Annual Report
वार्षिक रिपोर्ट
2018-2019

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

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Compiled and Edited by

Editorial Team

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Reviewed by

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

Vision

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

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Organisation: North Eastern Space Applications Centre

Address: Department of Space,
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Umiam- 793103, Meghalaya

has been assessed and found conforming to the following requirement

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

Mission

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

Director's Preface

North Eastern Space Applications Centre (NESAC), under the aegis of the Department of Space, Government of India has been making significant progress by taking the benefits of space technology to support developmental activities for different key areas like infrastructure planning, natural resources management, disaster etc. in the north eastern region of India. During 2018-19, the scientific activities of the centre have been expanded with a number of new projects and activities taken up while completing a number of important projects.

In the area of Remote Sensing applications in Agriculture and allied areas, under the second phase of the project on Applications of Remote Sensing and GIS for Sericulture Development, mapping of potential areas have been completed 70 priority districts from 25 states, where 20 districts were covered from NE region. The project atlas and the district-wise portals were released by Hon'ble Minister of Handloom, Textiles & Sericulture, Govt. of Assam on October 22, 2018 at Guwahati. Site Suitability Analysis for expansion of one horticultural crop in one district of each NE state has successfully been completed under CHAMAN programme. The scope of the project has been extended and additional 16 districts of NE states are being taken up as a second phase of the project. Few other projects like Assessment of soil fertility in Ri Bhoi district of Meghalaya, Identification of block wise winter rice areas in Meghalaya, Identification of suitable areas for expansion of orange in Meghalaya, Development of Decision Support System for early warning of selected Muga Silkworm diseases etc., have also been successfully completed.

In the area of remote sensing applications in Forestry, NESAC has been carrying out a number of projects in NE region like Assessment of biodiversity, estimation of growing stocks, Assessment of vegetation and soil carbon, Bamboo resources mapping, Forest biomass estimations, Wetland mapping, Study on shifting cultivation dynamics, Burnt area assessment, Wildlife habitat mapping, etc. Some of the other projects undertaken by the Forestry & Ecology Group are Landcover analysis and dynamics of Kaziranga National Park, Analysis of vegetation phenology of NER using time series satellite data, RS and GIS inputs for preparation of forest working plan in Arunachal Pradesh and Mizoram, SAR applications in estimation of above ground biomass in forests of NER, etc.

In the area of Hydrology & Water Resources, Flood Early Warning System (FLEWS) program has been expanded to all NE states. Simultaneously, institutional arrangements are getting established through series of stake holder meetings especially with the state disaster management authorities and State remote sensing centres. During 2018 monsoon, experimental alerts have been issued for Meghalaya, Arunachal Pradesh and Tripura. Other major projects taken up by the group are Preparation of River Atlas for Assam, Monitoring and Evaluation of IWMP watersheds and Assessment of utilization of irrigation potential created for Dhansiri, Champamati, Thoubal and Dholaithabi Irrigation Projects.

As part of Urban and Infrastructure Planning, NESAC has been formulating GIS-based Master/Development Plans for Shillong Planning Area, Meghalaya under Atal Mission for Rejuvenation and Urban Transformation (AMRUT) sub scheme. The sub scheme covers preparation of base maps & thematic maps, Urban database creation, Formulation of master plan and capacity building.

In the area of Geosciences, NESAC has carried out a number important studies including GPS based Total Electron Content (TEC) studies over North East India, Morphotectonics, Neotectonic and deformation studies, Ground water quality mapping, Environmental and Technological hazards assessment etc.

In the area of Information Technology & Geoinformatics, one of the major programmes of NESAC taken up as per the directive of North Eastern Council (NEC), Ministry of DoNER is creation of North Eastern Spatial Data Repository (NeSDR). The Election e-ATLAS developed by NESAC was successfully utilized for the first time in the country during recent General Lok Sabha Election for 2019 in the States of Manipur, Tripura, Sikkim, Nagaland, Meghalaya and Mizoram. NESAC has developed a project on monitoring GeoWeb application on the status of the projects/schemes funded by NEC for various developmental activities in NER. The centre has provided necessary training to the officials of BTC for geotagging of their schemes. The group is utilizing a number of statistical models, machine learning (ML)

as well as deep learning (DL) and other GeoData Analytical tools for near real-time predictive analysis, feature extraction and pattern recognition under various operational services and R & D activities.

NESAC has expanded its activities in the field of UAV remote sensing (UAV-RS) and applications. NESAC has demonstrated some unique applications such as tethered UAV for continuous surveillance, 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. Various research activities are presently carried out using UAVs are Crop damage and stress detection, Embankment survey & monitoring, Survey and mapping of community reserves and other protected areas and their eco sensitive zones in Meghalaya etc.

In the area of Satellite Communications, NESAC has established extensive network for distance education and remote healthcare in the region. In Tele-education project in north eastern states, all the 7 HUBs cum Teaching end and 316 Satellite Interactive Terminals (SIT) are operational in all the NE States. A new proposal for expansion of the Telemedicine network is under consideration. NESAC conducted a two-day workshop on 24th and 25th August 2018 for Telemedicine awareness generation in North East India at Guwahati, Assam in association with MoHFW, Govt. of India, North Eastern Council, Telemedicine Society of India, NEIGRIHMS, Shillong and GMC, Guwahati. NESAC supported Ministry of DoNER for monitoring of activities under NLCPR Scheme in the North Eastern States through Smartphone and Bluetooth enabled GAGAN Dongles to collect field data. ISRO-ONERA-CNES joint Ka-Band propagation experiment is operational at NESAC to assess atmospheric effects on propagation of Ka-Band signal for use in Satellite to earth communication.

In the Space and Atmospheric Science area, the group at NESAC are engaged in research to improve short and medium range weather forecast for NE region of India with focus on improving the severe weather forecast including lightning forecast. The group provides support and critical input in 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. To understand the heterogeneous properties of aerosol over the high altitude site, a new aerosol observatory has been established at Lachung located in northern Sikkim. Several other studies are being carried out by the group such as aerosol characterisation over high altitude station in Tawang, study on raindrop size distribution over a valley region, estimation of Surface layer flux over a mountaionus terrain, simulation of thunderstorm over NER of India using WRF model with assimilation of DWR data, developing a lightning early warning system over NER, preparing the lightning hazard zonation map for Meghalaya, thunderstorm nowcasting services for NER of India, study of hailstorms using reflectivity data etc. A network of 17 numbers of Automatic Weather Stations (AWS) has been set up in the Ranganadi Hydro Electric Project (RHEP) area in Arunachal Pradesh for developing a state of the art real time hydro-meteorological monitoring system in catchment areas upstream of RHEP which is funded by North Eastern Electric Power Corporation (NEEPCO).

Outreach activities of the Centre has increased manifold during past few years. State of the art infrastructure facility with lecture halls, practical laboratories, 80 bedded hostel with dining facility has come into operation during this year. In addition to two scheduled courses; one on Basic remote sensing and another on UAV Remote Sensing, the Centre has undertaken a large number of training programs for user departments in the region. A large number of students choose NESAC for their external project work. A large number of students representing various academic institutions visited NESAC as a part of their study tour programme during the year. As a part of societal commitment, NESAC took up several social activities for the nearby localities such as oragnisation of blood donation camp, Ayurvedic and Homeopathic medicine camp etc.

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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Vice Chancellor, North-Eastern Hill University

Chief General Manager, Telecom, BSNL

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Director, Indian Institute of Technology, Guwahati

Director, Satcom Programme, ISRO, Bangalore

Director, EDPO, ISRO, Bangalore

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

Contents

ABOUT THE CENTRE

The North Eastern Space Applications Centre (NESAC), a joint initiative of 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 18 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 (GIS) 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 applications services in the region in education, health care, disaster management support, and developmental communication. 3) To take up research in space and atmospheric science area and establish an instrumentation hub and networking with various academic institutions of NER. 4) To enable single window delivery of all possible space based support for disaster management. 5) To set up a regional level infrastructure for capacity building in the field of geospatial technology.

Management of the Centre

All policies, affairs, business of NESAC are decided by the NESAC Society. Chairman, NEC presides over the NESAC Society and the Secretary, DOS/Chairman ISRO is the Vice President. Other members of the Society are - Secretary, NEC; Chief Secretaries of the eight NER states, senior scientists from DOS and NEC and academia of NER. A Governing Council (GC), under 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 NER states in the areas of natural resources management, infrastructure planning, health, education, satellite communication and atmospheric science research. The centre has implemented a number of application projects sponsored by user agencies in the region, National/regional projects funded/coordinated by ISRO-DOS Centres, research and developmental projects under Earth Observation Applications (EO-A), Satellite Communications (SATCOM) programs, Disaster Management Support (DMS) program under the North Eastern Regional node for Disaster Risk Reduction (NER-DRR) and Space & Atmospheric Science Programs under the Atmospheric Science Program (ASP) and ISRO Geosphere Biosphere Program (IGBP).

Facilities

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

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

The Centre has got high-end servers and workstations for geospatial analysis and digital image processing, advanced systems for photogrammetry, hydrological modeling, etc, GIS and GNSS (Global Navigation Satellite System) equipments, Echo sounder, high quality output devices, etc. The Centre has 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 wide varieties of platforms to enable digital image processing, geospatial analysis and location based services. Capabilities and expertise do exist from both commercial of-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 close narrower interval for creation of spectral library.

Information Technology and Computing facilities

Over the years NESAC has established and enhanced IT infrastructure for carrying out research and outreach activities and also to provide operational services. The Centre has a Local Area Network (LAN) with 1Gbps Ethernet backbone connecting all the laboratories, facilities as well as administrative departments. Internet connectivity is provided throughout the NESAC office building with 1Gbps 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 cataloguing, 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 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 softwares 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 6 compute nodes (72 core) with 12 TB storage (SAN). The computing facility has been upgraded with another 4 compute nodes (80 cores) with addition of 8TB storage. The HPC is currently used for different operational and 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 FORTAN and C compilers and Python etc. Agisoft PhotoScan software was also installed in 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 and satellite phones for communication support under disaster conditions. NESAC also contributes through development of Mobile Apps as part of disaster management support. 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 Centre also supports Ka-band propagation experiment and NAVIC SPS-GPS receiver experiment.

Ka Band Propagation Experiment

Space and Atmospheric Science Research

The Centre has a dual polarized S band Doppler Weather Radar (DWR) installed at Sohra (Cherrapunjee), Meghalaya for studies in early warning of hydro-meteorological disasters, convective systems, cloud and precipitation physics, etc. The centre also hosts a Multi Wavelength Radiometer (MWR), Sunphotometer, 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 4 levels (at the heights of 6m, 10.5m, 18m, and 30m). 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 last one year, a Cloud Condensation Nuclei (CCN) counter has 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 light weight instruments. A network of 17 Automatic Weather Stations has also been set up in Ranganadi river catchment area with funding support from NEEPCO (North Eastern Electric Power Corporation Limited).

Library

During the Financial year 2017-18, the Library has added 437 scientific, 17 general books and 20 Hindi books in the collection. Subscription of Springer Nature & Scientific American e-journals and Springer 2018 engineering eBooks collection of 1221 titles under the Antariksh Gyaan (ISRO Library Consortium) have been added to the existing library collection.

The Library has implemented KOHA ILMS, which is an open source Integrated Library Management software having functions such as Acquisition, Cataloguing, Serials Control, and Circulation. Online access to Library holdings data is managed through Web-OPAC. Users have the facility to browse and search the Library database and view the status of a document or their own transactions and make on-line reservations for a document to be issued and renew their checked out items online.

The Library has implemented DSpace digital library software, which is an open source institutional repository software that collects, preserves, and disseminates research output in digital format created by the NESAC research community. The repository content can be accessed through the search and browse functionalities. Table of Contents of the newly added print resources are uploaded in the repository and shared to the users via email on a weekly basis.

In addition, the Library provides e-mail based services like, new additions of books and journals, Interactive services like reminders, reservations, advanced due reminders and overdue intimation and e-mail based reference service. Library website has been designed to disseminate up-to-date information from the Library. The website provides comprehensive information on the collections, e-resources, new additions and all the services provided by the Library. The page also serves as a portal to access e-resources.

The outreach facility

The outreach facility building was planned and constructed on one acre land about 500 m away from the office building. The construction work was started on 27.02.2017 and completed on 15.01.2019. There are three blocks namely: (i) Academic Block (ii) Hostel Block (iii) Utility Block.

Academic block: The building was planned and constructed as a framed structure with ground plus two floors having a plinth area of 1794 sqm. The building accommodates Fitness centre, Canteen & Dining hall, 2 number of Lecture Halls, with a capacity of 44 and 48 respectively, Smart class room-72 capacity and Computer lab-64 capacity, Video conference hall capacity of 15 persons, Conference Hall-64 capacity. In addition, 4 number of Faculty rooms, Office area, Server room, UPS room, Audio Video control room and electrical panel room are also located in this building. All lectures halls, conference halls are air conditioned with VRF Ductable AC.

Hostel Block: This block is designed and constructed in ground plus 4 floors. The plinth area of the block is 160 sqm. It consist 20 single rooms, 20 double rooms, dormitory – 2 nos with 10 people capacity each. At stilt floor, care taker room, maintenance room and laundry room are located in the hostel block.

Utility Block: This is a single storey building. The block consists of security room, GLR and water pump room, electrical sub-station and 380 KVA + 125 KVA DG sets enclosure. The plinth area is 130 sqm.

Unmanned Aerial Vehicle Facility

NESAC has expanded its activities in the field of UAV remote sensing (UAV-RS) and applications. At present NESAC has about 6 UAVs and a number of sensors to be mounted on the UAVs. With the advancement of 3D printing technology, in-house mini UAVs for experimental purpose have been developed. NESAC have added a few Quadcopters, Hexacopters and fixed wing UAVs during the year.

3D printed small Quadcopter

NESAC has demonstrated various applications such as tethered UAV for continuous surveillance, drop

Assembled Fixed wing

mechanism for dropping of medicine, food and relief materials at the time of disaster. NESAC has also integrated NAVIC based VTS (vehicle tracking system) for monitoring of UAVs. NESAC has been providing operational UAV services in the NER region. The Centre has conducted more than 25 UAV surveys in the year 2018-19 for different users departments in NER.

Sports and Recreation Facilities

NESAC is well equipped with gymnasium and recreational facilities at its residential complex and outreach facility. The gymnasium at outreach facility is having state of the art fitness equipments like treadmills, elliptical cross trainer and fitness Bike. The new gym facility houses equipments like 16 Station multi-gym, treadmill, elliptical trainer, rower, punching bag to name a few. Indoor games like badminton, table tennis, snooker and outdoor sports like volley ball cricket, Football are regularly played at NESAC. Regular staff of NESAC as well as students, trainees indulge in various sports and recreational activities. Annual Sports meets are also conducted by NESAC Recreation Committee in which staff of NESAC participates vigorously. On the event of Republic Day, Independence Day and NESAC Foundation Day, various cultural programs are organized by NESAC Recreation Committee for the staff of NESAC.

AGRICULTURE AND ALLIED AREAS

Applications of Remote Sensing and GIS in Sericulture Development-Phase II

Sericulture is a source of livelihood and provides gainful employment in the rural areas, especially for the women. The Central Silk Board (CSB), Ministry of Textiles has placed greater emphasis on improving the productivity at all stages of silk production to ensure higher returns to the stakeholders. Realizing that the space technology in the past has provided valuable inputs to the sericulture development, CSB entrusted NESAC to implemented a major project on Applications of Remote Sensing and GIS for Sericulture Development, which is having two major components: i) Identification and mapping of potential areas for sericulture development and ii) Development of a network of Sericulture Information Linkages and Knowledge System (SILKS). The first phase of the programme has successfully been completed covering 108 priority districts from 25 states, where 45 districts were covered from NE region.

As a second phase of the project, 70 additional priority districts are being covered in collaboration with State Remote Sensing Centres, a few other Central government Institutes and a large number of CSB regional centres and R&D institutes. Out of the total 70 districts, 20 districts were selected from 7 NE states (excluding Manipur) covering a total geographical area of 9,35,195 sq.km. Mapping of potential areas for sericulture development has been completed for the selected districts from NER. Among the NE states, Meghalaya is found to have maximum suitable areas (1,71,208 ha) that can be brought under Mulberry Sericulture. This is followed by Assam (1,49,442 ha) and Nagaland (27,648 ha). Due to limitation of physiographic conditions and climate, Sikkim is having very limited areas (19,821 ha) in one selected district that can be brought under sericulture activities.

Among non-mulberry sericulture, Assam and Meghalaya is having highest amount of suitable areas in terms of Muga rearing in the selected districts (1,96,212 ha and 82,524 ha, respectively). Assam, which is traditionally well-known for Muga is having highest areas suitable for Muga in the selected 7 districts. The lowest suitable areas for muga has been found in Arunachal Pradesh. Again, Assam has also the highest areas suitable for Eri (2,18,395 ha). Meghalaya occupies the second position with 48,859 ha in the selected 2 districts.

SILKS webportal developed as a part of the project has been put in the public domain under the domain name http://silks.csb.gov.in. SILKS is a single window, ICT-based information and advisory services system for the farmers, sericulture extension workers, administrators and planners working in the field of sericulture development. The spatial and non spatial database for 20 selected districts of NER have been integrated into SILKS web portal.

The project atlas having maps and statistics on potential areas for sericulture development for 20 selected districts of NER has been published and it was released by Sri Ranjit Dutta, Hon'ble Minister of Handloom, Textiles & Sericulture, Govt. of Assam on October 22, 2018 at Guwahati.

Release of Project Atlas for 20 districts of NER

Coordinated Horticulture Assessment & MAnagement using geoiNformatics (CHAMAN)

Mahalanobis National Crop Forecast Centre (MNCFC), Department of Agriculture, Cooperation & farmers' Welfare (DAC&FW), Govt. of India, New Delhi initiated the project titled Coordinated Horticulture Assessment & Management using GeoiNformatics (CHAMAN). Site Suitability Analysis for area expansion

of one horticultural crop in one district of each NE state has successfully been completed under CHAMAN programme. This component was coordinated by NESAC and implemented by State Remote Sensing Applications Centre (SRSAC) of NE states. A two days national workshop was organized during April 11-12, 2018 at Assam Administrative Staff College, Guwahati. The workshop was attended by around 50 delegates representing Ministry of Agriculture & Farmers Welfare, New Delhi, MNCFC, New Delhi, ISRO HQs, Bengaluru, Space Applications Centre, Ahmedabad, NESAC, SRSAC of NER, and state Dept. of Horticulture of selected states. State wise project reports were released in the workshop by Shri S.K. Pattanayak, IAS, Secretary, DAC&FW, Govt. of India.

Release of project reports of CHAMAN by Secretary, DAC&FW

The scope of the project has been extended with additional 16 districts of NE states are being taken up as a second phase of the project. The project has been implemented in collaboration with SRSAC of all the NE states. A project initiation meeting was organized on October 12, 2018 at NESAC and finalized the districts and the crops for the second phase.

Districts and crops selected for CHAMAN (Phase-II)

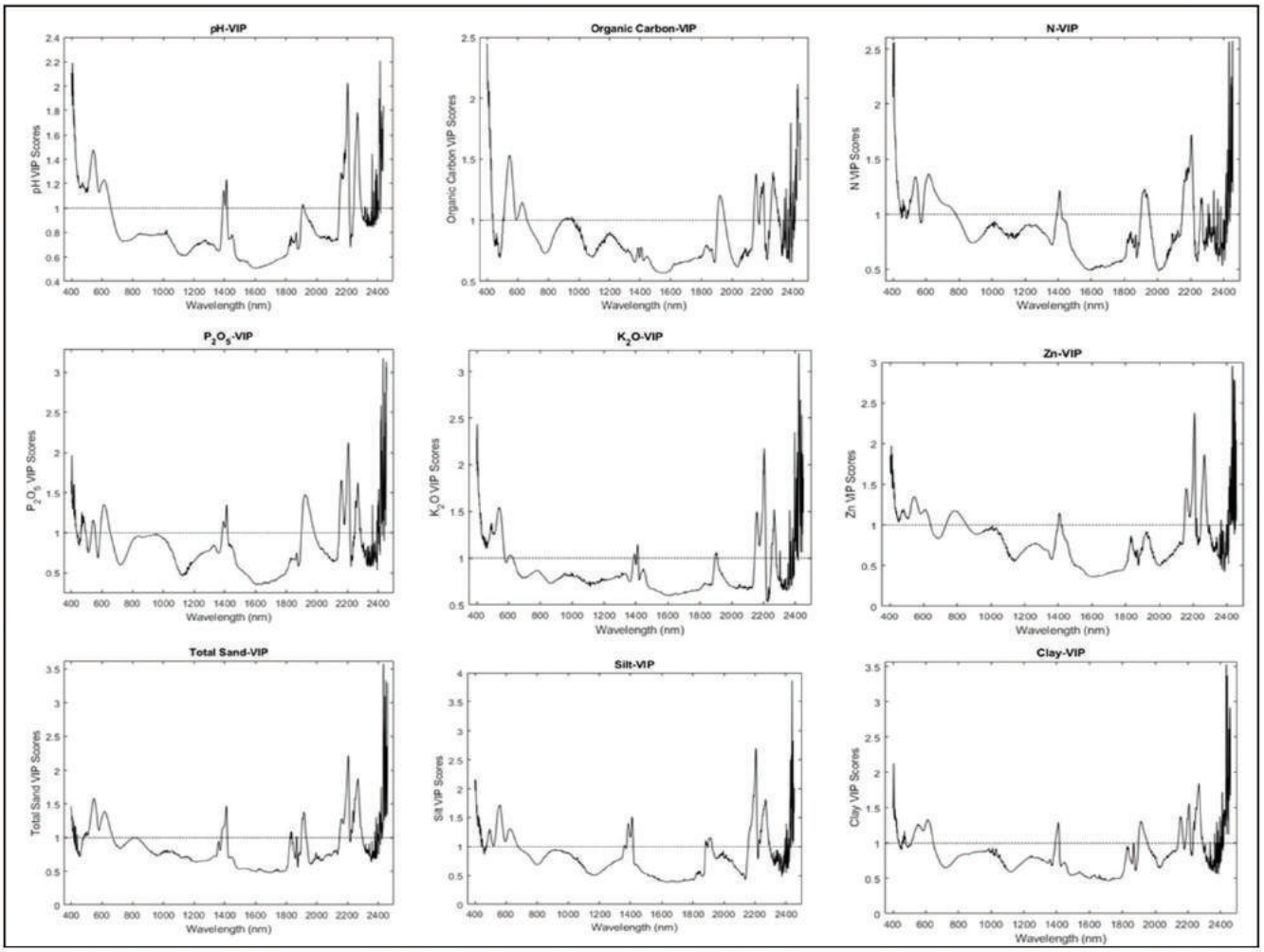
State	District	Crop
Arunachal Pradesh	Lower Subansiri	Large Cardamom
	Kamle	Orange
Assam	Nagaon	Assam Lemon
	Cachar	Pineapple
	Chirang	Turmeric
Manipur	Tamenglong	Orange
	Ukhrul	Kiwi
Meghalaya	East Garo Hills	Arecanut
	East Khasi Hills	Potato
Mizoram	Aizawl	Dragon fruit
	Serchhip	Dragon fruit
Nagaland	Wokha	Orange
	Phek	Kiwi
Sikkim	East District	Kiwi
Tripura	North District	Orange
	Unakoti	Pineapple

Review meeting of the CHAMAN project and external quality check of input database was conducted during March 27-29, 2019 at NESAC. All the states have satisfactorily completed the updation of input database.

Assessment of soil fertility in Ri Bhoi district of Meghalaya using hyperspectral spectroscopy

A thorough understanding of soil variability is essential for precision agriculture. The present understanding of soil variables is limited to very course scale (1: 50,000) which is not sufficient for precision agriculture in a country like India, where most of the farmers are small to marginal. In case of north eastern region of India, the average farm holding is less than 1 ha; therefore information about soil variability at farm scale level is required for precision agriculture. Realizing the importance of soil variability at farm scale level, Government of India has initiated a flagship programme under the Department of Agriculture, Cooperation and Farmers Welfare (DAC&FW), Ministry of Agriculture and Farmers Welfare (MoA&FW) for issuing of Soil Health Card (SHC) for each and every agricultural field of the country. The programme is implemented through the State Department of Agriculture, State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), Indian Council of Agricultural Research (ICAR) institutes and Central Agricultural Universities (CAUs).

