27,08,604.00	-	-	27,08,604.00	10%	7,29,652.00	1,97,895.00	-	9,27,547.00	17,81,057.00	19,78,952.00
17	Mobile Set	48,100.00	-	-	48,100.00	15%	25,846.00	2,716.00	-	28,562.00	19,538.00	22,254.00
18	Motorised Treadmill	1,26,000.00	-	-	1,26,000.00	15%	82,043.00	6,594.00	-	88,637.00	37,363.00	43,957.00

19	SMF Batteries	6,35,400.00	8,77,200.00	-	15,12,600.00	15%	4,29,466.00	1,62,470.00	-	5,91,936.00	9,20,664.00	2,05,934.00
20	Vending Machine	20,500.00	-	-	20,500.00	15%	13,928.00	986.00	-	14,914.00	5,586.00	6,572.00
21	Water Dispenser	21,200.00	81,000.00	-	1,02,200.00	15%	14,404.00	13,169.00	-	27,573.00	74,627.00	6,796.00
22	Wifi Connectivity	14,45,666.00	-	-	14,45,666.00	15%	2,16,743.00	1,84,338.00	-	4,01,081.00	10,44,585.00	12,28,923.00
23	Residential Complex	15,97,49,009.00	-	-	15,97,49,009.00	10%	2,30,21,388.00	1,36,72,762.00	-	3,66,94,150.00	12,30,54,859.00	13,67,27,621.00
24	Outreach Facilities	22,95,48,505.00	7,14,035.00	-	23,02,62,540.00	10%	1,89,20,544.00	2,11,34,200.00	-	4,00,54,744.00	19,02,07,796.00	21,06,27,961.00
Capital Work In Progress:												
25	CISF Quarter/ Barrack	6,08,87,709.00	3,60,91,945.00	-	9,69,79,654.00	0%	-	94,16,195.00	-	94,16,195.00	8,75,63,459.00	6,08,87,709.00
26	Residential Complex Phase II	50,02,272.00	3,28,00,557.00	-	3,78,02,829.00	0%	-	-	-	-	3,78,02,829.00	50,02,272.00
27	Annex Building Office		81,41,754.00		81,41,754.00	0%	-	-		-	81,41,754.00	-
28	Creche Buidling	-	6,67,629.00	-	6,67,629.00	0%	-	-	-	-	6,67,629.00	-
Intangible Assets:												
29	Software	56,48,841.00	3,95,850.00	-	60,44,691.00	25%	32,24,991.00	6,55,444.00	-	38,80,435.00	21,64,256.00	24,23,850.00
	TOTAL FOR CURRENT 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**
	TOTAL FOR PREVIOUS YEAR	**71,75,07,182.29**	**20,71,25,766.00**	**-**	**92,46,32,948.29**	**-**	**23,96,41,076.29**	**6,35,66,232.00**	**-**	**30,32,07,308.29**	**62,14,25,640.00**	**47,78,66,106.00**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

Sd/-
(Sk J ABDUL AZEEZ)
HEAD, P & GA

Sd/-
(P. L. N. RAJU)
DIRECTOR

Date: 19.08.2020

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-2020

(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	12,33,41,434.85		23,82,73,534.46	
b) MOD with Canara Bank	10,99,64,630.00		12,98,46,190.00	
c) MOD with SBI Umiam Bank	15,99,16,593.51	39,32,22,658.36		36,81,19,724.46
B. LOANS, ADVANCES AND OTHER ASSETS:				
1) Advances to:				
a) Staffs:				
TA/ DA	3,12,500.00		2,49,887.00	
Contingencies	71,500.00		80,276.00	
Others	3,52,205.00	7,36,205.00	60,000.00	3,90,163.00
b) Projects: (User & ISRO)	-	6,57,949.00	-	3,21,500.00
c) Others	-	35,48,967.00	-	13,52,452.00
d) Imprest amount to staff		15,000.00		15,000.00
2) Claims Receivable/ Recoverable	21,13,152.00	21,13,152.00	32,22,451.00	32,22,451.00
3) TDS Receivable	5,25,163.00	5,25,163.00	1,95,138.00	1,95,138.00
4) Interest Receivable	95,69,111.00	95,69,111.00	65,42,909.00	65,42,909.00
5) Deposits for:				
a) Telephone with BSNL	1,15,658.00		1,15,658.00	-
b) Deposit with MeECL	-		15,67,380.00	-
c) Satellite Data's with NRSC	31,75,687.00	32,91,345.00	32,25,654.00	49,08,692.00
6) Closing Stock of Cartridges	-	-	11,84,006.00	11,84,006.00
TOTAL		**41,36,79,550.36**		**38,62,52,035.46**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-	Sd/-	Sd/-	Sd/-
(RANADHIR PAL)	**(ANOOP B S)**	**(Sk J ABDUL AZEEZ)**	**(P. L. N. RAJU)**
PROPRIETOR	ACCOUNTS OFFICER	HEAD, P & GA	DIRECTOR

UDIN:19054234AAAADY8897

Date: 19.08.2020

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 INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2020

(Amount - ₹)

SCHEDULE 5 - GRANTS	Current Year	Previous Year
Central Government:		
a) Department of Space, Bangalore	23,78,00,000.00	19,98,00,000.00
b) North Eastern Council, Shillong	-	-
TOTAL	**23,78,00,000.00**	**19,98,00,000.00**
SCHEDULE 6 - OTHER INCOMES	**Current Year**	**Previous Year**
Miscellaneous	27,52,861.84	41,33,152.23
Maintenance Charges	5,58,020.17	2,55,612.00
Guest House Rent	6,06,554.00	7,86,786.00
Interest from Bank	1,21,97,513.00	73,98,184.00
TOTAL	**1,61,14,949.01**	**1,25,73,734.23**
SCHEDULE 7 - INCOME FROM SERVICES	**Current Year**	**Previous Year**
Service of Scientists	59,95,974.00	4,00,738.00
Infrastructure Usage	4,20,200.00	8,89,000.00
Institutional Overhead	1,35,68,358.00	-
TOTAL	**1,99,84,532.00**	**12,89,738.00**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

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(RANADHIR PAL)
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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2020

(Amount - ₹)

SCHEDULE 8 - ESTABLISHMENT EXPENSES		Current Year		Previous Year	
a)	Salary & Allowances	7,69,99,426.00		7,26,33,473.00	
b)	Honorarium	5,71,620.00		2,67,945.00	
c)	Employer Contributions towards NPS	45,11,766.00		32,35,095.00	
d)	Wages	43,58,128.00		34,78,908.00	
e)	LTC	9,52,499.00		21,50,090.00	
f)	Leave Encashment Expenses	2,41,812.00		2,32,571.00	
g)	Children Education Allowance	27,000.00		7,35,000.00	
h)	Outsourced DEO	40,04,339.00		30,89,122.00	
i)	Outsourced Electrician	18,85,920.00		16,90,683.00	
j)	Outsourced Worker for Various Services	1,36,10,362.00		1,10,20,061.00	
k)	NER-DRR (Salary)	60,26,645.00		46,27,699.00	
l)	CISF Salary	3,79,88,501.00		2,76,98,318.00	
m)	Retirement Pension	12,01,261.00		11,11,110.00	
n)	DWR-Outsourced worker	22,29,601.00		-	
o)	DWR-(Salary)	11,59,056.00	15,57,67,936.00	-	13,19,70,075.00
	TOTAL		**15,57,67,936.00**		**13,19,70,075.00**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2020

(Amount - ₹)