Generation and issue of SHC involves a series of steps starting with soil survey, collection of soil samples, analysis of soil samples, fertility interpretations and fertilizer recommendation. In traditional methods, composite soil samples consisting of 15 to 20 individual samples for an area of 12 to 20 ha are normally prepared, however, in precision agriculture, one soil sample per hectare is recommended. Though soil analysis is essential for agricultural planning, this has several disadvantages such as they are expensive, time consuming, and often cause environmental pollution. New methods such as mass spectroscopy, X-Ray



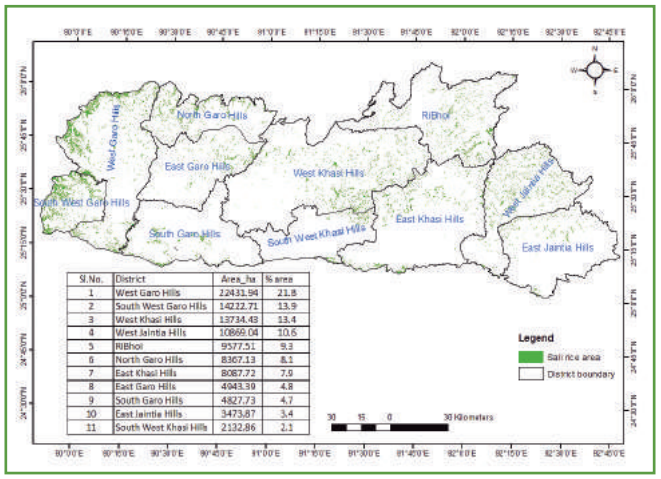
VIP values of different soil physical and chemical parameters

diffraction, nuclear magnetic resonance, visible-near infrared spectroscopy etc. can be used for analysis of soil attributes. These methods are rapid and easily repeatable since they do not require wet extraction of soil samples allowing analysis of dry soil samples. Keeping these in mind, NESAC has initiated this project under Technology Development Programme (TDP) with an objective to identify the spectral bands for different soil fertility parameters.

Soil samples were collected from 105 sites selected through stratified random sampling based on soil orders and land use/cover. Nine soil fertility parameters were selected viz. pH, soil organic carbon (SOC), available nitrogen (N), available phosphorus (P2O5), available potassium (K2O), available zinc (Zn), total sand, silt and clay. Pure spectra of soils were recorded in the dark room. Partial Least Square Regression (PLSR) was used to identify the most responsive spectral band(s). Variable Importance of Prediction (VIP) values more than 1.0 were considered as threshold value for selection of the bands. This has been observed that for all the soil fertility parameters, VIP is more than 1.0 in the spectral range of 400-450 nm, 1380-1420 nm (except SOC), 1900-1950 nm (except Zn) and 2100-2450 nm. Therefore, these spectral regions may be used for developing spectral indices for soil fertility parameters.

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

Directorate of Agriculture proposed to create a scientific database on winter paddy (Sali) paddy areas, which constitute about 67% of total paddy growing areas in Meghalaya and and entrusted NESAC to take up the mapping of Sali paddy areas in Meghalaya using RS & GIS technique. The database will be utilized for planning, increasing production and productivity of Sali rice in order to promote food security goals of the State. The Sali paddy areas have been mapped using LISS-IV imagery of year 2017-18. Intensive ground truth data have been collected from the entire state. The mapping



Sl.No.	District	Area_ha	% area
1	West Garo Hills	22431.94	21.8
2	South West Garo Hills	14232.71	13.9
3	West Khasi Hills	13734.43	13.4
4	West Jaintia Hills	10869.04	10.6
5	RiBhoi	9577.51	9.3
6	North Garo Hills	8367.13	8.1
7	East Khasi Hills	8087.72	7.9
8	East Garo Hills	4943.39	4.8
9	South Garo Hills	4827.73	4.7
10	East Jaintia Hills	3473.87	3.4
11	South West Khasi Hills	2132.86	2.1

Sali growing areas of Meghalaya

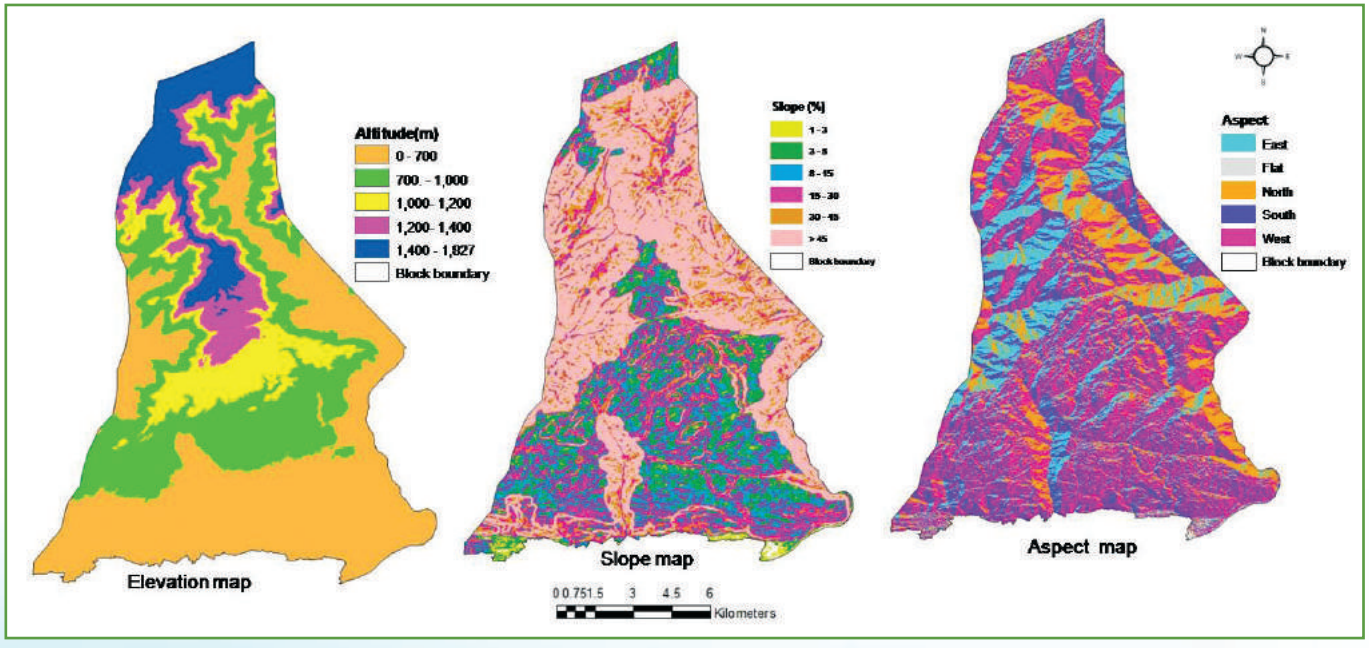
has been completed and maps have been sent to the user department for validation. It has been estimate that 1027 Sq.Km. area is under Sali rice in Meghalaya. Highest Sali paddy areas were found in West Garo Hills district and the lowest areas were found in South West Garo Hills district.

Identification of suitable areas for expansion of orange plantation in East Khasi Hills

Among the 8 north eastern states, Meghalaya is the leading state in both area and production of orange. In Meghalaya, Khasi mandarin orange is grown for commercial purpose, which occupies largest fruit growing area. Pynursla block of East Khasi hills is an important block which is producing good quality Khasi mandarin orange. Directorate of Agriculture, Govt. of Meghalaya wanted to expand orange plantation in this block and requested NESAC to identify the suitable areas for expansion of the areas. NESAC took up the exercise in collaboration with the Research Office, Directorate of Agriculture, Shillong. For identification of suitable areas for orange plantation, soil site suitability analysis is being carried out as per FAO (1983) guidelines. The existing soil map of 1:50,000 scale prepared by NESAC is being updated to 1:10,000 scale utilizing information derived from Resourcesat-2 LISS IV images of 2017-18 along with study of soil through soil sample collection. Different thematic maps viz., soil depth, drainage, flooding, texture, and gravel/ stoniness has been derived from the updated soil map. Land use land cover map of 1:10K scale is being prepared and will be used to extract the study area which includes all land use classes except forest, built up and barren rocky areas. CartoDEM version 3.0 has been used to prepare slope, aspect and elevation map. All these maps will be transferred to GIS environment and overlay analysis will be carried out to assess suitability of soil site for orange plantation by following FAO guidelines.

Identification of suitable areas for expansion of paddy in Umling block of Meghalaya

Paddy is an important crop of Umling block of Meghalaya. Umling is the only block in the state which is



Elevation, slope and aspect map of Pynursla block

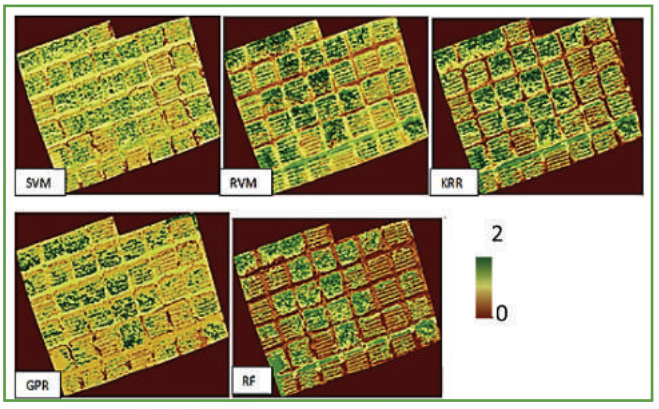
self sufficient in production of rice. On the other hand, districts like Jaintia Hills and East Khasi Hills produces very less quantity of rice compared to demand. Directorate of Agriculture, Govt. of Meghalaya has given emphasis to increase rice production by bringing new areas under paddy and they have selected Umling block as pilot site. In response to the request from Govt. of Meghalaya, NESAC has taken up this project to map the suitable areas for expansion of paddy following soil site suitability analysis as per FAO (1983) guidelines. Soil maps of 1:50,000 scale are being updated to 1:10,000 scale by studying soil profiles and soil sample analysis. Land use land cover map is being prepared by using LISS IV data of 2018-19. Slope, elevation and aspect maps will be prepared from CartoDEM version 3.0. and will be integrated for analysis to delineate suitable areas for expansion of paddy in the block.

Development of DSS for early warning of selected Muga Silkworm diseases and pests (Funded by CSB)

The study aims at identifying the various landscape and climatic parameters crucial for disease incidence; development of a decision support system for early warning of selected muga silkworm diseases, and dissemination of advisory services to farmers linking with the SILKS portal. Major economically important farms have been identified based on their spatial distribution of adaptibility under various physical and climatic conditions. Historical records of disease incidence and, climatic parameters have been analysed for five selected stations of major Muga growing belt since 2008 till 2018. Changes in landscape parameters have been studied over the years taking 5 km buffer from the farm locations. UAV was also flown in order to examine real time condition of the farm during the rearing season. Various landscapes parameters and climatic parameters that are crucial to Muga silkworm diseases and pest incidence, are being integrated adopting multivariate analysis. Correlation between disease incidents such as Flacherie with land surface temperature (LST) is found to be positive. With increase in areas under build up, agricultural activities, etc. results in increase in land surface temperature (LST), as LST increases beyond 20-22^{0}C, flacherie disease also increases and results in low productivity. Incidence of flacherie is very high with increase in LST in lakhimpur as compared to Nongpoh.

Characterization of Acid Soils under different land use pattern and its impact on Crop Growth

This study is taken up in collaboration with ICAR Research Complex, Umiam to develop spectroscopy based techniques for identification of abiotic stress in maize crops, grown in the hilly ecosystems of North East India. Leaf chlorophyll is the important biophysical parameter that indicates the crop heath condition. An attempt was made to estimate the leaf chlorophyll concentration of standing maize crop using handheld spectroradiometer and high resolution multi-spectral UAV images in Green, Red, Red-Edge and NIR bands. Machine learning algorithms were adopted to determine the chlorophyll estimates. Algorithms included were Support vector regression (SVM), Relevance vector regression (RVM), Gaussian process regression (GPR), Kernel ridge regression (KRR) and Random forest (RF) with K-fold cross validation. The multivariate analysis reveals the dominance of Red-band for chlorophyll estimation with R^2 values greater than 0.80. Among the machine learning algorithms, the Kernel-Ridge regression was found to be most robust method for developing chlorophyll estimation model with minimal RMSE (0.057 mg/gm) and regression coefficient of determination (R^2=0.904). The relevance vector machine also estimated chlorophyll concentration satisfactorily (R^2=0.87 with RMSE of 0.06 mg/gm), but took larger training time. These analytical methods allows for spatial estimation of chlorophyll to assess the heterogeneity of fields and make better farming decisions.



Estimated Chlorophyll (mg/gm) maps of all 39 plots using 5 different algorithms used

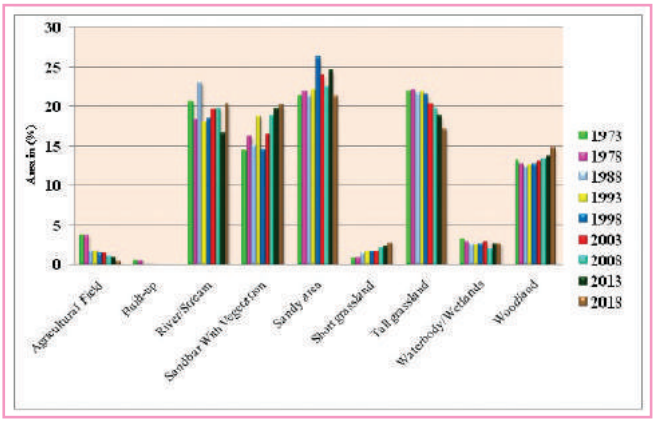
FORESTRY AND ECOLOGY

Forest cover of the north eastern region is unique and diverse owing to its location in the transition zone between the Indian, Indo-Malayan, and Indo-Chinese biogeographic region. The altitudinal variations from the plains of the Bhramaputra and Barak valley to the alpine zones in the Himalayas in north and rainfall patterns of southwest and northeast monsoon in the region also play a significant role in creating an environment congenial for bountiful forest resources. But these forests are under immense pressure as the ownership is mostly under the community, clan, or private land and little under the control of the States.

Over the years, NESAC has been carrying out different projects like assessment of biodiversity, estimation of growing stocks, assessment of vegetation and soil carbon, bamboo resources, forest biomass estimations, wetland mapping, shifting cultivation dynamics, burnt area assessment, wildlife habitat mapping, etc. in the region. Some of the major projects being undertaken by this group are detailed as follows.

Landcover analysis and dynamics of Kaziranga National Park

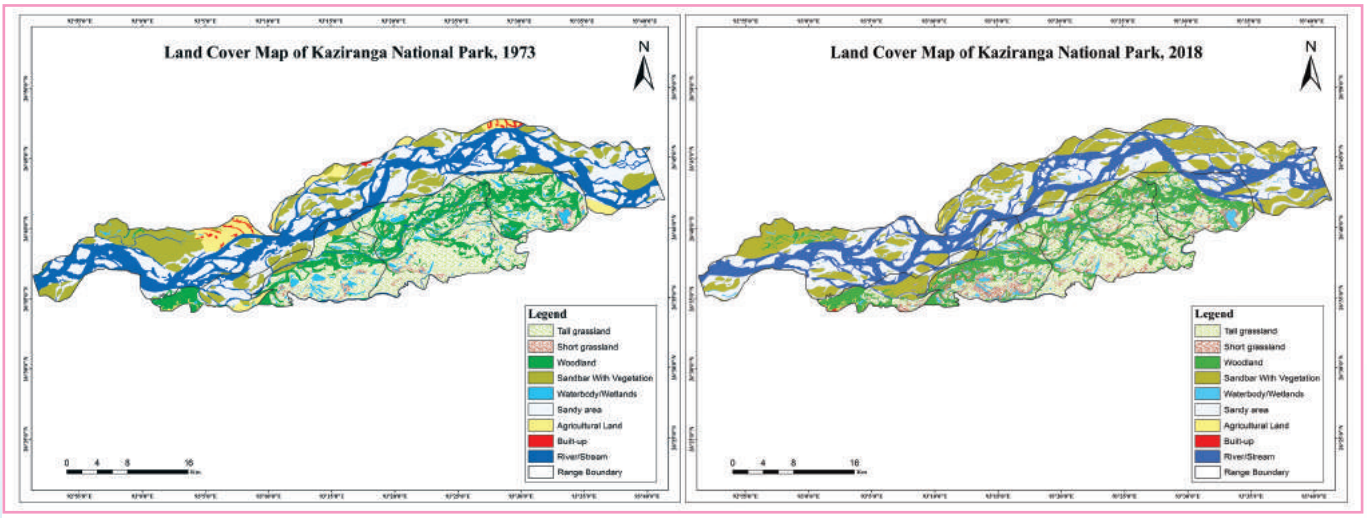
The project has been taken in collaboration and funding by Department of Environment & Forest, Govt. of Assam. The Kaziranga National Park is divided into five ranges viz. Kaziranga (Kohora), Western (Bagori), Eastern (Agoratoli), Burapahar and Northern. Land cover analysis and dynamics of the park have been studied using satellite data of 1973, 1978, 1988, 1993, 1998, 2003, 2008 and 2018 satellite data. The pattern of changes in the land cover have been also analysed in the park and it was observed that eastern range of the park is under severe threat from erosion. A draft project report has been prepared and is being finalised.



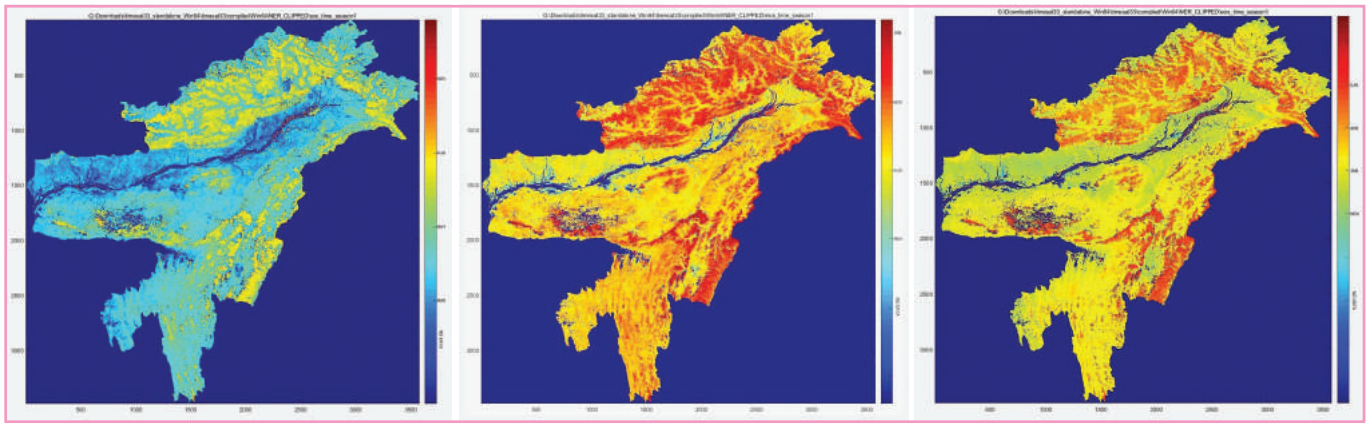
Area under different land covers categories in Kaziranga National Park during 1973-2018

Analysis of vegetation phenology of NER using time series satellite data

The project is initiated to map the distribution and variation in vegetation phenology variables for several natural vegetation types in North East India using time series satellite data. Preliminary analysis has been carried out using MODIS 16 days composite NDVI with a spatial resolution of 250 m and 1 km spatial resolution INSAT 3A CCD NDVI (10 days composite). Phenological parameters have been computed after smoothing the



Landcover map of Kaziranga National Park during 1973 and 2018

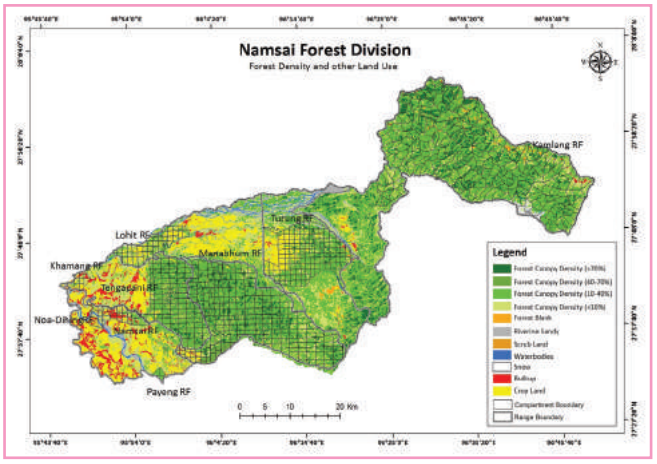


Start of season map *Middle of season map* *End of season map*

data by defining the threshold for the start and end of seasons. Seasonality parameters such as time for the start of the season, mid of the season, and end of the season has been calculated and maps have been generated.

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 stock estimation at compartment level for all the Reserved Forest under Namsai forest division is completed. Namsai forest division has a forest cover of 80 percent, and maximum area was under open canopy category (35.42% of the total geographical area). Reserved Forests under Wakro, Manabhum, and Tengapani range have most of the area under forest cover whereas those under Chowkham and Namsai range have two third of the area under forest and Turung RF under Medo range have four fifth of the area under forest cover. The growing stock information at compartment level of all RFs has been generated along with the phyto-sociological analysis of tree for all the ranges.



Forest canopy density overlayed with compartment boundaries in Namsai Division

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

For prepration of forest working plan for Darlawn division, the growing stock information have been generated for the Forest Department. Forest canopy density map at 1:10,000 scale prepared using cartosat-1

Forest canopy densities under different elevation categories in Namsai Division

Elevation Class (m)	Density Class (Hectare)					
	D1 (Canopy >70%)	D2 (Canopy 40-70%)	D3 (Canopy 10-40%)	D4 (Canopy <10%)	Other land use	Grand Total
<800	8766.80	15363.48	34947.50	16157.34	8982.40	84217.52
800-1800	3945.72	3999.78	12477.60	6296.96	1332.38	28052.44
>1800	5476.30	6574.98	16554.09	3852.74	1403.31	33861.42
Total	**18188.82**	**25938.23**	**63979.18**	**26307.05**	**11718.10**	**146131.38**

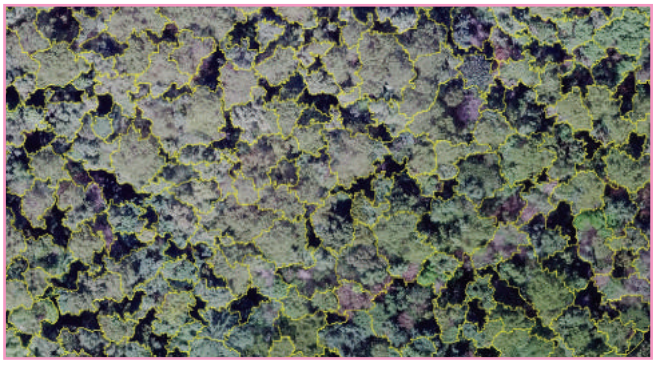
and LISS IV data and carto DEM were used for stratifying the forest. Based on field enumeration data from sampling points distributed on the basis of 25"x25" grids, growing stock information have been generated for each compartment at different girth classes and at different slope categories. Information on timber species composition, phyto-sociology, species richness, etc., has also been generated for each reserved forest of the division.

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

Synthetic Aperture Radar (SAR) data has gained importance for various remote sensing applications due to its all-weather capability and sensitivity towards geometrical and dielectric properties. In context of north-eastern region of India, which is mostly covered by clouds, SAR data is an alternative to optical data as it can penetrate through clouds. In the field of forestry, SAR can be used for forest height and biomass estimation and deforestation studies. To understand response to climate change and to estimate carbon pools, the accurate estimation of forest biomass is imperative. In contrast to optical data, synthetic aperture radar (SAR) data is more suitable for above ground biomass estimation. NESAC has taken up the initiative of using L band SAR data in collaboration with SAC, Ahmedabad for forest above-ground biomass estimation and mapping forest biomass of the north-east India. So far, the biomass maps for the state of Meghalaya have been generated using SAR data and the work is going on for other north-eastern states.

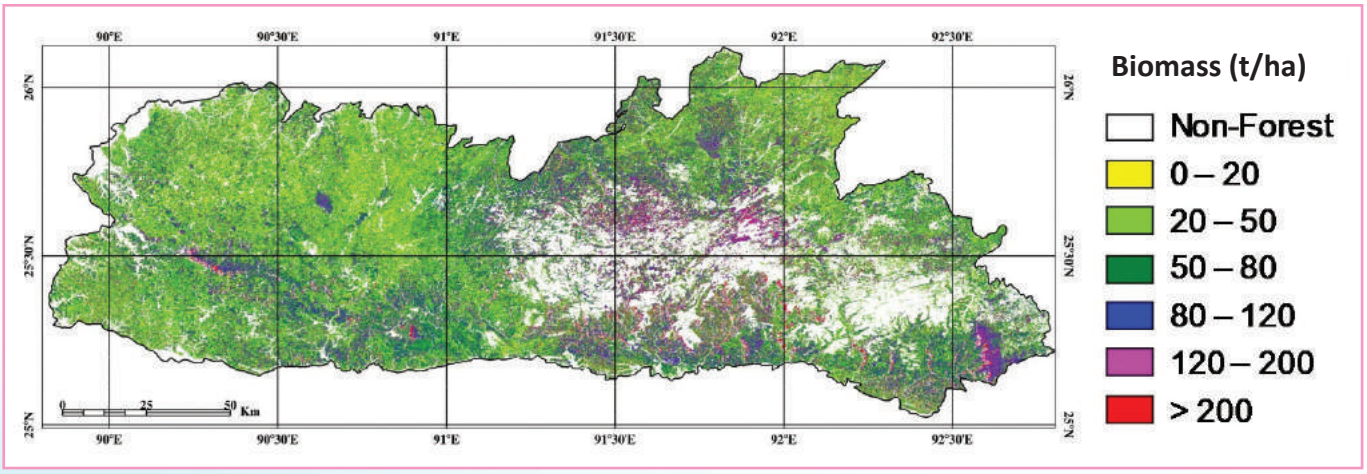
Use of Unmanned Aerial Vehicles (UAV) for automatic canopy delineation

Unmanned Aerial Vehicles (UAVs) are increasingly used in forestry due to its benefits of flexibility, low cost, reliability, autonomy, and capability of timely provision of high-resolution data. UAVs have already been used in various forestry applications such as forest mapping, forest management planning, canopy height model creation or mapping forest gaps. A forested area of the Botanical Survey of India in Umroi, Ribhoi-district of Meghalaya was mapped by automatic delineation of canopy cover using UAV-RGB image. The study area is an experimental garden with dense canopy and mixed species of around 10 hectares area. Flight campaign was conducted with RGB camera (DJI Zenmuse X3, 12 MP) onboard UAV Hex Copter (DJI Matrice 600). Around 250 images were processed in Pix4D software for generation of 3D point clouds, ortho-mosaic image and Digital Surface Model (DSM) of the study area.



Tree crown delineation by automatic segmentation method

A Digital Terrain Model was also generated using ground points. Multi-resolution segmentation was initially carried out using the RGB image. The estimates

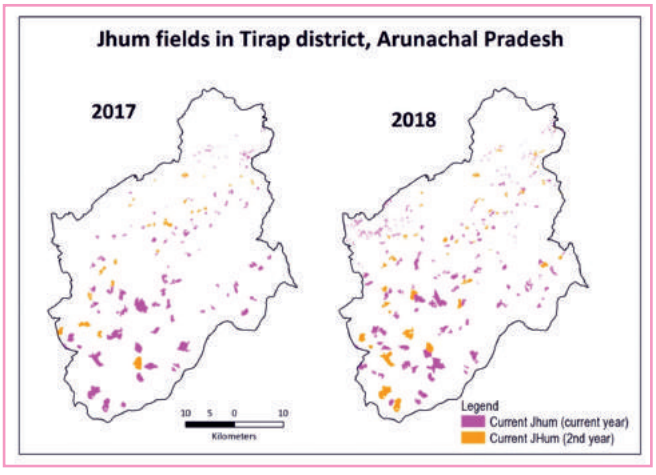


Biomass maps for the state of Meghalaya

were compared with ground inventory data in 10 sample sites of 0.1 hectare plots. Linear regression showed r^2 = 0.578 between UAV derived automatic segmentation and ground inventory, which can be improved using advanced sensors. The use of UAVs can help to minimize the ground inventory collection, especially in North East India, which has constraints of using space based remote sensing technique due to rugged topography, persistent cloud cover and dense vegetation which becomes hindrance in ground truth collection.

Monitoring of shifting cultivation fields in north eastern states

The area under shifting cultivation for the year 2017 and 2018 is being mapped for all the districts of the north eastern states under this monitoring exercise. During the current year, area statistics for two states (Assam and Arunachal Pradesh) is being reported. The area under shifting cultivation was found to be decreasing from 2017 to 2018. In Arunachal Pradesh it decreased from 0.50% to 0.45% and in Assam from 0.33% to 0.24 %. Some of the areas in Arunachal Pradesh could not be mapped in both the years due to cloud cover during the mapping period and it might also have led to less reporting of the area under current jhum.



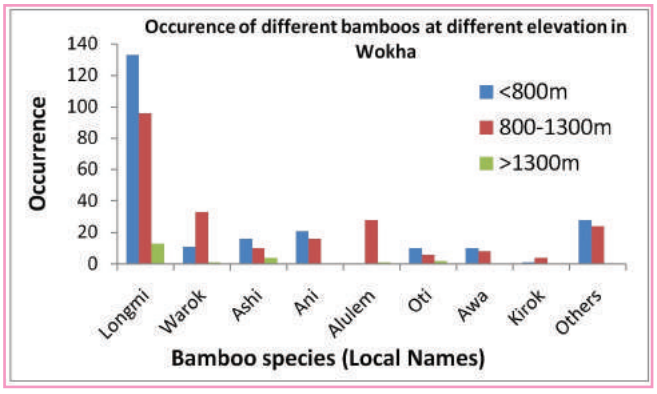
Shifting cultivation area in Tirap district, Arunachal Pradesh (2017-18)

Area under jhum fields in two states of north east India (ha)

State	2017	2018
Arunachal Pradesh	41405	37843
Assam	26184	18463

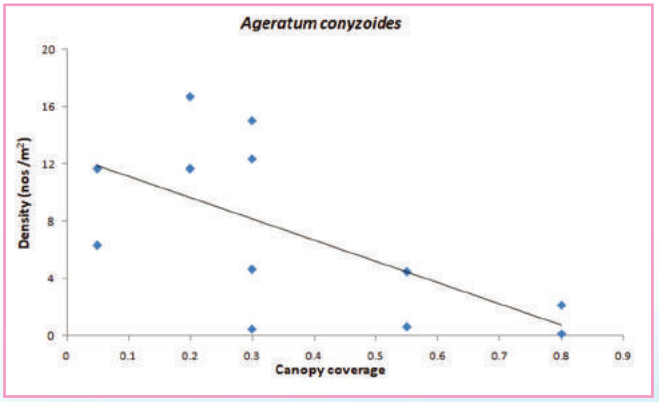
Spatial distribution of bamboo and estimation of bamboo biomass in Mokokchung and Wokha districts of Nagaland

The bamboo bearing area in the two districts of Wokha and Mokokchung have been mapped at large scale and it was found that an area of 8575 ha was under bamboo in Mokokchung district and 10499 ha under Wokha district. Field data on bamboo occurrence from pre-identified sampling points were collected along with fresh weight of sample culms. Dried weight of bamboo samples were derived after deducting the moisture content and the total bamboo biomass is estimated for the bamboo bearing area by extrapolating the mean growing stock for the two districts.



Mapping of major invasive species in Nagoan District of Assam

A pilot study was taken up to assess the status of invasive species in the forests of Nagaon District, Assam and to understand the extent of spread of these species for effective management. The study was taken up in collaboration with Nowgong College, Nagaon. Nagaon district covers an area of 4032 sq km out of which 713 sq. km. (17.6%) are notified Reserved Forests with a district population density of



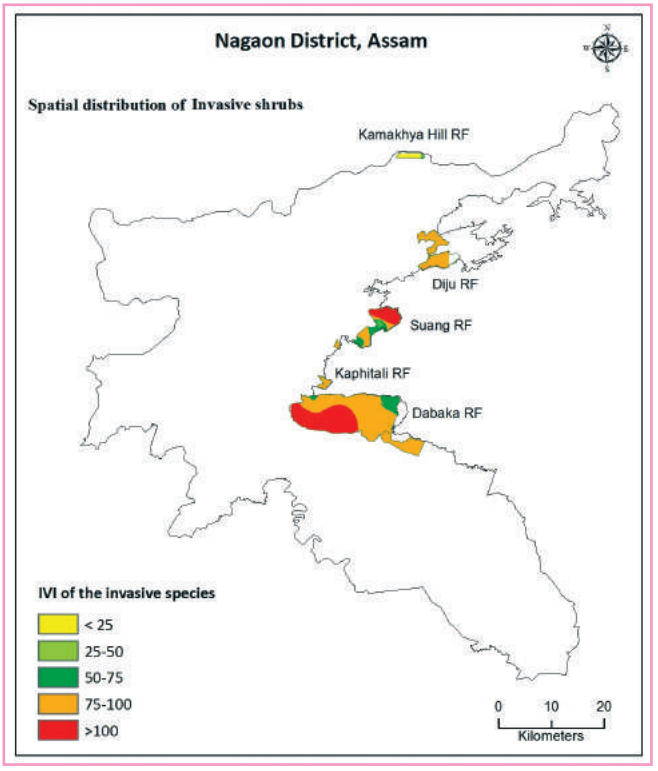
Density of A. conyzoides under different canopy cover

Bamboo stock estimates in the two districts of Nagaland

District	Bamboo bearing area (ha)	Culm number (in millions)				Bamboo biomass ('000 tones)
		2-5 cm diameter	5-8 cm diameter	>8 cm diameter	Total	
Wokha	10,558.18	4.39	6.00	2.59	12.99	112.2
Mokokchung	8,411.27	2.25	6.67	1.00	9.92	93.2
Total	**18,969.45**	**6.64**	**12.67**	**3.60**	**22.93**	**205.5**

711 persons per sq km. The forest canopy density and other land use were mapped at 1:10,000 scale using latest LISS-IV (2015-16) and Cartosat-1 (2014-15) data for all the RFs. Field data from pre-identified sampling points were gathered for herbs, shrubs, trees, etc., with more emphasis on herbs and shrubs. Based on the land use land cover and forest canopy density and the associated degree of abundance of the invasive species and the derived quantitative analysis of vegetation data, maps were prepared showing the area with the present distribution & degree of occurrence.

Among the herb invasive species *Ageratum conyzoides,*



Spatial distribution of invasive shrubs

Field enumeration for invasive species in dense forest

Saccharum spontaneum, and *Mikania micrantha* dominated the study area while among shrubs *Chromolaena odorata* and *Lantana camara* were the dominant species. A negative correlation was observed between forest canopy coverage and plant densities of the invasive species. The occurrence of invasive species was higher in the Dabaka RF and Kamakhya Hill RF.

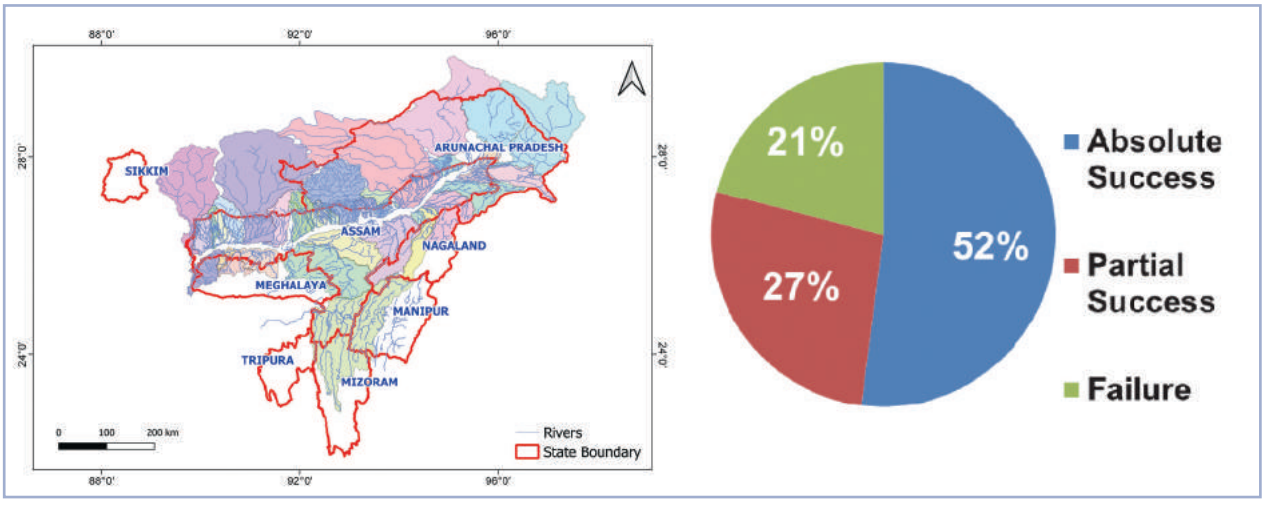
Field enumeration for invasive plants in open areas

HYDROLOGY & WATER RESOURCES

Flood Early Warning Systems (FLEWS)

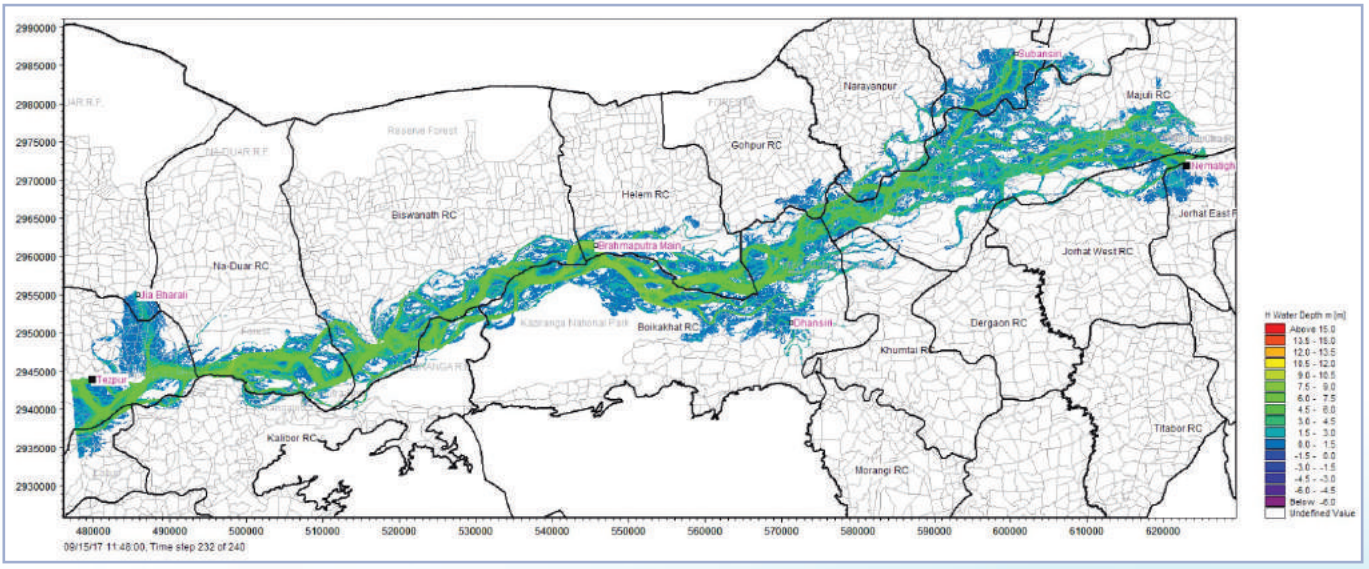
Flood Early Warning System (FLEWS) was initiated in the year 2009 on a pilot basis and became fully operational for Assam since 2012. At present the project covers all flood prone districts of Assam with actionable flood alerts in revenue circle level. All these years since the beginning, an average 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 second three year operational period from 2015 to 2017, at the request from Government of Assam, the third operational period from 2018 to 2020 has been started.

On the advice from Chairman, ISRO the present focus is on the extension of FLEWS services to other North Eastern states based on priority. The HEC-HMS models have been built for states of Arunachal (7 models), Nagaland (3 models), Tripura (5 models), Manipur (2 models), Mizoram (2 models), Meghalaya (8 models) and Sikkim (1 model). Presently the models have been built and made ready for calibration and validation. Simultaneously institutional arrangements are getting established through series of stakeholder meetings especially with the state level disaster management authorities and remote sensing centres. During 2018 monsoon an experimental alerts have been issued for Meghalaya, Arunachal Pradesh and Tripura.



FLEWS Catchments

FLEWS success rate in 2018



Sample Inundation Scenario

Flood inundation forecasting in Brahmaputra

The Union Ministry of Water Resources, Government of India through its major agency the Central Water Commission (CWC), has approached NESAC for collaboration on hydraulic simulation based flood inundation scenario generation in Brahmaputra valley. With the use of high resolution Digital Elevation Model, flood discharge and level based inundation scenario library will be generated.

The individual scenario from these libraries will be used in future as inundation forecast and advisories during flood season. The product generated out of this exercise will also help in scientific floodplain zonation and regulation. Presently hypothetical scenarios have been generated for the upper Assam sector of Nematighat to Tezpur.

Assam River Atlas

The river atlas preparation for Assam has been initiated during 2017. In this project, all the major and minor rivers entering Assam has been mapped at a scale of 1:4,000. Mapping includes 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 defined buffer. In addition to this, district wise river catchment maps are being prepared to show the origin of all the rivers entering the respective districts of Assam.

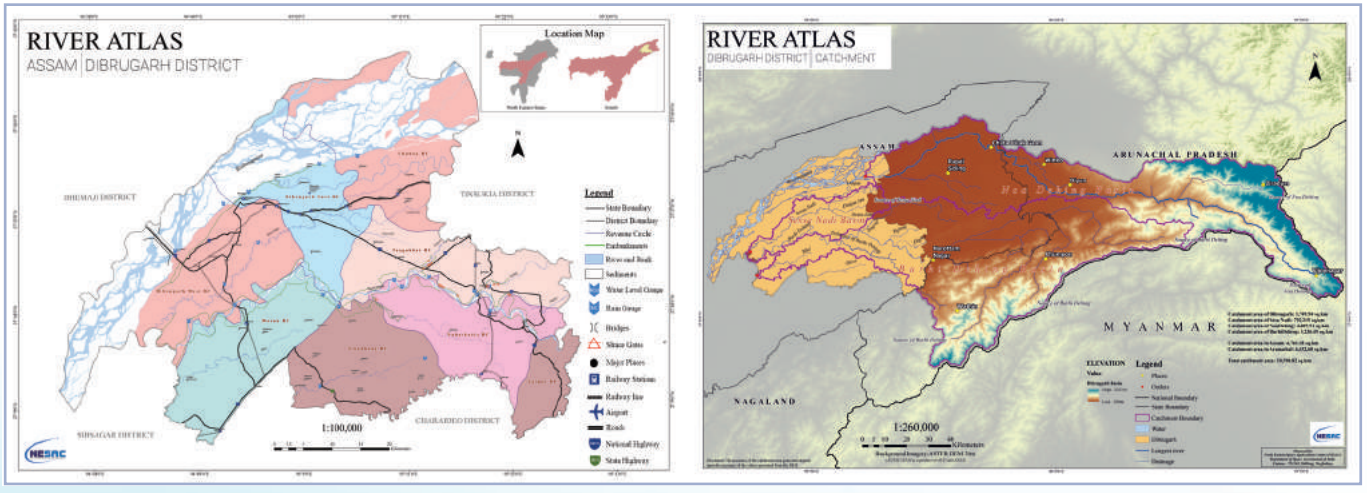
Presently 85% of the deliverables have been submitted to the user and funding agency. In an interim review of this project during January, 2018, Hon'ble Chief Minister, Assam, expressed satisfaction on progress of the project and hoped that this exercise will be of great help in river planning & development in Assam.

Monitoring and Evaluation of IWMP watersheds

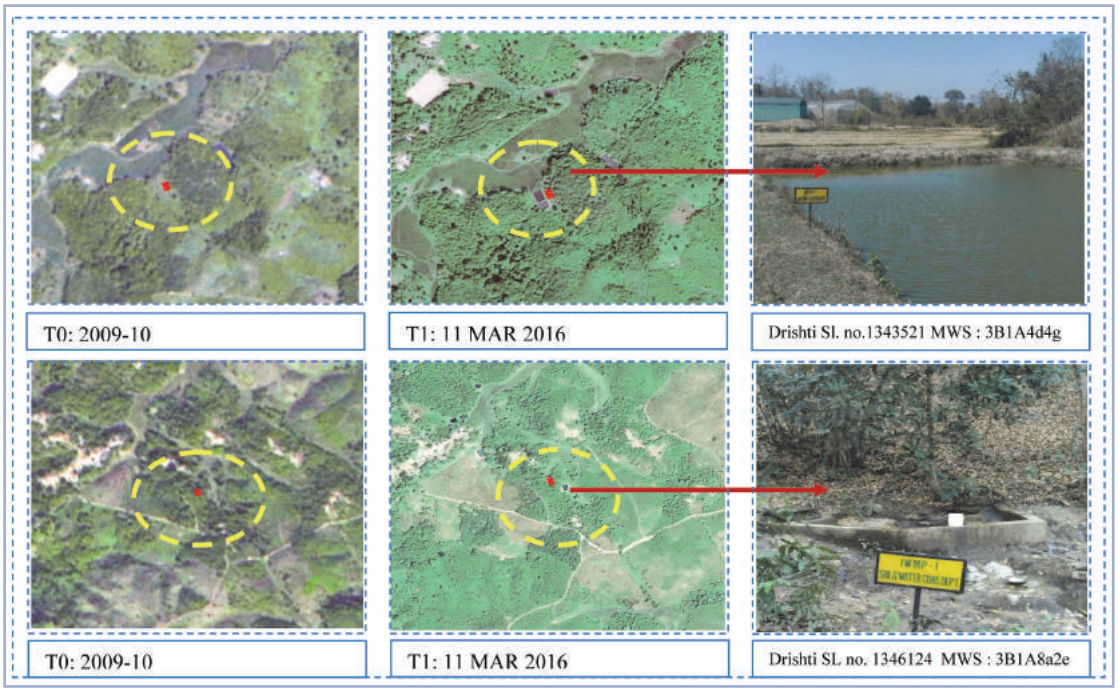
Department of Land Resources, Government of India implementing a monitoring and evaluation system using Space technology for the watersheds under IWMP (Integrated Watershed Monitoring Programme) and had an MoU with Department of Space for the same. National Remote Sensing Centre (NRSC), Hyderabad has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

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

All the processed data will be made available for online analysis/interpretation.



District river map *District catchment map*

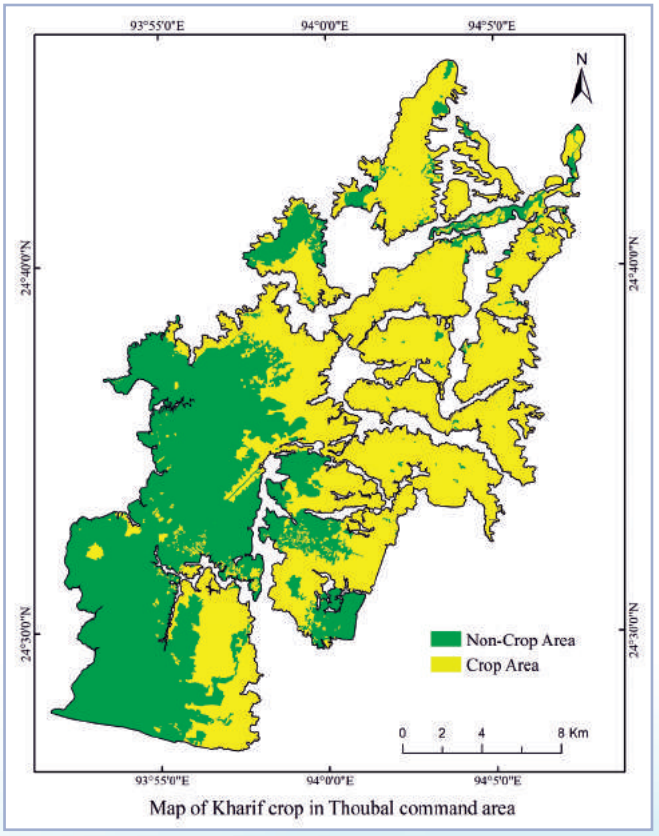


Monitoring of IWMP activities 1. Farm Pond & 2. Spring Chamber

Assessment of utilization of irrigation potential created for selected irrigation projects of NE India

This project is being executed as per the requests from the Ministry of Development of North Eastern Region (DoNER) with a aim to use of space technology to prepare action plans for selected watersheds. Ministry of Water resources was assigned to take up a pilot study for monitoring of actual utilization for some Major and Medium irrigation projects in collaboration with NESAC. Accordingly, Central Water Commission, North Eastern Office at shillong requested NESAC to carry out the project work for assessment of utilization of Irrigation potential created for Champamati, Dhansiri, Dolaithabi and Thoubal irrigation scheme located at Assam and Manipur.

The study shows that estimated gross command area (GCA) and Culturable Command area (CCA) of Dholaithabi and Champamati irrigation scheme is less than proposed GCA and CCA. The estimated GCA and CCA for Dholaithabi is lesser by 31% and 8.8% respectively. Similarly estimated GCA and CCA of Champamati is lesser by 0.6% and 14% respectively. On the other hand, the estimated GCA of Dhansiri and Thoubal irrigation scheme is higher than the proposed GCA by 2.3% and 11.8% respectively. But the estimated CCA for both the project is lesser than the proposed ones by 5.6% and 16.8% respectively. The irrigation potential utilized is 100% for all four irrigation schemes in kharif season but it is very poor in rabi season. The irrigation potential utilized in rabi season is 10% for Champamati, 14% for Dhansiri, 0.3% for Dholaithabi and 11% for Thoubal irrigation scheme respectively.