SCHEDULE 9 - OTHER ADMINISTRATIVE EXPENSES & etc.		Current Year		Previous Year	
1	Postage, Courier & Telephone Charges	7,43,676.00		8,13,339.00	
2	Bank Charges	30,974.15		3,330.00	
3	Electricity & Power Charges	74,84,757.00		44,59,171.00	
4	Maintenance of Garden	1,74,449.00		1,59,795.00	
5	Printing & Stationery	28,26,173.00		25,64,036.00	
6	Advertisement & Publicity	17,75,692.00		12,85,966.00	
7	Hiring of Vehicles	26,85,853.00		25,71,104.00	
8	Travelling & Conveyance	27,85,456.00		42,73,644.23	
9	Professional Charges	11,49,166.00		9,67,572.00	
10	Project Expenses [In-house]	24,93,888.00		9,70,125.00	
11	Repair & Maintenance	1,16,34,878.00		1,41,23,322.00	
12	Books & Periodicals	68,329.00		40,084.00	
13	Trainings/ Seminars & Workshops	1,57,603.00		5,94,800.00	
14	Medical Expenses	14,36,809.00		9,56,610.00	
15	DWR Cherrapunji Expenses	26,89,120.00		-	
16	Other Charges	11,44,560.00		31,33,316.00	
17	POL	13,95,592.00		6,33,199.00	
18	Sanitary Items	6,54,057.00		5,71,916.00	
19	Hindi Week Celebrations	4,21,972.00		7,010.00	
20	Annual Maintenance Contracts	16,00,965.00		10,35,159.00	
21	Miscellaneous Expenses	13,96,302.00		16,42,750.00	
22	Repair & Maintenance of Vehicles	1,03,723.00		1,62,696.00	
23	Operational Charges & Maintenance of Canteen	3,79,866.00		9,46,287.00	
24	ICRB Examination	2,50,330.00		6,79,020.00	
25	NER-DRR Expenses	2,54,674.00		5,49,955.00	
26	CISF Expenses	10,57,652.00		7,51,177.00	
27	Supply of Water for Hostels	21,000.00	4,68,17,516.15	18,050.00	4,39,13,433.23
	TOTAL		**4,68,17,516.15**		**4,39,13,433.23**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
PROPRIETOR
UDIN:19054234AAAADY8897

Sd/-
(ANOOP B S)
ACCOUNTS OFFICER

Sd/-
(Sk J ABDUL AZEEZ)
HEAD, P & GA

Sd/-
(P. L. N. RAJU)
DIRECTOR

Date: 19.08.2020

भारत सरकार / GOVERNMENT OF INDIA
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SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH-2020

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 30.09.19 – 100% as per the applicable rate.
   - Assets acquired after 30.09.19 – 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 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 **R PAL & Co** Chartered Accountants		for and on behalf of **NORTH EASTERN SPACE APPLICATIONS CENTRE**	
Sd/- **(RANADHIR PAL)** PROPRIETOR UDIN:19054234AAAADY8897	Sd/- **(ANOOP B S)** ACCOUNTS OFFICER	Sd/- **(Sk J ABDUL AZEEZ)** HEAD, P & GA	Sd/- **(P. L. N. RAJU)** DIRECTOR

Date: 19.08.2020

भारत सरकार / GOVERNMENT OF INDIA
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SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH-2020

SCHEDULE 11 – NOTES ON THE ACCOUNTS & CONTINGENT LIABILITIES

NOTES ON THE ACCOUNTS

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

b) Pension, gratuity and leave encashment liability has been provided till 31.03.2020.

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-2020 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 **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-	Sd/-	Sd/-	Sd/-
(RANADHIR PAL)	**(ANOOP B S)**	**(Sk J ABDUL AZEEZ)**	**(P. L. N. RAJU)**
PROPRIETOR	ACCOUNTS OFFICER	HEAD, P & GA	DIRECTOR

UDIN:19054234AAAADY8897

Date: 19.08.2020

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

Department of Space, Government of India

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www.nesac.gov.in

Designed & Printed by: Imagic Creatives Pvt Ltd, Bangalore - 560071