Kharif crop areas in Thoubal Command area, Manipur

URBAN AND REGIONAL PLANNING

Urban Planning by its nature is concerned with shaping the future of urban settlements and allocation of land for residential, commercial, institutional and industrial development. Planning and development means the physical and economic growth, which meets effectively the social needs of the human society. The urban and regional planning applications primarily deal with designing and management of urban areas and its environment with all infrastructural amenities available ensuring the orderly development of settlements and communities. The Urban and regional planning group at NESAC is involved in various national and state level projects.

The Centre has been actively involved in Land Use/ Land cover mapping and urban sprawl monitoring, urban infrastructure mapping, cadastral level mapping and updation using satellite and aerial data and has contributed in preparation of Master Plan / Development Plan, Transportation Plan, Urban Site Suitability Analysis, Urban Environmental Planning etc.

About AMRUT

Government of India launched Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 2015 as Centrally Sponsored Scheme with the objectives to:

a. Ensure that every household has access to a tap with assured supply of water and a sewerage connection.
b. Increase the amenity value of cities by developing greenery and well maintained open spaces (e.g. parks).
c. Reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling).
d. One purpose of the Mission is to improve governance through a set of Reforms. During the Mission period, 11 reforms are being implemented.

Formulation of GIS-based Master/Development Plans for 500 AMRUT cities is one of the important reforms under AMRUT, which has been approved as a 100% centrally funded sub scheme with budget outlay of Rs. 515 crores.

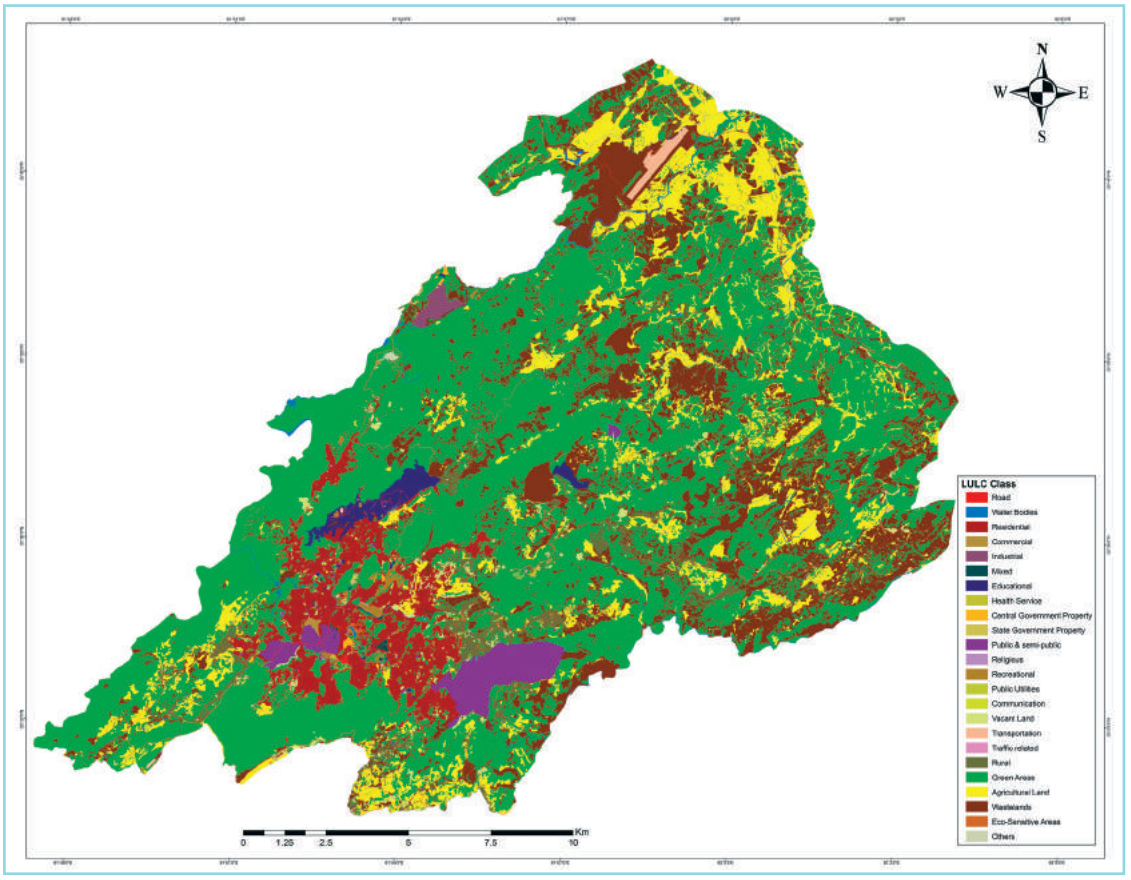
The objective is to develop common digital geo-referenced base maps and land use maps using Geographical Information System (GIS) and Master plan formulation.

The major components of the sub scheme are:

a. Preparation of Base Map & Thematic Maps: Final base maps in the form of user-friendly spatial products at the functional scale of 1:4000 having defined layers as per Design & Standards. City /town base map and thematic maps including existing landuse map which is prerequisite for formulation of master plan and other plans.
b. Urban Database Creation: Sector-wise data collection and data analysis report of 25 aspects as per Design & Standards.
c. Formulation of Master Plan: Formulation of Master Plan of city as per State Town & Country Planning Act, which includes demand assessment, identification of issues, projected requirements, development strategy and draft proposals on the GIS base map and sector wise data analysis.
d. Capacity Building: Build capacity among town planning, line departments and other concerned personnel at State and local levels including ULBs and development authorities to create a cadre of professionals proficient in the use of GIS technology for using and updating databases in urban planning and management.

Geodatabase creation of shillong planning area, Meghalaya AMRUT sub-scheme

Creation of GIS-based Master/Development Plans for Shillong Planning Area covering an area of 312 km^2 at 1:4000 scale is being carried out at NESAC. 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.



Urban Land-Use/Land-Cover (LULC) of Shillong Planning Area

Landuse - Shillong Planning Area (2019)

Sl. No	Landuse	Area (in sq km)	Percentage of Total
1	Residential	16.99	5.45
2	Commercial	0.23	0.07
3	Mixed	0.12	0.04
4	Public & Semi Public	6.16	1.98
5	Administrative	0.35	0.11
6	Institutional	2.97	0.95
7	Organised open space	1.37	0.44
8	Industrial	0.82	0.26
9	Circulation	4.85	1.56
10	Religious	0.03	0.01
11	Public Utilities	0.01	0.00
12	Rural	6.98	2.24
13	Communication	0.00	0.00
14	Others	0.09	0.03
15	Vacant Land	2.86	0.92
16	Conservation	55.46	17.81
17	Urban Agriculture	34.66	11.13
18	Forest & water bodies	177.50	56.99
	TOTAL	**311.47**	**100**

Formulation of GIS Based Master Plan Under AMRUT for Shillong Planning Area, Meghalaya

Land Resource Plan

Development in Shillong Planning Area has been constrained by terrain suitability and forest area. While 13% of the total area is already developed (40.9 Sq Km), abundance of hills, wetlands, water bodies, eco sensitive and forest areas has limited the potential area to be developed to only 13.8 %. The landuse distribution of Shillong Planning Area indicates its administrative and educational standpoint as well as the presence of defence establishment in the city. While residential areas take away nearly 41% of the total developed land, areas under administrative, institutional, public & semi-public use accounted for 23% of land. 11.9% of the area comes under circulation, which is indicative of the hilly terrain of Shillong Planning Area. Though, the land use for circulation appears to be significant, as per the Master Plan, it is in fact, inadequate as is evident from narrow roads, areas without vehicular roads and missing links. A land resource plan is prepared for the whole planning area.

Land Resource Plan - Shillong Planning Area (2019)

Sl. No	Land Use	Area (in sq.km)	Percentage to total area
1	Developed Area	40.985	13.16
2	Undevelopable Area	0.057	0.02
3	Developable Area	58.264	18.71
4	Agricultural Area	34.66	11.13
5	Forests & Water Bodies	177.5	56.99
	Total area	**311.47**	**100.00**

Traffic Ananlysis

In the absence of rail and inland waterways, road transport plays the important role of communication in the city of Shillong. National Highway No. 40 starts from Jorabat and terminates at Tamabil (Dawki) on the Indo - Bangla border covering a total distance of 163 kms. This National Highway (NH-40) consists of 2 (two) sections, namely the Guwahati – Shillong (G.S.) section and the Shillong – Tamabil (S.T.) section. The area of interest for traffic analysis is Guwahati – Shillong section particularly taken from Umiam junction (point) to Rilbong junction. The urban agglomeration of Shillong city is being disected by this major road and serves as a lifeline for the city. The city being the most important hub in the state is a victim of congestion and traffic mismanagement. Narrow roads, unavailability of proper parking spaces and heavy vehicles manoeuvring through the city, contributes to road congestion. Most of the roads in Shillong are single lane and the inability to expand such roads because of topography and land ownership pattern adds to the problem of congestion.

Outer cordon classified volume count surveys has been conducted for 12 hours at identified critical intersections (at Rilbong junction and Umiam Junction) within the study area on a typical working day and on a non working day. These information has helped in identifying the traffic issues at the intersection and understandig the critical movements including the inter and Intra city traffic Analysis of the primary survey data collected enables us to understand the level of congestion on the identified stretch of road from Umiam flyover junction to Rilbong junction. It is evident that the peak hour for Traffic is 9 am till 10:30 am. The passenger car unit, which is a measure of the impact that a mode of transport has on traffic variables (such as headway, speed, density)compared to a single standard passenger car, where the accepted value should be less than 1 for free flowing traffic. It is observed that the passengr car unit per hour is as high as 1.85 during the peak hour and diminishes to 1.51 during the non peak hour and is still higher than the threshold value of 1.

Turning movement of vehicles at Rilbong and Umiam Junctions

Rilbong Junction			
Non working day		Working day	
Direction	Volume	Direction	Volume
Guwahati – Shillong	5377	Guwahati – Shillong	8434
Shillong – Guwahati	9312	Shillong – Guwahati	6387
Guwahati – Sohra	4273	Guwahati – Sohra	2049
Sohra – Guwahati	4045	Sohra – Guwahati	8032
Shillong – Sohra	6225	Shillong – Sohra	6817
Sohra – Shillong	6050	Sohra – Shillong	8032
TOTAL	**35282**		**39751**
Umiam Junction			
Guwahati – Shillong	3647	Guwahati – Shillong	4895
Umroi – Shillong	576	Umroi – Shillong	545
Shillong – Umroi	1291	Shillong – Umroi	1295
Shillong – Guwahati	5507	Shillong – Guwahati	4112
TOTAL	**11021**		**10847**

GEOSCIENCES

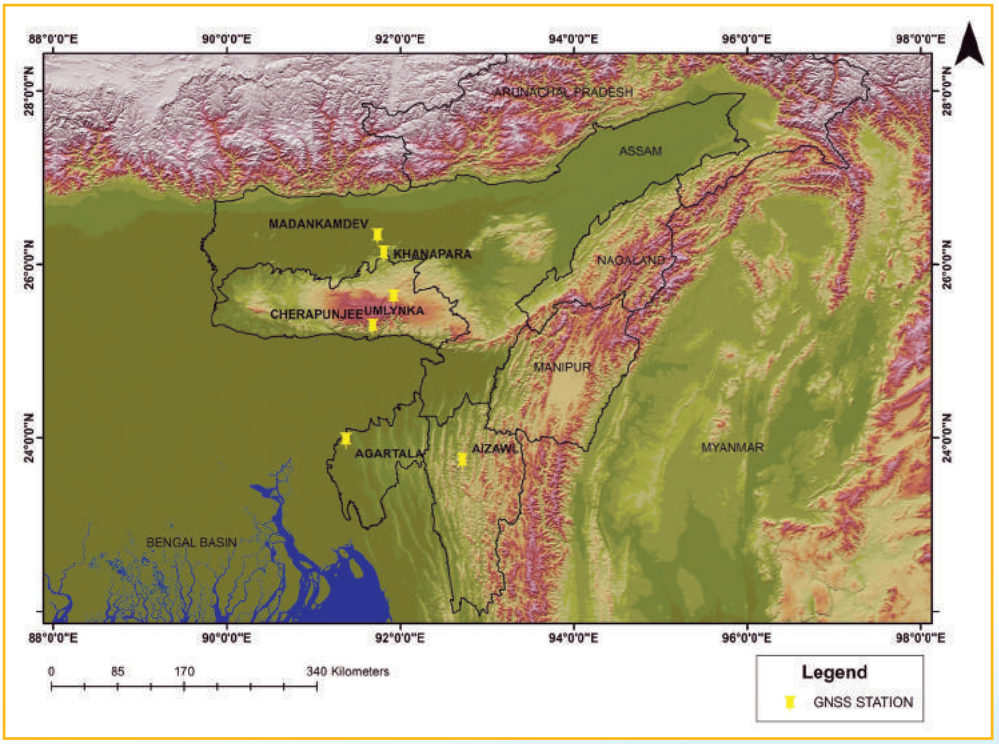
Geosciences team at NESAC is actively engaged in various geological studies by using core Geological knowledge in combination with Remote Sensing and latest Geological and Geophysical technology. In the past year, the team has carried out some of the interesting studies including GPS based Total Electron Content (TEC) studies in North East India, Morphotectonics, Neotectonic and deformation studies, Ground water quality mapping, Environmental and Technological hazards assessment, to name a few. It has provided important inputs to National Green Tribunal (NGT) for planning and restoration of Coal mines affected areas of Jaintia Hills, Meghalaya. The Centre has also provided hands on training and short courses on RS & GIS and GNSS applications in Geosciences to user departments (ONGC, SDMA's, and State Forest Dept. etc). Some of the important studies carried out during 2018-2019 are summarized below.

Earthquake precursory studies using GNSS data

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 (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 will be utilized in present collaborative work of NESAC-NEHU. The study aims to detect TEC variations in the ionosphere and analyse the same for precursory detection of impending earthquakes. Several studies show that the TEC in the ionosphere behaves abnormally prior to the occurrence of earthquakes. These abnormalities in the ionosphere is actually linked to the deformation and stress accumulation in the earth's crust. TEC is found to be varying anomalously before an earthquake due to various processes that may include enhancement of the emission of radon and release of p-holes due to peroxy defect in the earth's crust, a major solar flare, geomagnetic storm activities in the upper atmosphere, etc.

CORS at Sohra (Meghalaya)

Detail analysis on 2016 Mw 6.7 Imphal earthquake



Singapore Earth Observatory GNSS network in north east India

was carried out using three GPSCORS installed each at Sohra (Meghalaya), Khanapara (Assam) and Madankamdev (Assam). TEC time series, prior to earthquake indicates strong consistent positive anomalies at regular intervals. The time at which the TEC deviation is maximum and minimum is noted and is named as anomaly time. It is observed that for positive anomaly, at detected anomaly time, TEC concentration increases towards the epicenter. For negative anomaly, TEC concentration decreases towards the epicenter. It is also observed that with distance, the magnitude of TEC anomaly decreases and the maximum anomalous values are observed near to the earthquake epicenter.

Near real time precursor detection system at NESAC

An attempt is being made to analyse TEC variations observed by GNSS IGS stations, located in different parts of continents together with geomagnetic storm indices in single platform. NESAC is working on developing a system that enables decision makers to observe the ionospheric condition prior to earthquake. The system will serve as an excellent tool for pre earthquake anomaly detection and monitoring and may open up new avenue towards understanding earthquake phenomenon.

The main aim of this project is to computerize the processes of anomaly detection in near real time. The objectives of this project are to provide following features:

a) To estimate TEC values of each station automatically.
b) To calculate the mean, standard deviation, upper bound and lower bound automatically.
c) To generate the plot of TEC values and time automatically.
d) To plot the graph of Disturbance Storm-Time (Dst) and 3 hour geomagnetic activity index (Kp) automatically.
e) Calculation of anomalies and sending emails alerting about the anomalies that have occurred.

System validations with large number of post event analysis are in progress to rectify and improve the monitoring system.

Multiparametric Geophysical Observatory (MPGO) data analysis for precursor study

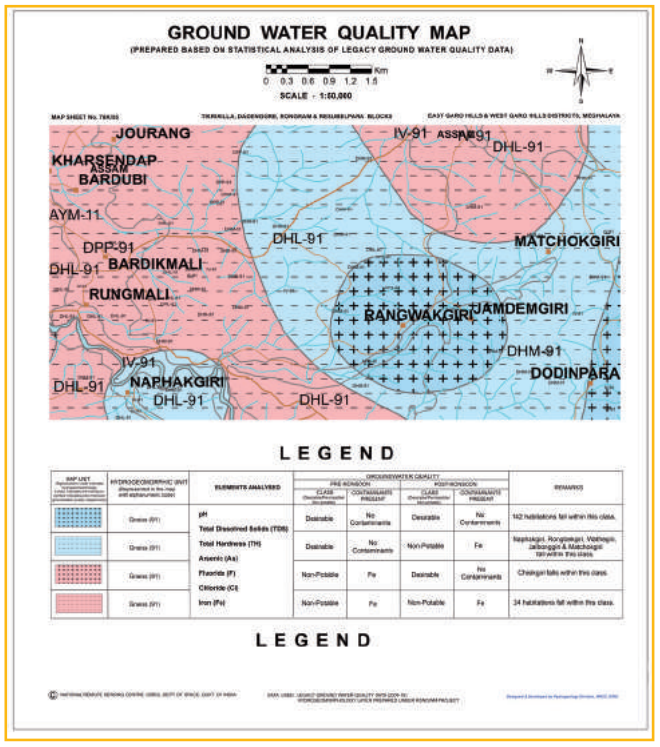
NESAC has also taken up collaborative work with North East Institute of Science and Technology, Jorhat, Assam, for analysis of Multiparametric Geophysical Observatory (MPGO) data to study the earthquake precursors. The study includes the analysis of Soil Radon (Rn-222) emanation, geomagnetic total field intensity (Btotal) and TEC in ionosphere prior to earthquakes in North East India. To start with the analysis, NESAC-NEIST has carried out case study of Mw 5.5, Kokrajhar earthquake that occurred on 12th September, 2018 using the Multiparametric Geophysical Observatory (MPGO) at Ouguri Hills, Tezpur, Assam. Prominent anomalies were observed in the soil Rn-222 emanation, B total and TEC time series prior to the event.

Groundwater quality mapping of Meghalaya under National Rural Drinking Water Programme

Groundwater is a very important source of water supply. It is vital for existence of all forms of life, for human consumption, industrialization, and agricultural activities. Over exploitation of groundwater to meet the demands of overgrowing population, increase in modern industrial and agricultural activities is becoming a global phenomenon. At the same time, the quality is also deteriorating tremendously due to anthropogenic activities that leads to serious concern for conservation of good, clean water, fit for wild life, human, as well as aquatic life.

To understand the quality status of groundwater in national scale, the project was formulated under National Rural Drinking Water Programme sponsored by Ministry of Drinking Water and Sanitation, Govt. of India and it was implemented by National Remote Sensing Centre (NRSC), Hyderabad. The aim of the project is to prepare Groundwater Quality Map corresponding to Survey of India Topographical Map (1:50,000 scale) using the available legacy data with various line departments of Central and State Governments. NESAC carried out the preparation of Groundwater Quality Map for the state of Meghalaya.

The Ground Water Quality map provides information on quality of Ground Water with respect to different



Groundwater quality map

constituents, i.e. pH, F, Fe, Cl, TDS, etc, in terms of desirable, permissible and non-potable classes as per BIS Standards. Blue, yellow and red colours indicate pre monsoon quality and +, ., - symbols indicate post monsoon quality for desirable, permissible and non-potable classes.

Active fault mapping using high-resolution data and geophysical survey in few selected segments of NER

NESAC with Department of Applied Geology, Dibrugarh University is carrying out collaborative work on Active fault mapping using high-resolution data and geophysical survey with an objective of Morphotectonic analysis for understanding the relationship between tectonics and geomorphology and dating of paleo earthquake events using C14 and optically stimulated luminescence (OSL) techniques.

Various geomorphic indices have been calculated for Kopili and Diyung River basin and studied in detail, which reveal active tectonics in this area. Bank stratigraphy was studied in detail in thirteen locations. The geological and geomorphological maps have also been updated for the study area. The sand samples collected in the field have been sent for OSL purpose. This will eventually help us to constrain the age of the events occurring in this area.

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

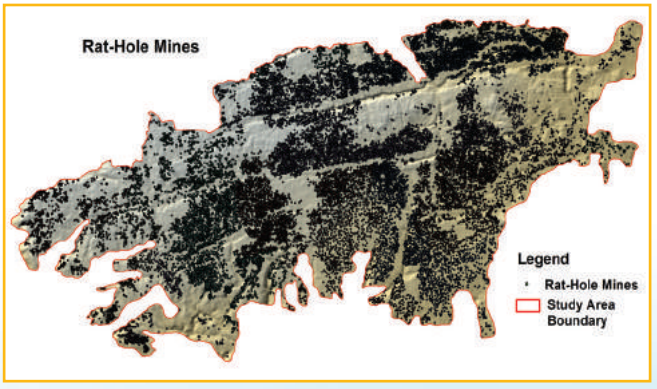
The project was initiated at the request of Meghalaya State Pollution Control Board (MSPCB), Govt. of Meghalaya under the direction of Independent Committee constituted by Hon'ble National Green Tribunal (NGT). The aim of the project is to provide inputs for planning and restoration of selected areas affected by coal mining in the state of Meghalaya using very high resolution TripleSat and GF 2 satellite data having 0.8 m panchromatic and 3.2 m multispectral resolution as well as other collateral data with the following main objectives

- Preparation/interpretation of one season land use and land cover map
- Preparation/interpretation of drainage, watersheds/catchments, rat-holes mines
- Preparation/interpretation of base map (roads & settlements), location of coal depots and water sample locations (entire state - user input, springs), etc.

The study area covers 823 sq.km (approx.) covering parts of East and West Jaintia Hills, West and South West Khasi Hills.

Some of the completed inputs for planning and restoration of coal mines affected areas of Jaintia Hills are Road & Settlement, Drainage and Spring, etc.

The project is expected to be completed by September 2019. The total number of rat role mines identified using high resolution satellite data, which will be one of the important inputs for assessment of coal mines affected areas.

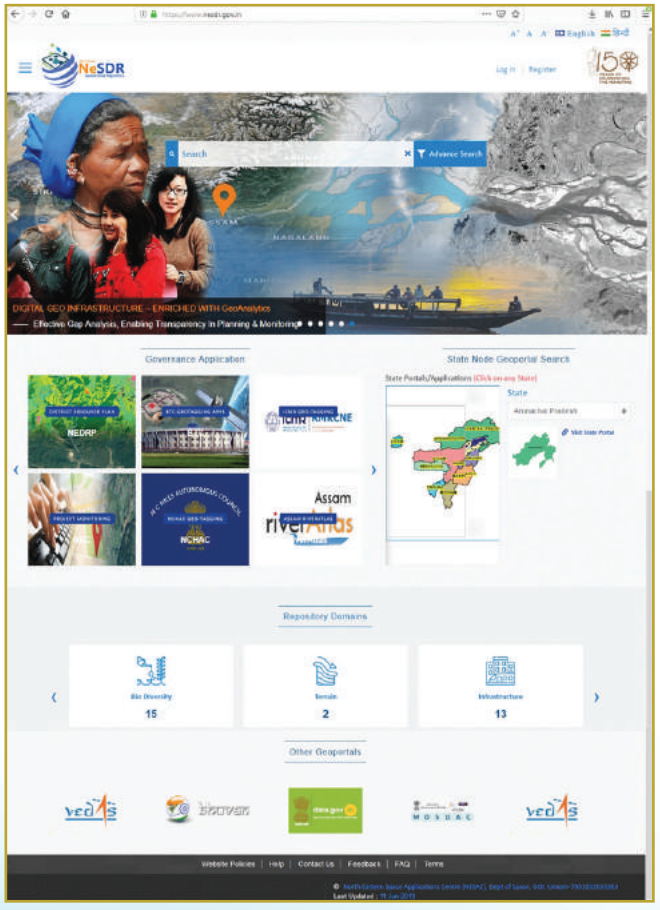


Rat-hole mines superimposed on SRTM DEM

IT & GEOINFORMATICS

North Eastern Spatial Data Repository (NeSDR)

The NeSDR is one of the major programme of NESAC taken up as per the directive of North Eastern Council (NEC), Ministry of DoNER with the objective to establish 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 Node will be responsible for State data generated by SRSACs or other Line Departments. The NeSDR is populated with 290 State level data pertaining to Natural resources, Infrastructures, Disaster management support, action plan, etc. generated under different projects of ISRO/ DOS/SRSACs and other Central/State Government agencies for the states of NE region. NeSDR facilitates users to visualize, retrieve, Geo-process and publish geospatial layers of interest through online registration via secure authentication gateway. Beta version of the NeSDR portal is under final stage of completion.



Home page of NeSDR (https://www.nesdr.gov.in/)

Under this programme, IT infrastructure of SRSACs have been strengthen in order to provide State specific GeoWeb services to the user Departments. Each of the SRSACs have been provided 4 high-end workstations, 2 servers with 10TB SAN storage, 10mbps dedicated internet bandwidth. The communication link between Central Node and respective State Node is through Virtual Private Network (VPN) to enable data cataloguing, sharing, retrieving etc. in a decentralized mode from respective State Nodes. A number of GeoWeb application services are being hosted via NeSDR platform towards empowering Governance activities of the user Departments.

NEC, Ministry of DoNER, Meghalaya Basin Development Authority (MBDA), Bodoland Territorial Council (BTC), Assam, Dima Hasao Autonomous District Council, Assam, ICMR-RMRC, NE, Dibrugarh, Assam, Central Silk Board (CSB), Bangalore, Offices of Chief Electoral Officers Election Department of NE States are the major users of NeSDR Governance Web applications.

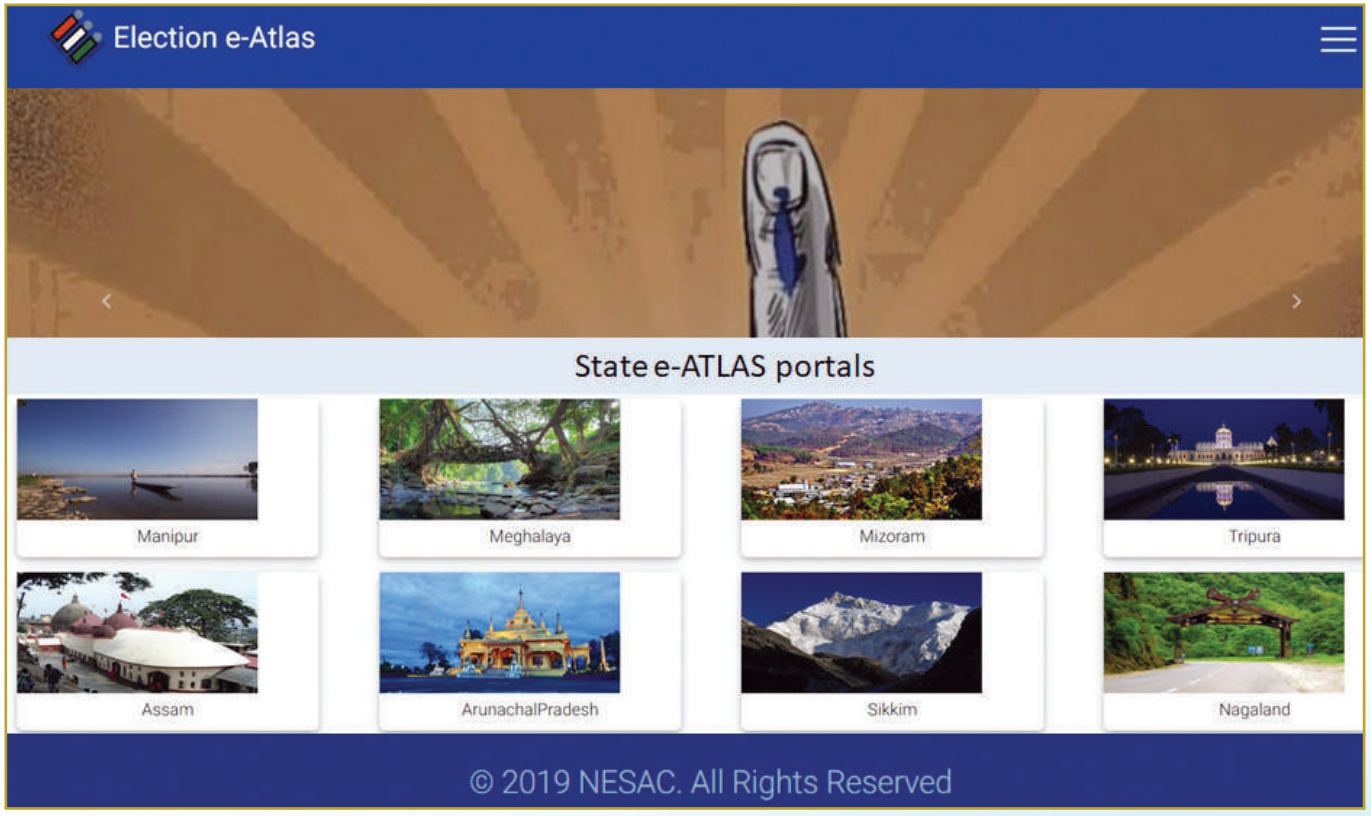
Development of PAN NE Election e-ATLAS for NE States

The Election e-ATLAS is one of the unique initiatives of NESAC in collaboration with SRSACs of NE region to empower the electoral process in the States of NE region. The e-ATLAS was conceptualized based on the requirements and guidelines defined by respective Chief Electoral Officers of states and the application has been developed using open source software and standards for wider and free accessibility. Live visualization of polling updates and turnout spatially from the control room on the day of election is the vital component of system. It also generates the live heat map polls based on the live feed of polling updates from the various polling stations. Further, the e-ATLAS application allows for real time positional tracking of important election officials during the election as

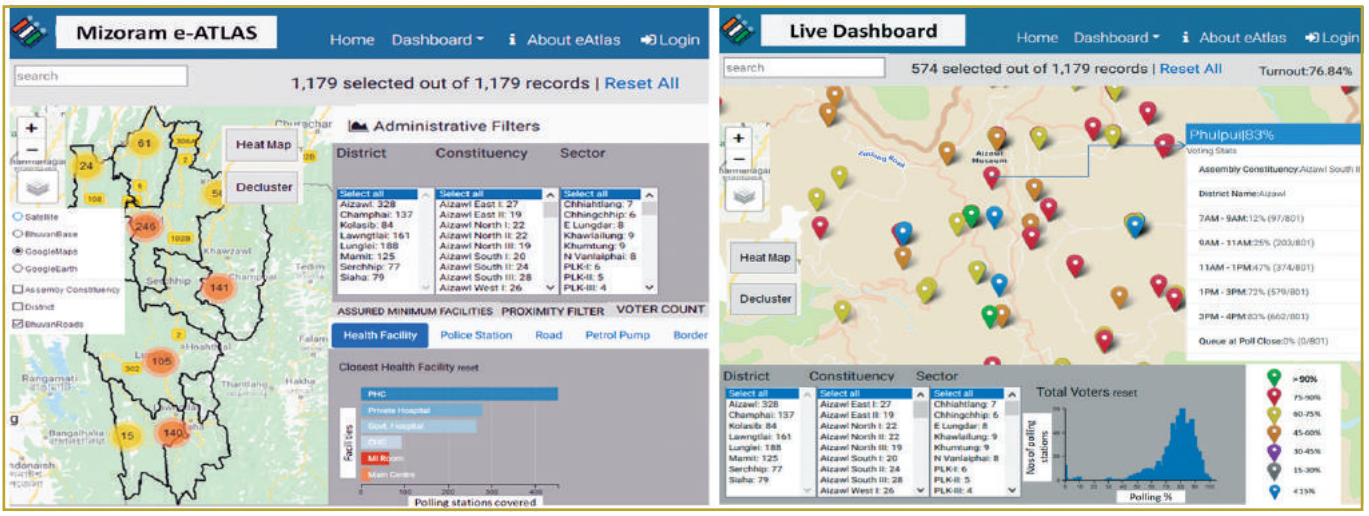
required by the CEO. The e-ATLAS therefore, ensures the increased accountability, transparency and efficiency of the electoral system towards strengthening the democratic process. On pilot basis, the Election e-ATLAS was successfully utilized for the first time in the country during the Meghalaya Legislative Assembly Election held on February 27, 2018 for the district of Ribhoi, Meghalaya and during by-election of 43-Williamnagar (ST) assembly constituency of Meghalaya held on April 27, 2018. With the successful utilization of e-ATLAS, it was then officially launched on 27th September, 2018 by Shri Frederick K Kharkongor, IAS, CEO, Meghalaya during their State Level Function in Shillong. The application was extended to Mizoram and it was used effectively for the entire state during Mizoram Legislative Assembly Election held on 28 November, 2018. This success further led to series of live demonstrations on e-ATLAS given respective Chief Electoral Officers of other states in the region. Based on their feedbacks, these applications were customized. The Election e-ATLAS was successfully utilized for the first time in the country during recent General Lok Sabha Election for 2019 in the States of Manipur, Tripura, Sikkim, Nagaland, Meghalaya and Mizoram. The e-ATLAS is also being developed for the States of Arunachal Pradesh and Assam.

GeoTagging and Monitoring of NEC funded Projects/schemes in NE region

NESAC has been developing a number of Dashboard cum mobile applications at the request of Goverrtment Departments of NE region. 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. Progress of the project status are monitored via in three modes - Mobile Apps, satellite imagery and drone images. Satellite and drone images are being used where the project site is relatively large and leading to the construction of roads, stadium etc. Till now, total 95 projects of NEC running in 165 locations of NE region are integrated. Those projects are falling into 10 major development sectors of NEC. Bhuvan satellite imagery along with other base maps have been effectively integrated in the Dashboard for better visualization of project status. The current status of the total 17 projects sites have been monitored and analysed using UAV as well as mobile application and integrated into the monitoring dashboard.



Homepage of e-ATLAS developed for NE region



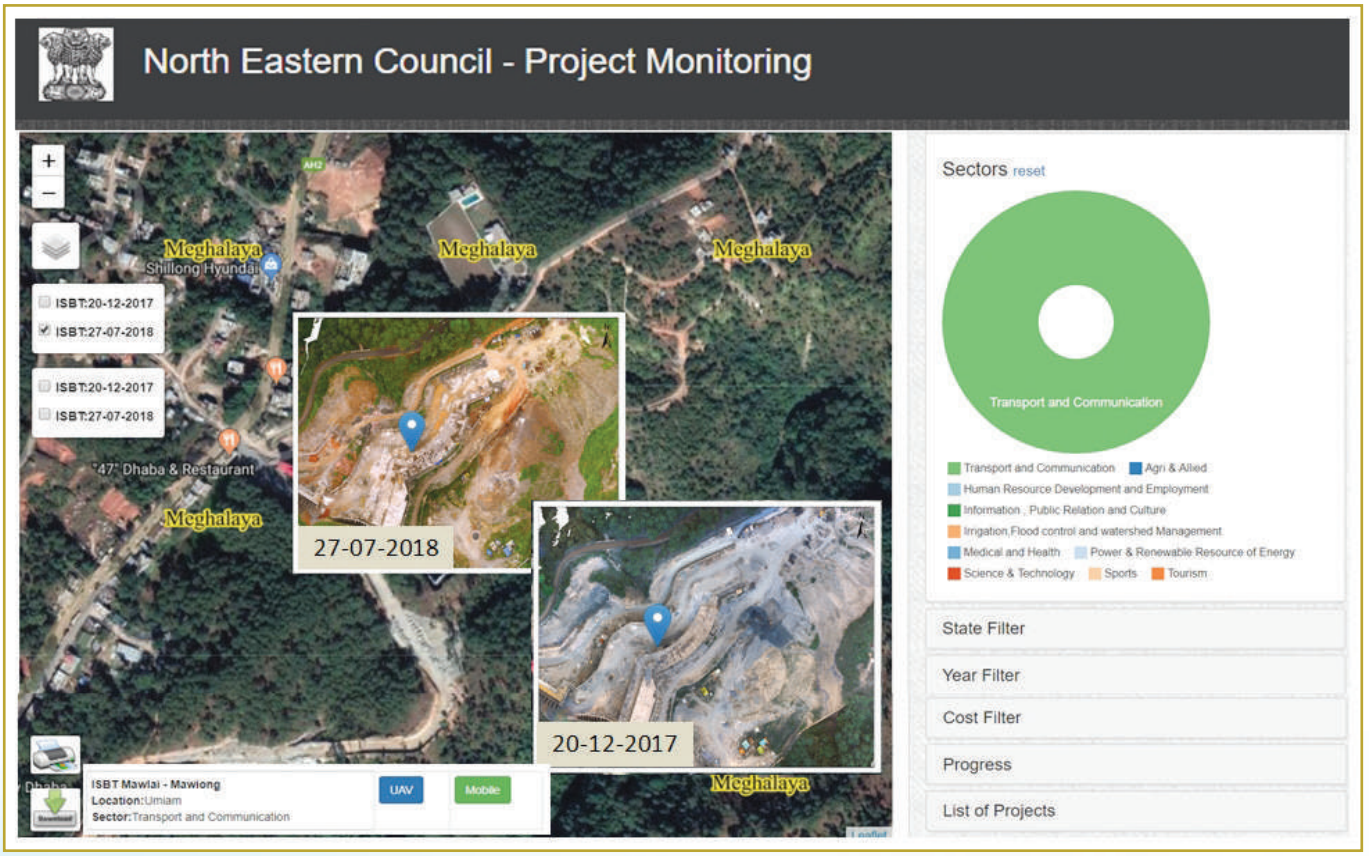
Live Dashboard application developed for the States of Mizoram

Incident reporting Apps

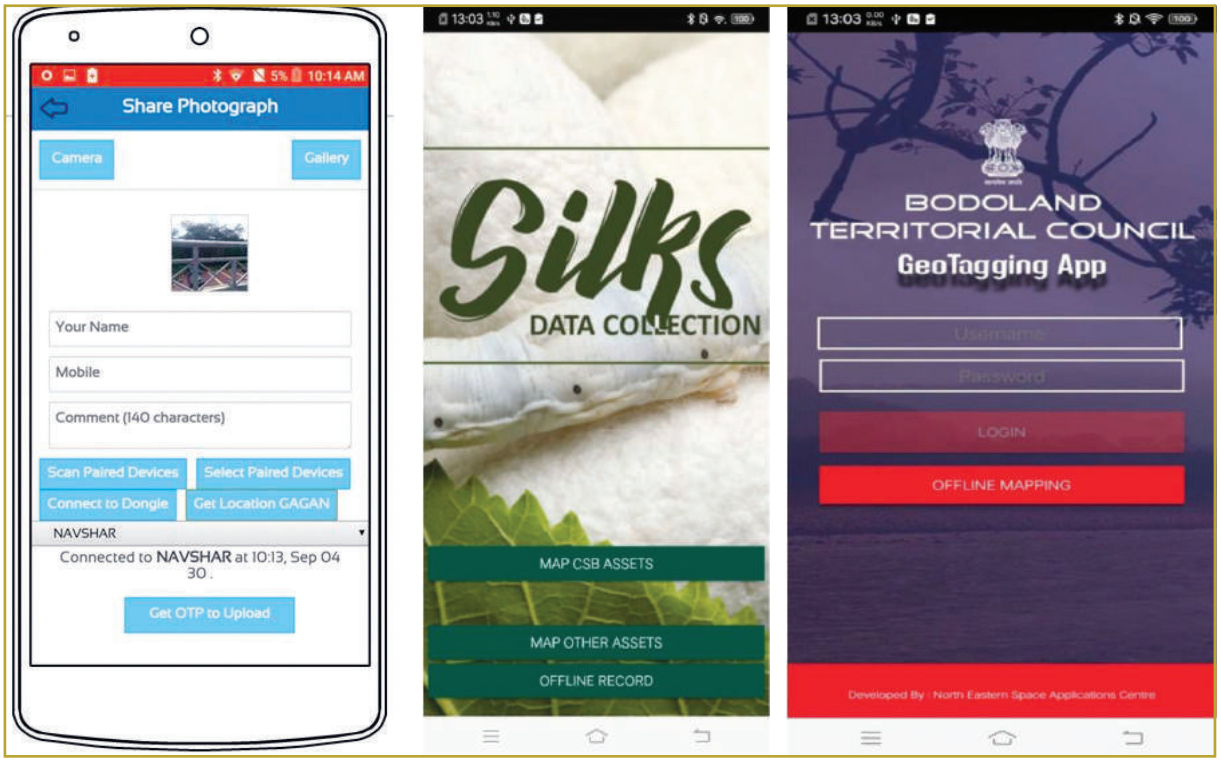
Control room setup at O/o CEO, Manipur during Poll day

Other GeoTagging applications developed for the Government Departments of NE region

A number of Government Departments approached NESAC for development of dashboard cum mobile application for geotagging and monitoring of the developmental schemes. Currently, Bodoland Territorial Council (BTC) of Assam is using the geotagging application developed by NESAC. Total 2198



NEC project monitoring Dashboard application depicting the progress of the construction of Inter-State Bus Terminus (ISBT) of Meghalaya located at Mawiong (Mawlai), Shillong, Meghalaya.



Mobile Apps developed for CSB for asset mapping

BTC mobile for geotagging schemes

projects of BTC need to be geotagged. NESAC has provided necessary training cum hands-on to the officials of BTC for geotagging of their schemes. NESAC has developed mobile application for field data survey under the project "Operational feasibility of additional intervention package for accelerated malaria control in areas with jhum cultivators" of RMRC/ICMR. The GAGAN location based feature is integrated in order to receive higher positional accuracy. Similar mobile application was also developed for CSB for mapping of various assets of CSB, Ministry of Textile. On the request of Ministry of DoNER, NESAC has integrated the GAGAN interface into the MyDONER application of MDoNER developed jointly in collaboration with NEC. Recently, NESAC has initiated the development of application for geotagging of more than 700 schemes of Dima Hasao Autonomous District Council, Assam.

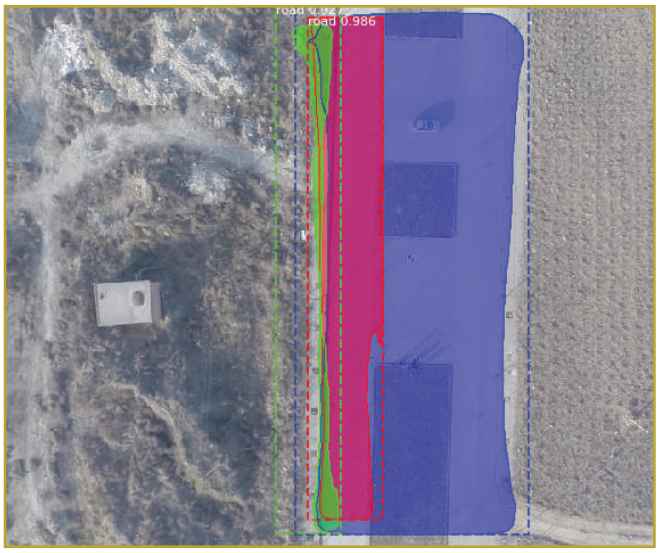
Utilization of Machine Learning/Deep Learning Techniques

NESAC is utilizing a number of statistical models, machine learning (ML) as well as deep learning (DL) and other GeoData Analytical tools for near real-time predictive analysis, feature extraction and pattern recognition under various operational services including R & D activities. NESAC is also actively participating as core member of the Inter Centre Task Team on AI and Big Data analytics of ISRO towards implementation of pilot application oriented projects and effective use of ML/DL techniques. Some of the techniques developed by NESAC are illustrated below:

a) **Object Detection and Image analysis in UAV using DL:** Convolution neural network (CNN) was trained with 100 scenes of UAV to detect an object of interest more accurately. The same (CNN) was trained with 1000 UAV images for object detection of agriculture fields automatically. Tense or flow object detection API was for implementation of CNN.

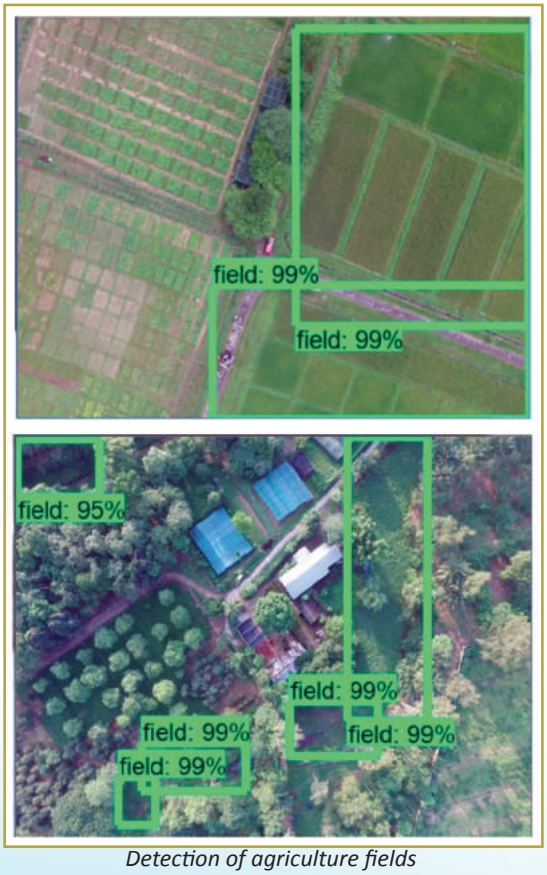
NESAC has developed and trained Deep Learning model to extract road features from UAV images. This road extraction model has been integrated in ISRO ML/DL platform which is result of very high level inter center task committee to study and adopt AI/ML/DL/Big Data. With this model 400x400 mts mosaic area road network has been generated automatically in case studies.

b) **Mapping of mining areas using Google Earth Engine:** With the increase in spatial and temporal resolution of satellite imagery, the quantity of openly available geospatial data is tremendous. Optimal utilization can change the face of



Road detection using CNN

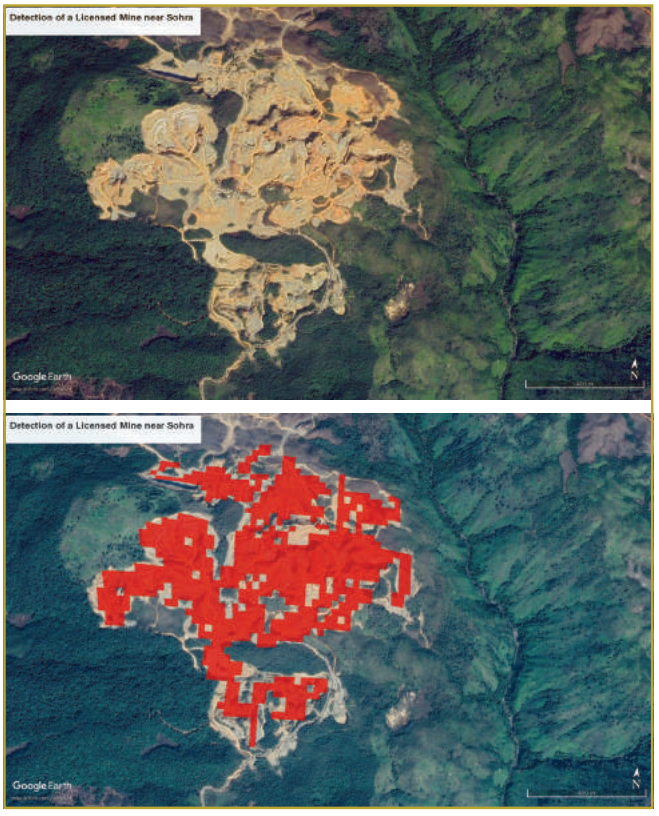
socio-economic inputs presently available. For undertaking this large scale analysis on a temporal or spatial scale, high end systems have been the traditional requirement. However, with the onset of cloud based systems, this large scale spatio-temporal analysis has been made feasible even with a relatively low-end PC with a good internet connection. Google Earth Engine is one such platform which permits large scale remote sensing analysis with the freely available datasets.



Detection of agriculture fields

Extraction of roads using UNet from drone images

We have undertaken one potential governance application to identify mined lands on a test case for this purpose. Clearly, identification of the number and extent of mining operations in the state is a crucial governance requirement. Recent advancements in remote sensing and GIS technologies can permit large scale identification and mapping of mined lands. Analysis was carried out for the state of Meghalaya. In order to aid the administrative departments in the monitoring of these operations, a web portal was developed that



Identification of open cast limestone mine in Sohra (Red colour indicates the open cast limestone mining)

permits querying various attributes. Vegetation loss in the East and West Jaintia hills districts of Meghalaya has been estimated using Earth engine and attributed it to coal mining, limestone mining or jhum cultivation.

PHOTOGRAMMETRY & UAV APPLICATIONS

UAV-Remote Sensing (UAV-RS) and Applications

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 the geospatial data on land resources and 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 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.

Embankment survey & monitoring using Unmanned Aerial Vehicle (UAV)

Floods are among the most destructive acts of nature. Flood damages to agriculture, houses and public utilities world-wide amounts to billions of dollars each year in addition to the loss of precious human and cattle lives. In majority of cases, 'flooding' is caused by a river over-spilling or breaching its banks. River morphology is concerned with the structure and form of rivers including channel configuration, channel geometry, bed form and profile characteristics. Various flood control structural measures such as construction of embankments, channel improvements, raising of villages, selective dredging, etc. have been implemented in past to reduce the impact of the flood disaster on human life and property. It is essential to monitor the embankments regularly to identify the vulnerable reaches. Conventional methods of river surveys are time consuming and expensive. Satellite remote sensing based morphological studies were found to be quite useful in following areas:

- To identify the changes in river course over a time period
- To identify the erosion prone areas along the river course
- To study the efficacy of flood management structures

Maps such as the river configuration and flood control works can be effectively used to identify the vulnerable river reaches and status of the flood control embankments so that necessary measures can be taken accordingly to avoid breaches. Accurate embankment-risk mapping is critical for supporting emergency-response planning, developing land use plans and regulations with regard to the monitoring and construction/ reconstruction of structures and infrastructures, and providing damage assessment in both spatial and temporal measurements. However, the reliability and accuracy of such embankment-risk maps are dependent on the quality of the digital elevation model (DEM) and the spatial & temporal resolution of the images.

Unmanned Aerial Vehicle (UAV) is proven to be highly useful for mapping applications and have a great potential for fast and accurate on-demand DEM production in flood-assessment applications. Moreover, use of UAV in airborne surveys has many advantages such as risk reduction, better overview, survey of inaccessible locations, improved data density, faster data acquisition, higher data resolution and lower costs. There is increasing interest in the use of very-large-scale aerial imagery for flood-assessment applications and monitoring and UAVs are flexible image acquisition tools for such a purpose. It has been planned to use UAV, for embankment survey & monitoring along Ranganadi river in Lakhimpur and Puthimari river in Rangia of Assam state. This work has been carried out as pilot project for Assam State Disaster Management Authority, Government of Assam. The scope of work consists of the following tasks:

Task-1: Data acquisition using UAV

A multi-rotor UAV (M600) was used. This enables vertical takeoff and landing, which are often needed in mountain sites, where there are few open wide spaces without obstacles. It is also more reliable to perform an irregular, linear, and low flight with Zenmuse X3 RGB camera. The specification of Zenmuse X3 is given in table given below. The data acquisition has been done for two different study sites, namely, Lakhimpur and Rangia of Assam State. During the data acquisition process, about 7103 images and 3305 images were recorded for Lakhimpur and Rangia respectively which cover an approx. areas of 27 Sq.Km and 7.96 Sq.km. The average flying heights above the ground for both the study areas were maintained at 145m.

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

Point Cloud

Orthomosaic/ orthophoto

	Lakhimpur-Part1 (12.7 Sq.Km)	Lakhimpur-Part2 (14.5 Sq.Km)	Rangia (7.96 Sq.Km)
No. of Images	3389	3714	3305
No. of GCPs	18	13	19
RMSE	0.157307 (0.751 pix)	0.154118 (0.715 pix)	0.14974 (0.802 pix)
GSD	5.26 cm/pix	5.33 cm/pix	4.93 cm/pix
DSM	10.5 cm/pix	10.7 cm/pix	19.7 cm/pix
Point density	90.2 points/sq m	87.9 points/sq m	25.6673 points/sq m

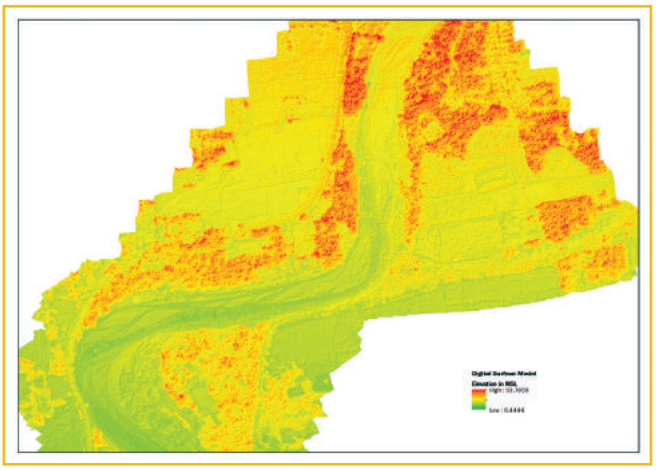
Task-2: Ground Control Points collection

Ground control points (GCPs) were collected using existing sources and DGPS survey method. The GCPs were collected in Geographic Coordinate System (GCS) and vertical reference with respect to ellipsoidal heights. A total of 29 GCPs were collected for Lakhimpur and 19 GCPs for Rangia. Since the area of Lakhimpur is large, the data has been processed into two parts with 12.7 Sq.Km and 14.5 Sq.Km respectively.

Task-3: Generation of Point Cloud, Digital Surface Model (DSM) and Ortho rectified image

The data is then transformed into any of the following types of products using UAV data processing software.

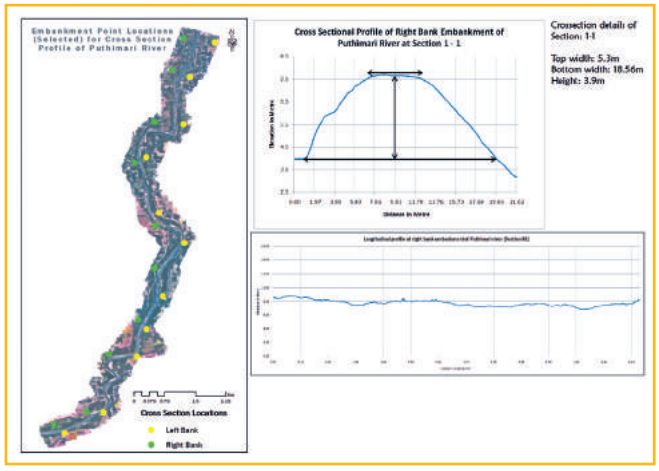
- ***Point clouds:*** sets of data points in a 3D coordinate system that represent the external surface of a terrain or object.
- ***Orthomosaics/ orthophotos/ images:*** files containing aerial photographs geometrically corrected so that the scale is uniform with ground sampling distance (GSD).
- ***Digital 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.



Digital Surface Model

Task-4: Plotting of River embankment Longitudinal/ Cross sectional profiles

Using the orthophotos and DSM, the longitudinal and the cross-sectional profiles are generated and plotted for the left bank embankments and the right bank embankments.

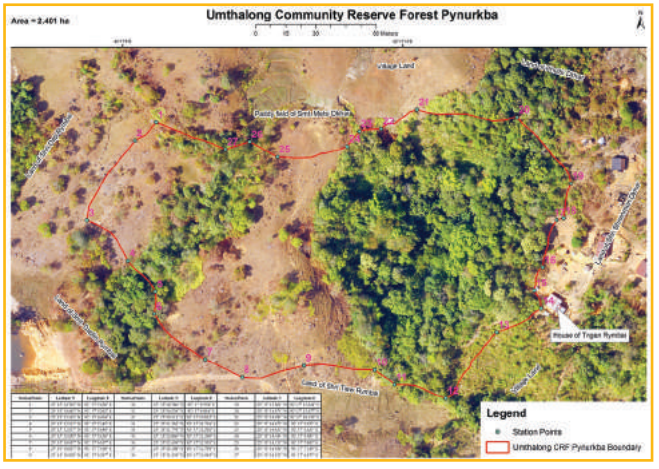


Embankment longitudinal and cross section profile

The profiles help to effectively identify the vulnerable river reaches and status of the flood control embankments so that necessary measures can be taken accordingly to avoid breaches.

Survey and mapping of community reserves and other protected areas and their eco sensitive zones in Meghalaya

Surveying technique like DGPS and total station have been widely used for mapping in the recent past. In addition, with the development of UAV based surveys, time and manpower requirement have reduced drastically for any kind of land survey. The objectives of this work is to surveys and map the community reserve forests as well as national parks in Meghalaya using multi geophysical approach (DGPS/ Total Station/UAV). DGPS survey is carried out to establish the base points and collect the GCPs. These points are used to establish the initial point/ location for total station survey to continue the data acquisition process of the study area. UAV is deployed to acquire the aerial photographs with predefined flight plans of the study areas. Using photogrammetric techniques, UAV data are processed to generate point clouds, digital surface model and orthophotos. The integration of GCPs improves the accuracy of the resultant outputs in centimeters. Using the field surveyed data (DGPS/ Total Station/UAV), boundary maps of each community reserves and its eco-sensitive zone are delineated in GIS platform. The deliverable of the project include



Ka Khloo Blai Mynso Community Reserve Forest

boundary of each reserve forests and the maps defining areas of Eco-sensitive zone in GIS platform. This work has been for conducted for Chief Wildlife Warden, Government of Meghalaya. It has been proposed by the User dept. to carry out the survey and mapping of 64 notified Community Reserves, 7 proposed Community Reserves, 4 proposed Eco-sensitive Zones of protected areas & 2 National Parks and Wildlife Sanctuaries for the State of Meghalaya. In the current year, survey have been completed for community reserve forests in East Jantia Hills Districts, 4 community reserve forests in West Jantia Hills Districts and 1 proposed eco sensitive zone of Baghmara Pitcher Plan Sanctuary, South Garo Hills District.

SATELLITE COMMUNICATION

NESAC is implementing ISRO's Satellite Communication (SATCOM) based societal development programs like Tele-Education, Tele-Medicine, Emergency Communication System etc. in the North Eastern States as one of its mandates. As part of it, NESAC has established extensive network for distance education and remote healthcare in the region. Facilities like SATCOM studio for content generation, transportable 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, etc are available at NESAC.

Tele-education project in north eastern states

All the 7 HUBs cum Teaching end and 316 Satellite Interactive Terminal (SIT) are operational in all the North Eastern States. For the state of Nagaland, the network will be managed by State Council of Educational Research and Training (SCERT). Re-commissioning of HUB and SIT is in progress in new location. The state wise break up of SITs is as follows: Arunachal Pradesh-50, Assam-32, Manipur-25, Meghalaya-47, Mizoram-50, Nagaland-45, Sikkim-50 and Tripura-50. 28 more SITs will be commissioned in Nagaland soon. The state wise utilization status of the Tele-Education project during 2018-19 is given in table below.

Inauguration of Tele-education network in Manipur

Partcipants interacts with Director, DECU

Name of State	No. of operational SITs	Total No. of Programs	Total participants
Assam	32	44	10450
Arunachal Pradesh	51	03	51
Meghalaya	45	More than 300	More than 5000
Manipur	25	Around 30	Around 1000
Mizoram	50	164	Around 2000
Nagaland	17	Nil	Nil
Sikkim	50	17	Around 1000
Tripura	50	Around 30	Around 1000

State-wise utilization under Tele-Education project

Telemedicine

NESAC conducted a two-day workshop on August 24-25, 2019 for creating awareness about Telemedicine in North East India at Guwahati, Assam in association with MoHFW, Govt. of India, North Eastern Council, Telemedicine Society of India, NEIGRIHMS, Shillong and GMC, Guwahati. A new proposal for expansion of the Telemedicine network is under consideration.

Telemedicine workshop at Guwahati

Communication support for disaster management

NESAC received five SMRs and five SatSleeve terminals from SAC, Ahmedabad and they are under testing. These terminals use GSAT-6 satellite for satellite telephony. NESAC has a transportable VSAT terminal for emergency communication. An ISRO VPN Node has been set up at NESAC to communicate with NDMA, New Delhi and SDMAs of all NER states at the time of emergency.

Location based services applications using GAGAN

NESAC supported Ministry of DoNER for monitoring of activities under NLCPR Scheme in NER through smartphones and Bluetooth enabled GAGAN Dongles to collect field data. NESAC procured 500 Smartphone and 500 GAGAN dongles and arranged a one-day workshop on 4th September 2018 at NESAC for demonstration, training, and distribution of the Dongles & Smartphones with mobile Apps for field data collection for officials of Planning Department of NER States for various projects under NLCPR Scheme Around 50 Officials from various departments of NER states attended the meeting. Participants took part in the hands-on demonstration. Later, 500 sets of GAGAN devices and smartphones were handed over to the Planning Department officials of each state. Later on in a separate meeting in Guwahati, Assam, NESAC also provided technical support in the distribution of 130 GAGAN Dongles and Smartphones to identified officials in the state of Assam.

Workshop for official of planning dept. of NER for NLCPR scheme

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 propagation of Ka-Band signal for use in Satellite to earth communication. This includes the equipments like, 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 set up, 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. has been deduced from the equipment.

Hands on training on GAGAN devices

SPACE AND ATMOSPHERIC SCIENCE AREA

The Space and Atmospheric Science group at NESAC is one major group working with focus on understanding and characterizing the major drivers of climate change like aerosols and greenhouse gases, through collection and analysis of in-situ data, satellite based data and products, and numerical modeling. Research on improving short and medium range weather forecast for NE region of India with 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 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.

Aerosol Radiative Forcing over India – Activities in NE region

Establishment of high altitude aerosol observatory at Lachung, Sikkim

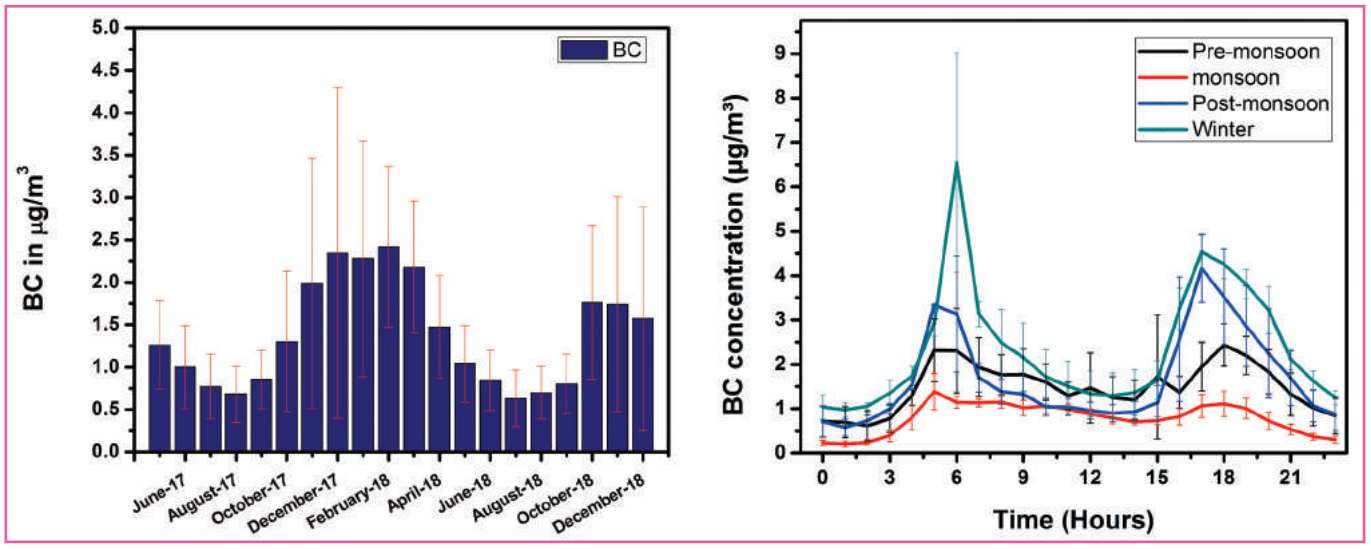
A new aerosol observatory has been established at Lachung (27.4°N, 88.4°E; 2650 m), located in northern Sikkim. The observatory has been established in collaboration with Space Physics Laboratory (SPL), Thiruvananthapuram to understand the heterogeneous properties of aerosol over the high altitude site. The proximity of several glaciers from the measurement site will provide unique opportunity to look into the aerosol-Cryosphere interaction. Several instruments are operated continuously to characterize the physical and optical properties of aerosol. Initial data analysis shows that Lachung is mostly dominated by carbonaceous aerosols, where mean black carbon mass concentration is found to be 1.67 μgm^{-3}. Analysis of carbonaceous aerosol components also showed relatively higher values of organic carbon (OC) to elemental carbon (EC) ratio (i.e., OC/EC of 15.0) indicating higher influence of biomass burning aerosols in the eastern Himalayan region. The BC concentration over Lachung is however less than that over other hilly stations in NE region like, Shillong and Tawang.

Aerosol characterisation over high altitude station Tawang

The Tawang aerosol observatory set up in collaboration with SPL has completed two years of existence. One Microtops Sunphotometer was installed at Tawang observatory during the year and both the instrument were operated continuously. BC concentration was measured by using seven-wavelengths (370, 470, 520, 590, 660, 880, and 950 nm) Aethalometer while Sunphotomete provided aerosol optical depth (AOD) data at five wavelength.

Mass concentration of BC over Tawang exhibits a significant annual variation. The mean BC concentration over Tawang from June, 2017 to December, 2018 shows that the highest value of BC concentration is observed in February 2018 with an average of 2.42 ±0.95 $\mu g/m^3$ and in the month of July 2018 the value is minimum with an average of around 0.63 ±0.38 $\mu g/m^3$. Mean annual BC concentration over Tawang was found as 1.53 ± 0.83 $\mu g/m^3$ which is quite higher compared to the reported BC concentrations of high altitude remote places globally. The concentration shows strong seasonality with maximum average value of 2.15 ± 0.58

Lachung Observatory (left), instruments inside the observatory (centre) and diurnal profile of BC aerosol over Lachung, Shillong, and Tawang (right).

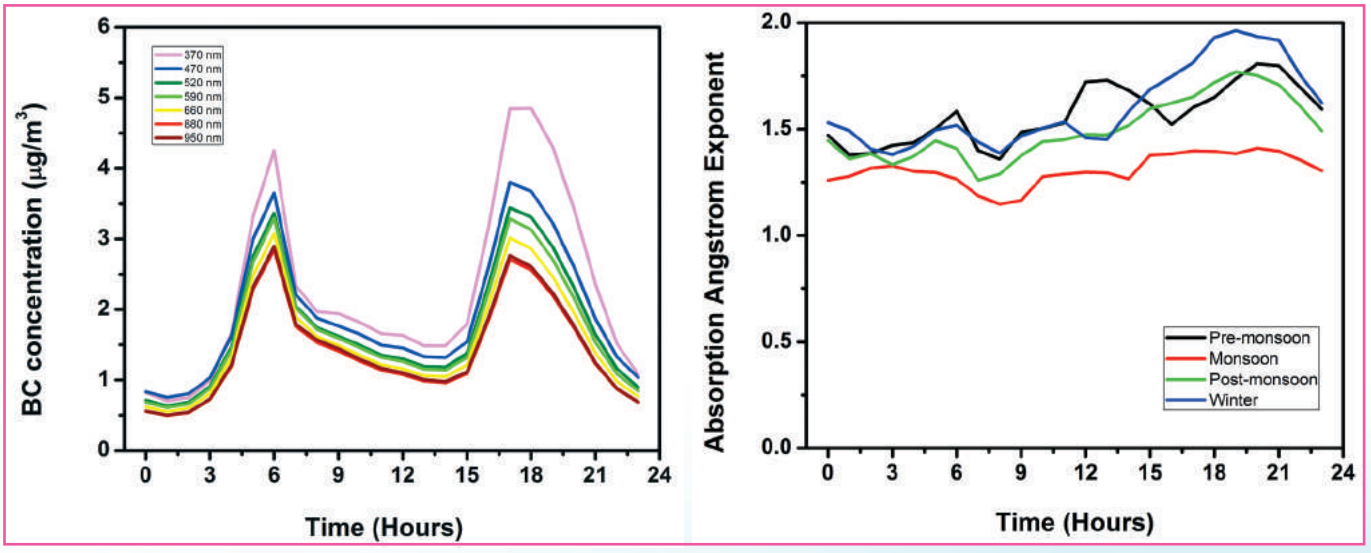


Monthly mean BC over Tawang (left) and mean diurnal variation of BC for different seasons.

µg/m^3 in winter. In pre-monsoon, monsoon and post-monsoon seasons, this value go to 1.49 ± 0.52 µg/m^3, 0.78 ± 0.15 µg/m^3, and 1.69 ± 0.41 µg/m^3 respectively. From the month of October, BC concentration increases gradually and reaches its maximum concentration in February. After that it starts to decrease and average BC concentration goes down in the monsoon because of 'wash out effect' by rainfall.

The mean diurnal variations of BC concentrations that occur during each day in different seasons, show prominent morning and evening peaks for every season though in monsoon, BC concentration does not vary considerably over a day. In post-monsoon, monsoon, and pre-monsoon seasons, morning peak occurs before than that in winter which might be related to the time of sunrise as it is delayed during winter season. The trend in diurnal variation indicates influence of local lifestyle, typical of a high altitude hilly station. On an average BC concentration increases more than 4 times during morning and evening peaks compared to mean value during night hours in all seasons.

Efforts have been made to provide insight into the sources and evolution of BC aerosol over the measurement site. Absorption Angström exponent (alpha) values for BC over Tawang are more than unity throughout the year which indicate probable sources are of fine mode origin. Over a day, this alpha value gets more strength during evening hours reaching as close to 2 especially in winter. Spectral optical analysis also supports the above mentioned fact that BC originated from biomass burning dominates in overall BC loading over Tawang.

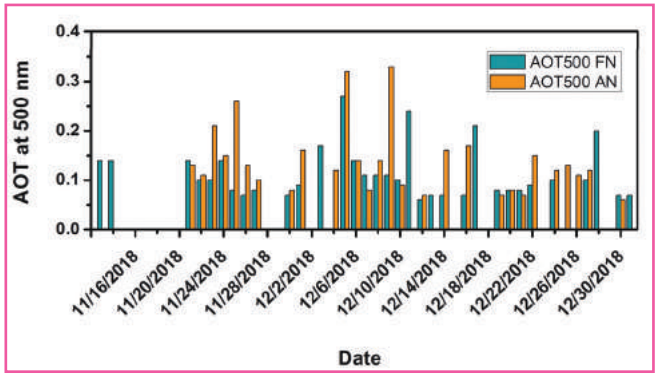


Spectral BC concentration over Tawang (left) and mean diurnal variation of Angström exponent for different seasons.

5 days' backward trajectories calculated for all the seasons using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model indicates significant contributions in total BC loading over Tawang from Brahmaputra river valley (BRV) throughout the year and from Indo Gangetic Plain (IGP) during winter season.

Aerosol charatcerisation over Tawang

The AOD obtained by MICROTOPS-II sunphotometer have been analyzed in the spectral range 0.34–0.87

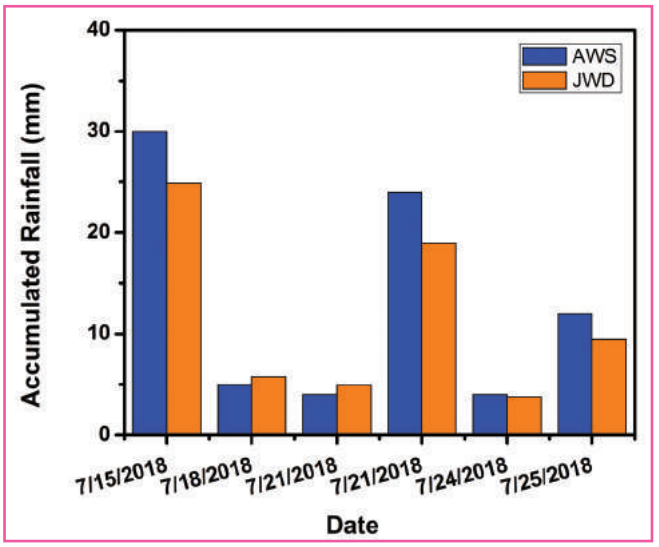


AOD (also known as AOT) over Tawang for forenoon and afternoon hours

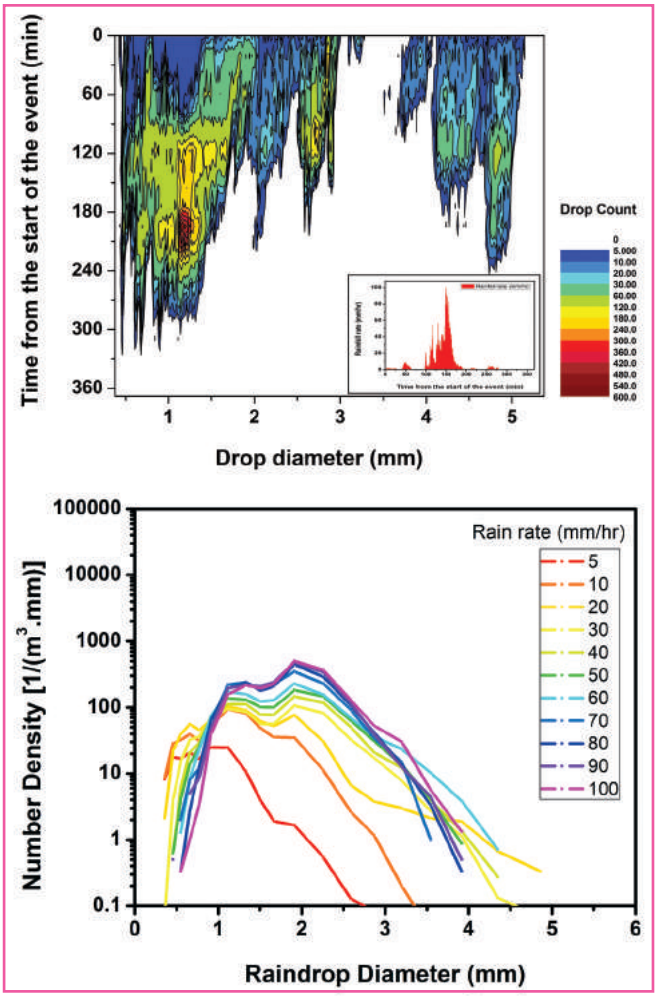
µm over Tawang from Nov 2018 to Dec 2018. Spectral AOD measurements show very little variation over a day. Wavelength dependence on shorter wavelengths is little more than that on longer wavelengths which indicates dominance of accumulation mode particles in the atmospheric column over Tawang. Strength of AOD values at 500 nm during afternoon and during forenoon is comparable in most cases.

Study on raindrop size distribution over a valley region

In situ measurements of precipitation and rain drop size distribution (DSD) have been done by a Joss–Waldvogel Disdrometer (JWD) from July 2018 to October 2018 over Umiam. Distinct rainfall events were selected and categorized for analysis. Accumulated rainfall obtained from JWD and collocated Automatic Weather Station (AWS) were intercompared for different rain events and correlation coefficient of 0.992 was found. However, it was found that for light rain cases rainfall is little overestimated by JWD whereas it is underestimated in moderate to heavy rainrate events. This small disagreement might be accountable to the errors arising from tipping bucket raingauge measurement principles used in the AWS.



Comparison of Accumulated Rainfall obtained from JWD and AWS



DSDs for every minute of spectra measurements during a rain event with instantaneous rain rate for the same event shown in inset (top) and Average drop size distribution with different rain rates

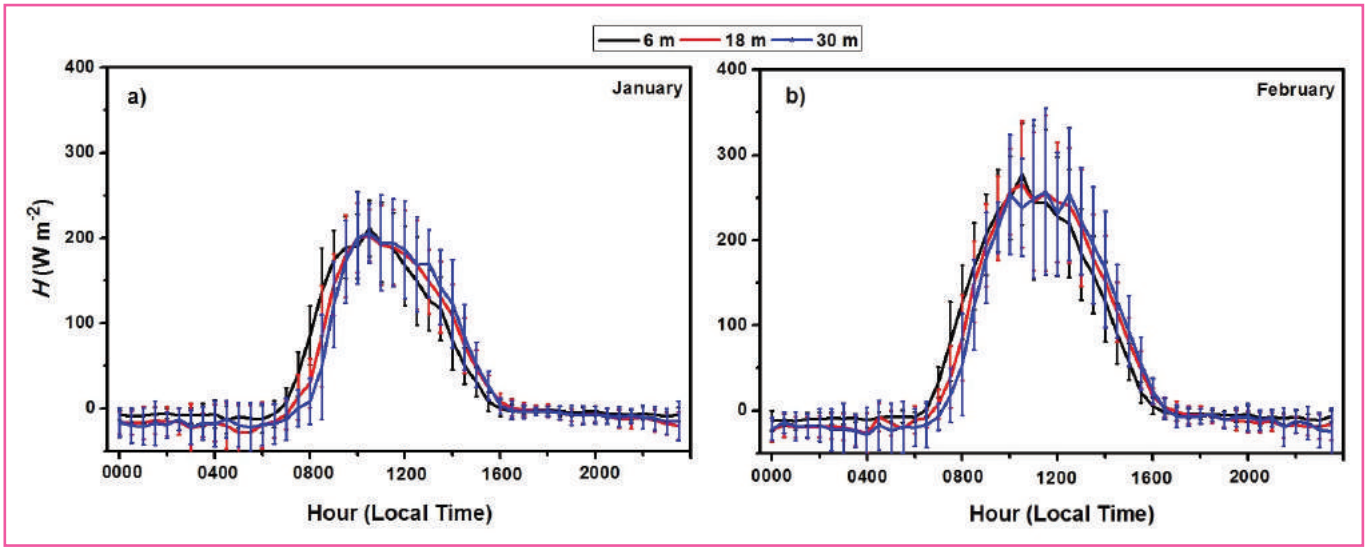
A rainfall event of five hours duration was analyzed to understand the DSD over the site. Temporal sequence of rain DSD with an event sampling time of 1 min

were collected and plotted. During initial phase of rain events, rain drops with higher diameter (more than 4 mm) are present simultaneously with drops of lower diameter. However, towards the later part the number concentration of bigger drops decreases while the smaller rain drops increases. DSDs obtained from different rain rates have been analyzed and the same is found to vary with rain rates. The minimum drop diameter in a DSD almost remain same for different rain rates while the maximum drop diameter and drop diameter with highest number concentration varies with rain rate.

Estimation of Surface layer flux over a mountaionus terrain

Micrometeorological studies are essential for an understanding of surface-air exchange of pollutants, trace gases, ecosystem processes, carbon dioxide uptake by Earth ecosystems, and in energy balance. In a spatial domain, the net surface flux consists of turbulent and mesoscale parts. The heterogeneity in the surface cover (e.g., irregular vegetation and artificial structures) and the topography account for the remarkable influence on the circulation of the wind and measurements of turbulent fluxes e.g., sensible heat flux (H, conductive heat flux from the earth's surface to the atmosphere), momentum flux (τ, rate of change of horizontal momentum which is moving across a unit area), etc. Surface turbulent fluxes can be directly measured using fast response sensors like sonic anemometers with the help of eddy-covariance (EC) method. Over the complex terrains, extreme care has to be taken when calculating the fluxes using the EC method.

The monthly mean diurnal H was estimated from the CSAT3 sonic anemometers installed at 6 m, 18 m, and 30 m. During the daytime, sensible heat flux increased by 36%, 37%, and 35% from January to February at the 6 m, 18 m, and 30 m levels, respectively. As upward heat transfer from the Earth's surface increases, this leds to increased convection reaching a maximum at 1000-1100 Hrs with flow from the south-west direction. The value of sensible heat flux decreased at 1130 Hrs when the wind direction shifted from south-west to south, followed by a slight increase in sensible heat flux before it decayed. The negative values of sensible heat flux (typically in the range of -2 to -25 Wm^{-2}) increased from January to February, which specifies a small heat transfer from the atmosphere to the surface at night. In winter season, the daily average of sensible heat flux at Umiam was approximately 50 Wm^{-2} for all levels.



Diurnal variation of H for January (left) and February (right) at the 6-m (in black), 18-m (in red), and the 30-m (in blue) levels.

The monthly mean diurnal variation of turbulent kinetic energy (TKE) during January and February was also computed. TKE is directly connected to the momentum, heat, and moisture transport through the atmospheric boundary layer. The peak value of TKE in February is 22%, 23%, and 21% higher than January at the 6 m, 18 m, and 30 m levels, respectively, with TKE reaching its peak at the same time as H also attained its maximum in January. During the late afternoon and evening hours, TKE reduced due to decreasing solar radiation.

The variation in TKE showed a continuous increase in turbulence production because of higher daytime surface heating and higher wind speeds. Interestingly, the night-time values also increased from January to February indicating higher turbulence intensity due to higher wind speeds. The transition of TKE on short time spans between 1200-1300 Hrs is associated with a rapid shift in ground-level wind gradients and fluxes.

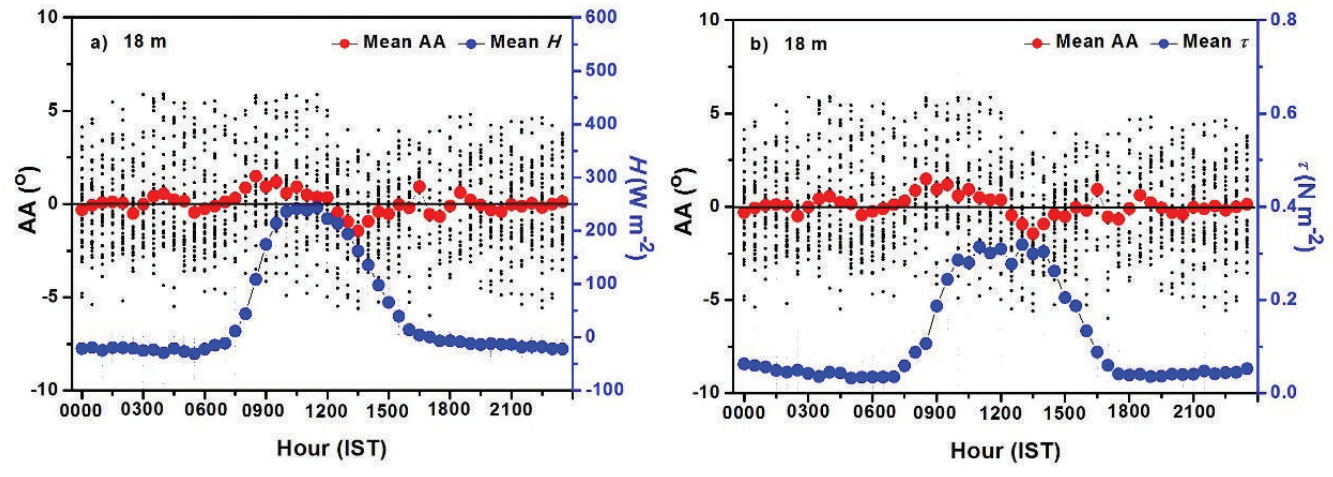
The momentum flux showed a distinct diurnal variation throughout January and February. The peak magnitude of τ has been observed during the daytime at 1300-1400 Hrs in January at all levels. The momentum flux has a peak value about 2 to 3 h after the peak value in sensible heat flux. Momentum flux is related to the covariance of fluctuations in velocity components; hence the higher wind speed in February contributed to higher momentum flux at all levels. Due to the change in wind direction from the south-west to the south-east during the daytime, the value of τ decreased at 1130-1230 Hrs. It was noted that during the daytime a local thermal circulation was dominant.

The flux-angle distribution is defined as the variation of flux with the angle of attacks (AA). Flux angle distribution can be used to infer the process of flux transport like an increase (decrease) in the scalar flux concentration or momentum by correlating with the upslope (downslope). The diurnal variation of mean AA to mean sensible heat flux (H) and τ for the observational period at 18 m level is shown in figure. Results show that the variations of mean AA are different under different stability conditions. During all atmospheric conditions (unstable, stable and neutral), AA varied between ±6°. It is found that during positive (negative) AA there was an increase (decrease) in both flux concentration and H. Present results highlights that positive (negative) AA were associated with the upslope (downslope) over the complex terrain and were in tune with observations from complex terrain.

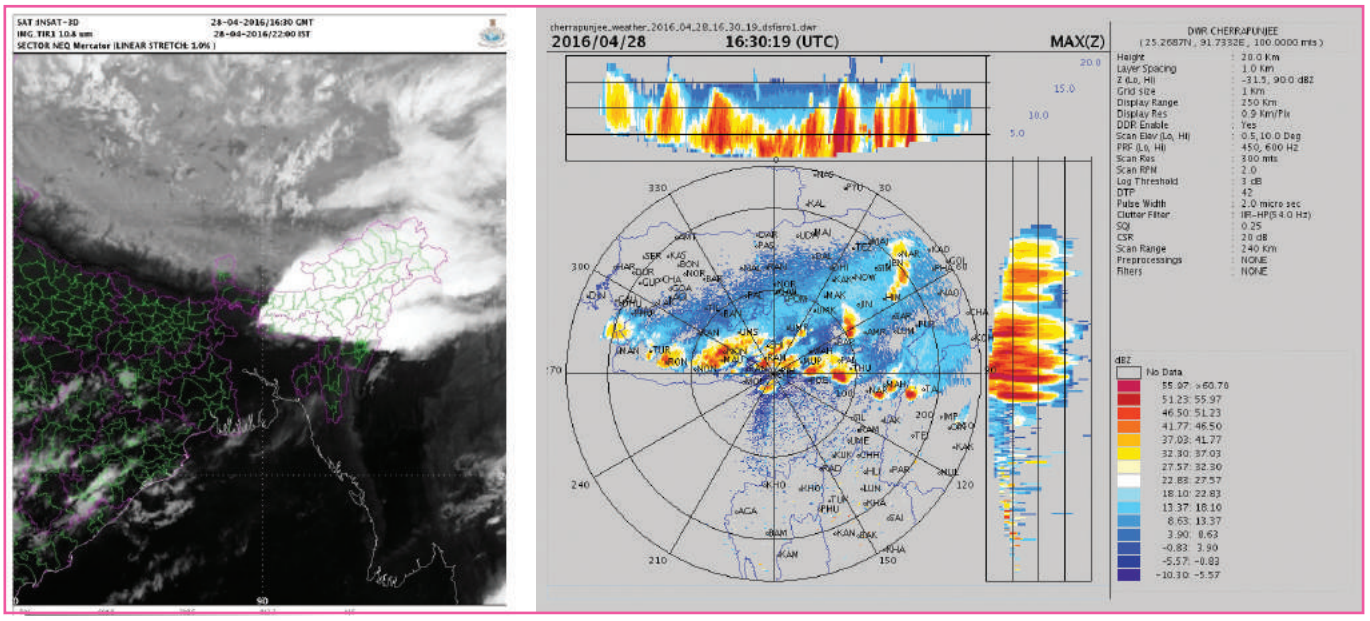
Simulation of thunderstorm over NER of India using WRF model with assimilation of DWR data

Numerical Weather Prediction (NWP) models are used globally for early warning of hazardous events such as Flood, Thunderstorm, Lightning, Cyclone, etc. Although the successful early warnings of cyclone, floods, etc. has resulted in reduced death toll in the recent times, the prediction of thunderstorms, extreme localized rainfall, etc has remained challenging. In the last decade, several studies indicated that assimilation of Doppler Weather Radar (DWR) data in NWP models could improve the forecasting ability of such extreme weather events. Reflectivity and radial velocity are two major parameters available from DWR data for assimilation. These parameters are very significant because, reflectivity gives information about amount of rainfall whereas radial velocity holds information on vertical atmospheric motions.

This work is the first attempt in utilizing Sohra (erstwhile Cherrapunjee) DWR data in Weather Research and Forecasting (WRF) model for the



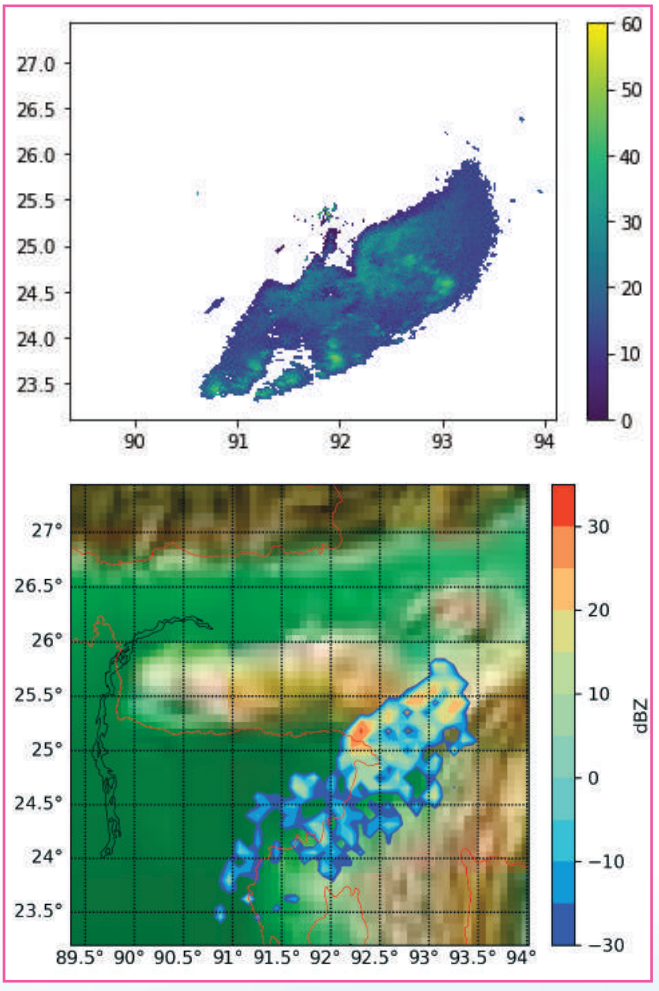
Dependency of H (left) and τ (right) concentration on mean AA (red circle) for the observational period at the 18 m heights



INSAT-3D Satellite image for 16:30 UTC on 26th April 2016 (left) and max reflectivity image from the Sohra DWR (right) for the same time depicting a thunderstorm.

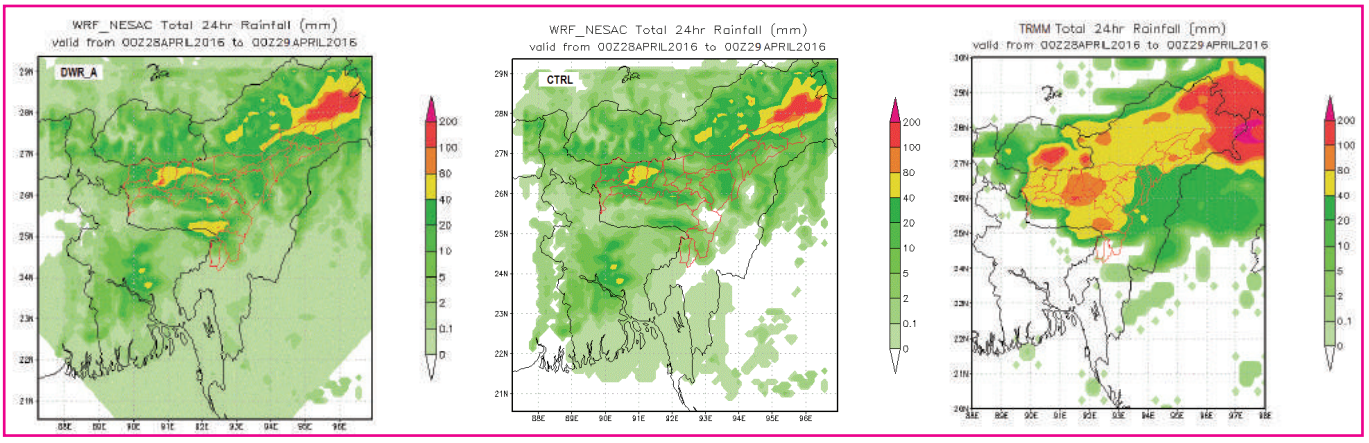
prediction of thunderstorm. In this study, impact of assimilation of reflectivity and radial velocity from DWR has been assessed using the WRF model at 9 km / 3 km spatial resolution. Region specific background error statistics were generated before these data could be assimilated. A python module has been developed to retrieve the DWR data and convert them into a WRF-3DVAR compatible format. The initial and boundary conditions are taken from NCEP GFS at half degree resolution. To study the impact of DWR data in thunderstorm simulation, some case studies have been carried out. One case study was on the thunderstorm that developed over Meghalaya, Southern Assam, and Manipur on 28th April 2016 as identified by both DWR and Satellite image.

The DWR completes one volume scan in 11 minutes, comprising of 360 degree azimuth scan for 10 elevation angles ranging from 0.5 to 21 degrees. The DWR covers a distance of 250 km (up to 500 km only for Z) with spatial resolution of 300 m. Since the resolution of the DWR data is very high as compared to the model domain (9-3km), therefore using a python module the data has been transformed to the Cartesian grid with the map projection same as the model. Using the same python module, data has been quality checked for clutter removal as well as to discard data beyond the limit of 2-30 m/s and reflectivity out of the range 10–60 dBz. The thunderstorm considered here initiated at 16:30 UTC of 28th April 2016, however the model is initialized at 00:00 UTC to spin up the convective process.



Sohra DWR data preprocessing using Python module with reflectivity in raster format (top) and radial velocity in tiff format (bottom).

Initially the experiments are carried out at 9 km resolution to study the impact of DWR data assimilation in rainfall prediction during the thunderstorm event. forecast of thunderstorm and rainfall. The experiments with DWR data assimilation detected the thunderstorm formation and rainfall intensity more realistically as

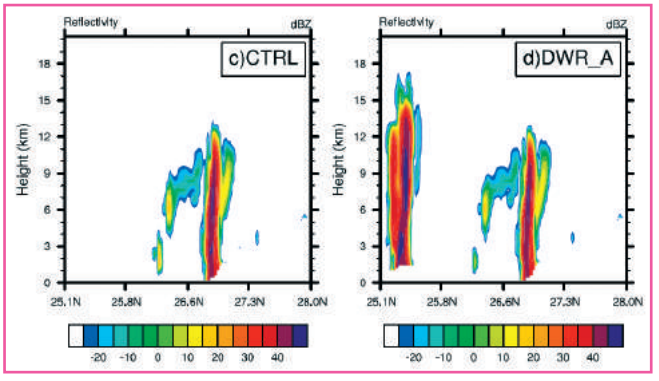


WRF 24 hr rainfall forecast valid from 20160428 00UTC to 20160429 00UTC in mm with DWR data assimilation (left), without data assimilation (centre), and actual rainfall as measured by TRMM.

However, it is observed that although DWR data assimilation improves the detection of rainfall core but overall it underestimates the rainfall amount. It may be due to the fact that, apart from DWR data no other data has been assimilated in the model. As a result, at 9 km resolution the convective as well as rainfall forcing processes may not be triggered by the parameterization schemes due to lack of information present in the first guess files. Reflectivity data from DWR gives information about the existence of precipitation only, but no information about water vapor, temperature and other fields. Therefore, convective processes cannot be activated by DWR data until and unless there exist information on prior instability required for convection.

For the next set of experiments, another domain at 3 km resolution was taken over a small area within the same thunderstorm event. To investigate the instability in the atmosphere, equivalent potential temperature, reflectivity and vertical velocity from both the experiments are compared and it is observed that assimilation of DWR data reveals the presence of moist warm core corresponding to strong updraft that further enhances the instability to build up the thunderstorm. Tall cloud growth up to 15 km favorable for severe thunderstorm was also seen in the simulated experiments with DWR data assimilation, which was completely missing when DWR data was not assimilated.

It has been observed that DWR has positive impact on compared to model run without DWR data assimilation. However, more rigorous work needs to be done in the future for appropriate utilization of the data.



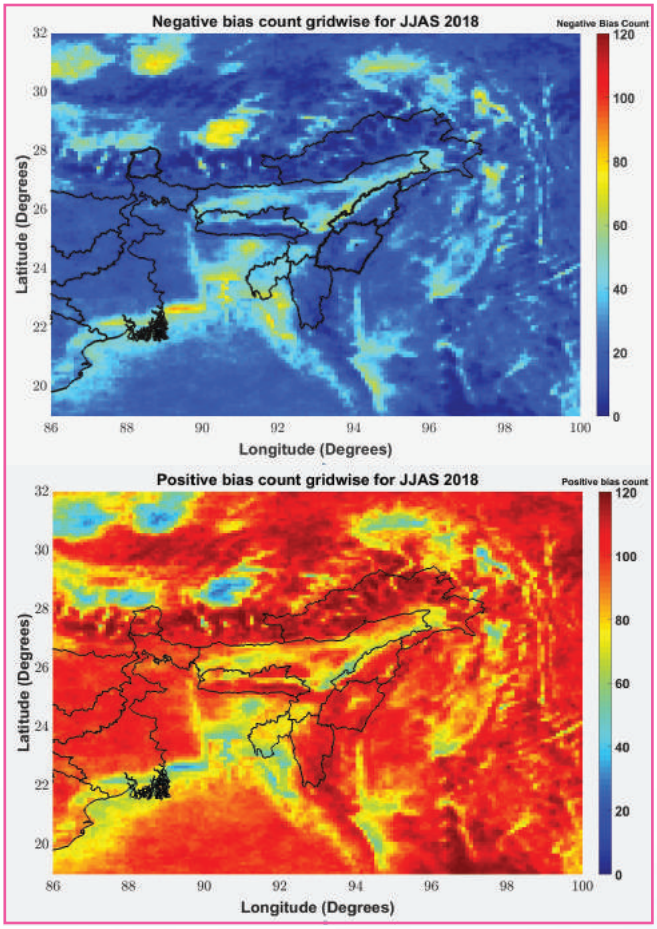
Presence of tall thunderstorm cloud was seen when DWR data is assimilated in WRF model (right) while the same is absent when no data is assimilated (left).

Validation of daily accumulated WRF rainfall for NER of India

NESAC provides daily weather forecast using the WRF model. The WRF rainfall forecast for the JJAS (June-July-August-September) months has been validated with respect to a satellite rainfall estimate over the NER of India. Further, a bias correction has been implemented in the model output to reduce the systematic bias present in the forecasted rainfall. The model was initialized daily using Global Forecast System (GFS) half degree data and a daily forecast of 2 days was generated. The investigation is done with respect to GPM IMERG (GPM-MS) rainfall product available at 0.1 X 0.1 degree spatial resolution and 30 minutes of

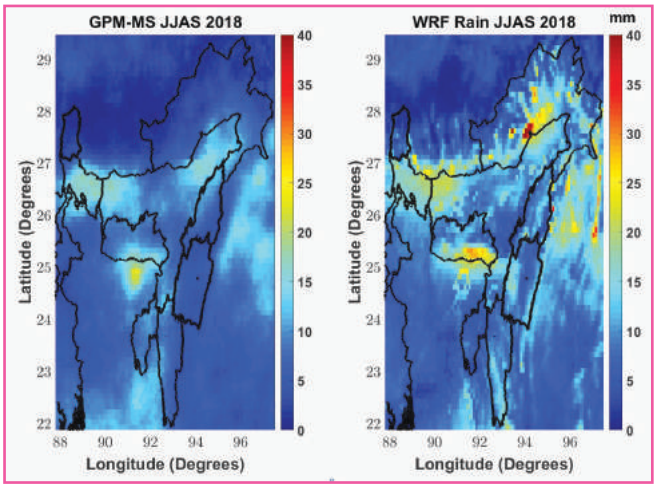
temporal resolution. The validation strategy used in this study entails the estimation of the performance metrics like, Bias (mean error), Root Mean Square Deviation (RMSD), Statistically significant ($p<0.05$) Pearson's correlation coefficient (CC), Accuracy estimate, and Comparison with respect to AWS rainfall and box Whiskers plot representation of station wise bias with GPM IMERG.

The comparison of mean of WRF and GPM daily accumulated rainfall indicates an overestimation of the WRF simulated rainfall over parts of Meghalaya, Western Assam, and Arunachal Pradesh. The valleys had a lower bias compared to mountainous regions of NE, like the foothills of Himalayas. Considering the GPM as a reference level we have estimated the systematic bias of WRF simulated rainfall and applied the same for the bias correction in WRF simulated rainfall. It may be noted that GPM based rainfall estimates has its own limitations particularly over the hilly regions. However, GPM estimates of rainfall are one of the best sources of spatial rainfall data at high resolution.



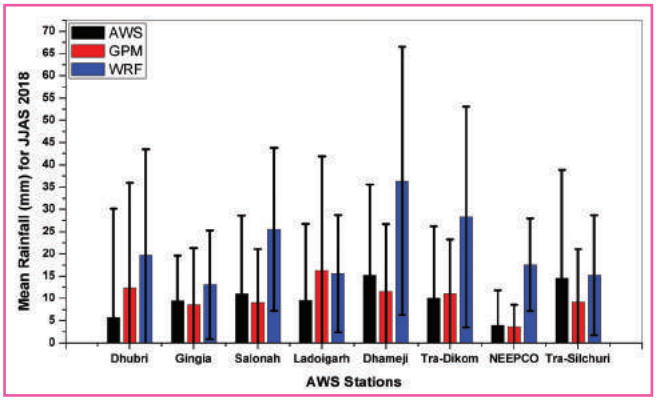
Grid wise positive and negative bias count days during the whole monsoon season.

To estimate the average bias, grid wise positive and negative bias count days were analyzed and based on the mean value and number of days positive or negative bias occurred over any grid point, a systematic bias correction was applied. The bias correction improves the mean WRF rainfall significantly and reduces the over estimation over above mentioned areas. To improve the bias correction method more effectively, grid wise mean bias standard deviation estimates are planned for inclusion in the bias correction methodology.



Seasonal mean of daily accumulated rainfall GPM-MS (left) and bias corrected WRF-rainfall (right).

To assess the model performance after bias correction, we have further analyzed the RMSE, accuracy, correlation coefficient, and box Whiskers plot. All the performance indicators improved significantly after the bias correction.



Comparison of mean rainfall from AWS, GPM-MS, and WRF-rain over various AWS locations during JJAS 2018.

It is observed that there is large deviation among AWS measured rainfall with WRF simulated rainfall estimation. The maximum over estimation along with higher standard deviation of WRF rainfall has been

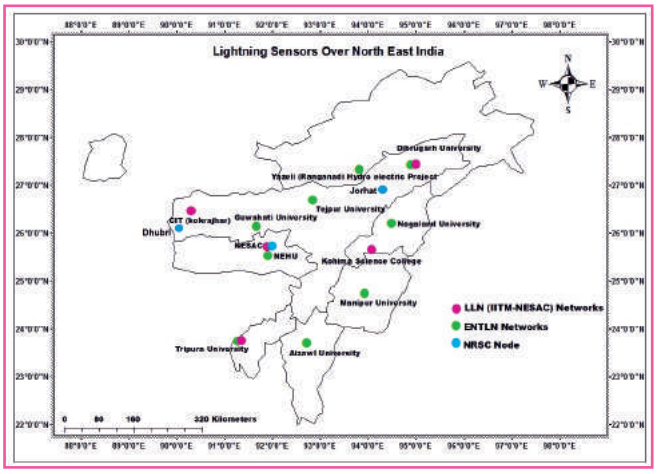
noticed over the Dhemeji region (in Assam but foothills of Arunachal Pradesh). This is also important to mention that the location is situated in the transition region of plain and mountainous region, where the model performance decreases due to plain and mountainous terrain anomaly. The station at Lahdoigarh (Jorhat), Assam shows well agreements between GPM estimated and WRF simulated rainfall.

This analysis suggests that the performance of bias corrected WRF rainfall over the NER is comparatively more reliable. Efforts are being made to use this bias correction method for operational forecast of rainfall, particularly for the flood forecasting activities. However, these results should be used in light of the fact that GPM itself has some inherent ambiguities when it comes to estimating surface rain over a complex terrain. Further research with respect to the evaluation of GPM in a complex terrain along with the optimized bias correction methodology must be done.

Developing a lightning early warning system over NER

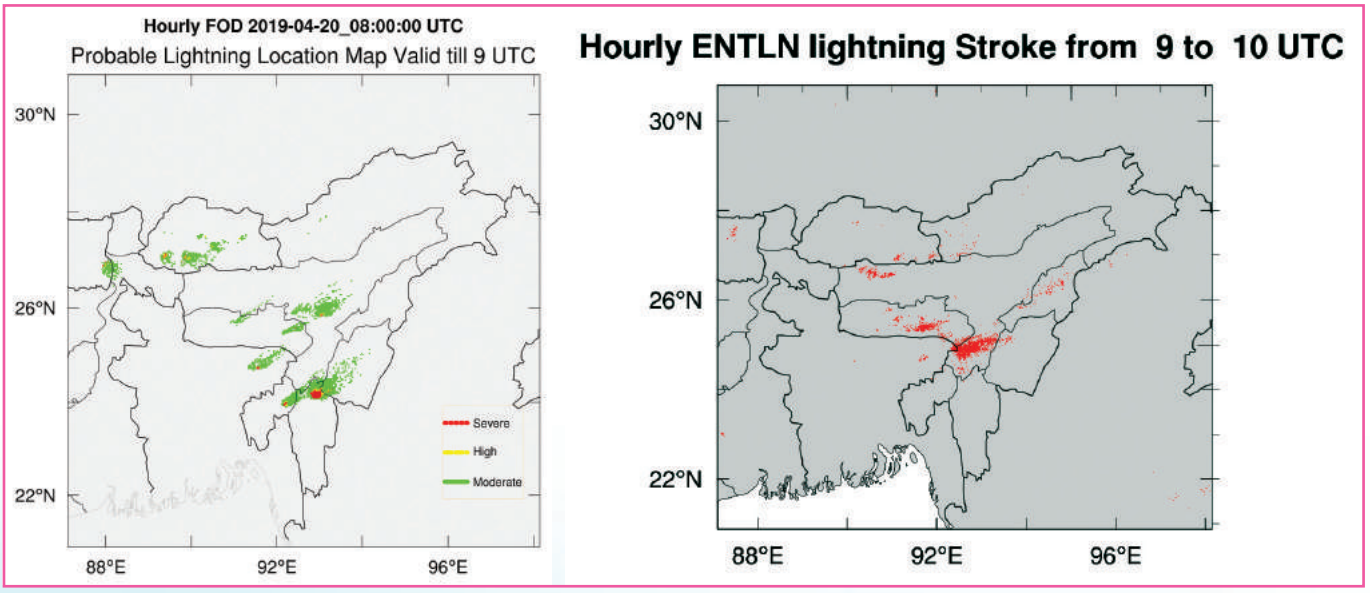
NER of India is highly vulnerable for lightning which takes more than 50 lives annually with highest casualty reported in Assam. An actionable lightning early warning system has the potential to reduce this death toll significantly. NESAC therefore initiated research to develop a lightning early warning system which can forecast probable lightning locations in NER with actionable lead time.

Ground based lightning detectors are one of the best sources of lightning data. During the year 2018-19, various new ground based lightning detection sensors has been installed over NER with the initiative of NESAC and in collaboration with Indian Institute of Tropical Meteorology (IITM), Pune and National Remote Sensing Centre (NRSC), Hyderabad. In addition, NESAC also procured the lightning data from ENTLN (Earth Network Total Lightning Network) for cross platform validation of lightning data.



Locations of lightning detectors over NER set up in collaboration with different agencies.

With lightning data from different devices, the lightning forecasting system was developed by implementing the assimilation of ground based lightning data in a numerical model. This is the fast ever successful effort in India to implement such ground based lightning data assimilation into the model. The model was run three times a day to provide forecast for next 3-4 hours from



Forecasted lightning flash origin density with 3 hours lead time (left) and observed lightning location detected by ENTLN data.

the time of issue of forecast. The forecast generated showed the probable lightning occurring zones. The lightning origin density count was classified into moderate, high, and severe represented with green, yellow, and red color respectively. All the forecast were uploaded to the NERDRR website and also sent to all the concerned state and district disaster management authorities. The forecast was validated using ENTLN lightning location data. A spatial shift between the simulated and observed lightning location was observed on many days. The possible reason could be the time interval for lightning data assimilation. Due to limitations in computation resources, the centre is unable to run the model at the time interval that best suits such dynamic weather system.

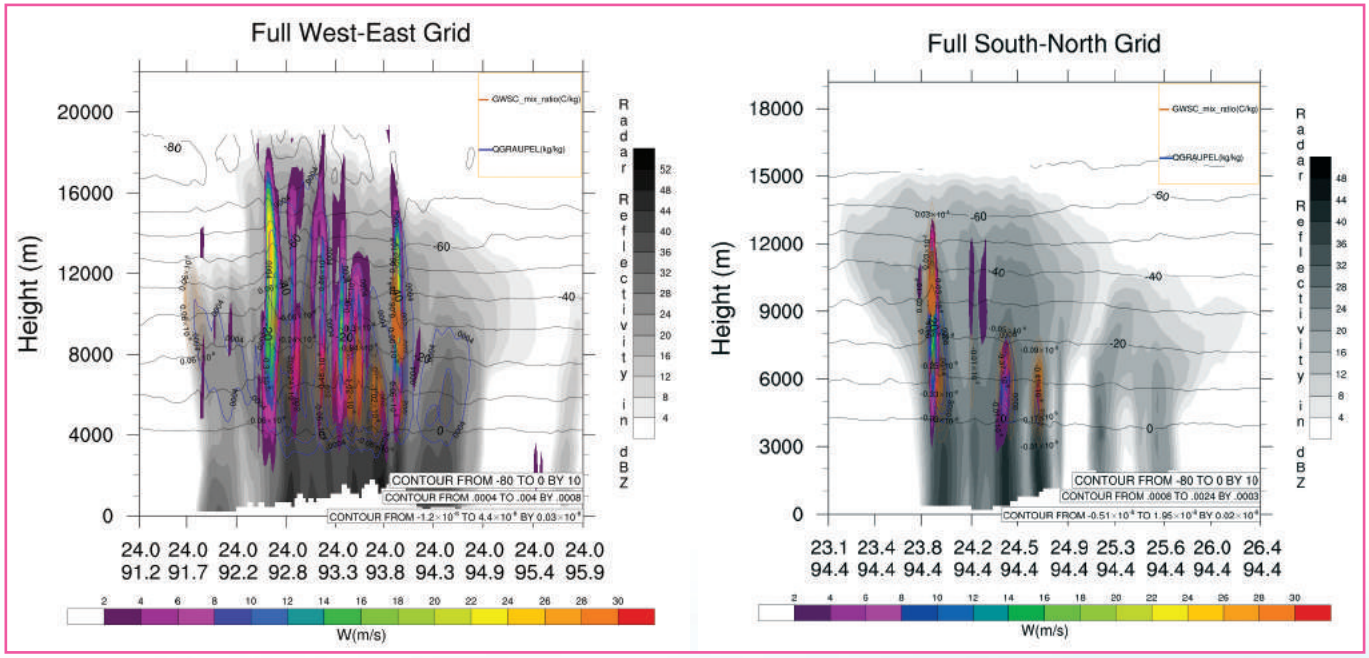
The model simulated cloud microphysical and intensity parameters are studied more precisely to understand the Physics of charging and discharging mechanism in a cloud. The vertical structure of a storm during 3rd April, 2017 has been simulated to study the microphysical characteristics of the vertically extended cloud. The north-south cross section of the storm and east-west cross section of the storm has been separately studied. Several parameters like vertical velocity, radial reflectivity, groupel mixing ratio, isotherm lines, electric field magnitude, space charge mixing ratio, etc. are simulated. The model simulated parameters were analysed and it was found that they represent the expected theoretical values. It was also observed that the charging in cloud takes place in 4-10 km range. Due to lack of in-situ data on these parameters, a detail validation of these cloud microphysical parameters could not be done.

Preparing the lightning hazard zonation map for Meghalaya

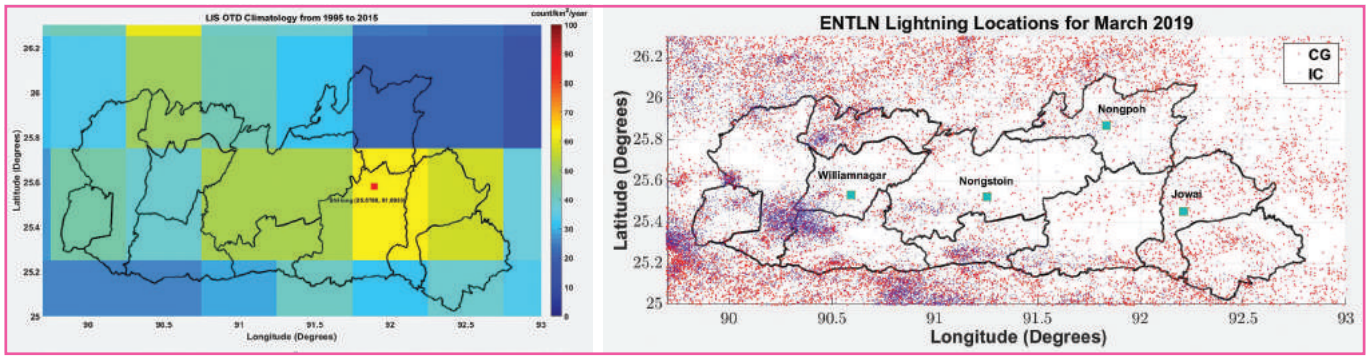
The state of Meghalaya is one of the highly vulnerable state for lightning. NESAC is planning to utilize Lightning Imaging Sensor data onboard TRMM satellite and ground based lightning detection sensors data for lightning hazard mapping of Meghalaya. For initial assessment, the LIS-OTD long term database and ENTLN data are used to prepare the hazard map. Further, utilizing the ENTLN lightning data, a classification has been done with respect to the Intra cloud Lightning discharge (IC) and cloud to ground lightning discharge (CG) over Meghalaya.

Thunderstorm nowcasting services for NER of India

Extreme weather event like thunderstorm has been a major concern for NER of India. In comparison to other natural disasters like earthquake and flood, thunderstorms are more frequent phenomena. Heavy wind, rain, and lightning associated with severe storms

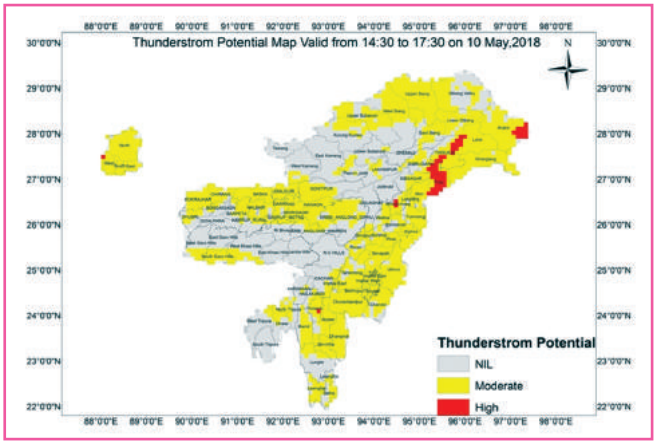


Vertical cross section of X-Z plane through an intense convective cell through south-north and west-east grid. The simulated Radar reflectivity (dBZ, gray shades), Vertical velocities (m/s), Graupel mixing ratio (blue contour), Graupel water space charge mixing ratio (orange contour), and the isotherm lines (^{0}C, black horizontal lines) are shown.



LIS-OTD lightning climatology map for Meghalaya (left) and ENTLN measured total lightning over Meghalaya for March, 2019

causes severe damage to humans, cattle, and properties. These severe storm events can be predicted by analyzing the current weather situations as thunderstorm is associated to the instability in the atmosphere. The thunderstorm nowcasting system, developed at NESAC for the entire NER was continued during the year. The nowcasting was done in two tier system consisting of preparation of "Thunderstorm Potential Map" and "Thunderstorm Nowcasting Bulletin". Thunderstorm potential map was prepared using the WRF model that forecast all major atmospheric instability parameters, like Convective Available Potential Energy (CAPE), Convective Inhibition Energy (CIN), Lifting index, and K-index. Additionally, the available moisture in atmosphere is also incorporated while preparing the potential map. The thunderstorm potential map identifies the regions having high potential to generate thunderstorm of different intensity. The thunderstorm nowcasting bulletin is also prepared by near real time monitoring of weather conditions using data from Satellites, DWR, Lightning Sensors, and AWS. Both the potential maps and bulletins are generated thrice daily during pre-monsoon season (15 March–15 June), with lead time of three and four hour respectively. The services are delivered to the concerned stakeholders directly by e-mail and also through NESAC website.



Thunderstorm Potential Map for 10th May, 2018

For validation of the alerts issued, INSAT-3D satellite (TIR- 1 channel images) and ground based lightning sensor data has been used. Table below shows the major validation statistics obtained by comparing with INSAT-3D TIR (thermal infrared) channel images and lightning locations provided by ENTLN (Earth Network Total Lightning Network).

Sensitivity of WRF model to simulate thunderstorm over NER of India

NESAC has been using the WRF model to predict thunderstorms. The WRF model has many sets of physical schemes, but the selection of right set of

Validation statistics for thunderstorm alerts issued during 2018

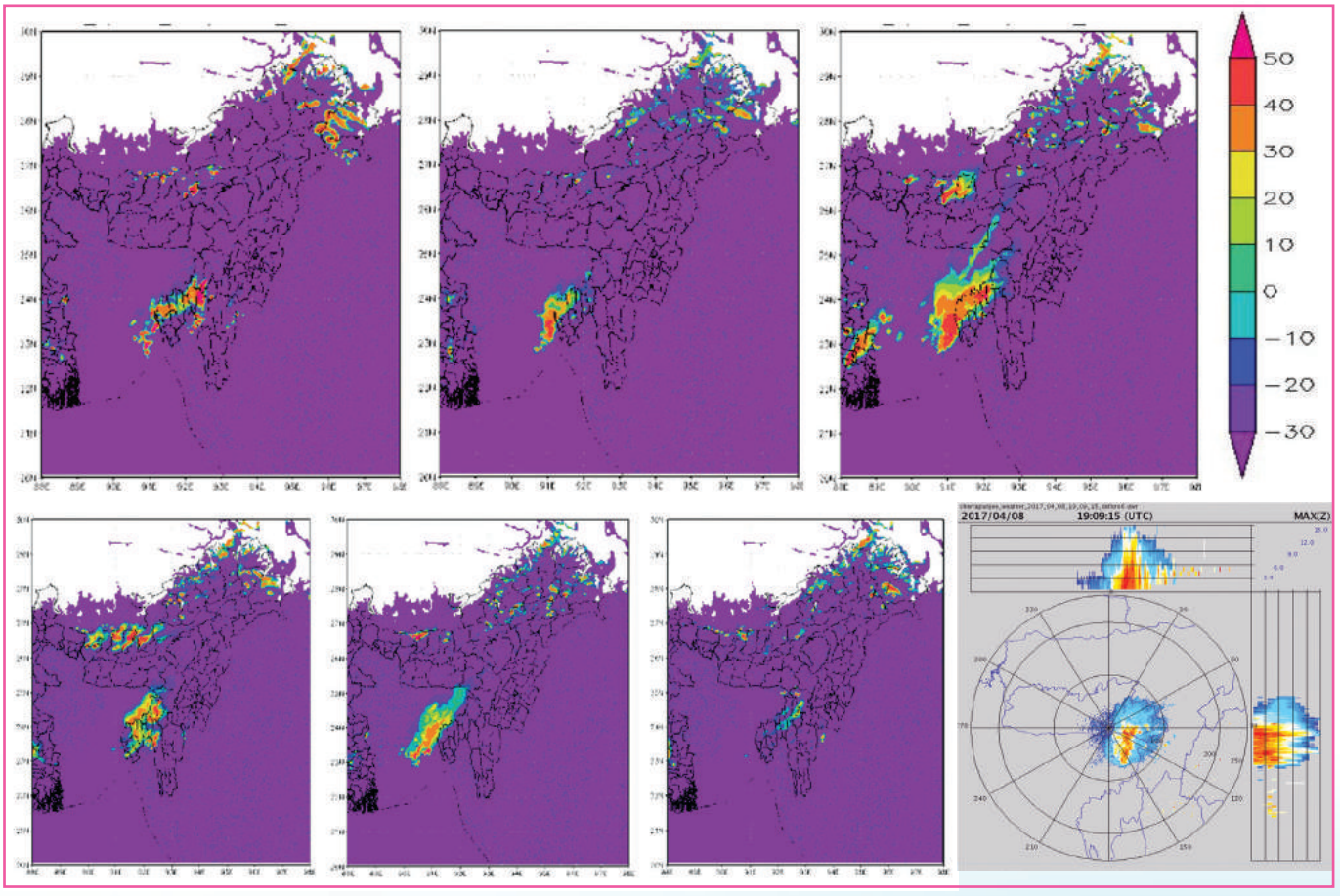
Validation Parameters	Range	Perfect Score	Score for April	Score for May	Score for June
Probability of detection	0 to 1	1	0.71	0.76	0.81
False alarm ration	0 to 1	0	0.52	0.41	0.48
Equitable threat score	-1/3 to 1	1	0.41	0.43	0.45
Extreme dependency	-1 to 1	1	0.69	0.63	0.58
Frequency bias	0 to Infinity	>1 is over-estimation and <1 is under-estimation	1.9	1.5	1.42
Critical success index	0 to 1	1	0.41	0.47	0.48

schemes for a particular region is very important in order to improve the model performance. A study has been conducted to examine the sensitivity of WRF model with different combinations of cloud Micro Physics (MP) scheme and Planetary Boundary Layer (PBL) scheme to simulate thunderstorm related features over NER of India. In total 12 combinations of MP and PBL schemes were used to simulate features like maximum reflectivity, CAPE, CIN, K-Index, precipitation and relative humidity.

Observed maximum reflectivity obtained from DWR stationed at Sohra was used to validate the simulated reflectivity from model. It was observed that, In general there was a lateral shift in the simulated radar reflectivity towards south west direction. Moreover temporal shift was also observed in few simulations, as the simulated system was visible one hour before its actual observation. However, there were few combination where, no temporal shift or spatial shift was observed. Similarly simulated CAPE and precipitation data was also compared with reanalysis ERA-interim and GPM data respectively. RMSE estimation for CAPE shows higher RMSE value for northern Bangladesh, Sikkim, western Meghalaya, western Assam and Bay of Bengal region. While lower RMSE was observed for eastern Assam and eastern Arunachal Pradesh. Similarly RMSE for precipitation was also computed with all simulations against GPM rainfall which reveals that all the simulations shows high value of RMSE over western Assam, eastern Arunachal Pradesh and southern Bangladesh region while for Mizoram, Manipur, and Nagaland, the RMSE values were comparatively lower. A comparison of simulated vertical profile of relative humidity with all 12 combinations against sounder data was also done for three stations (Guwahati, Agartala, and Dhaka). Apart from this, a quantitative comparison of CAPE, CINE and K-index was also done with the observed sounding data. This study gives a firsthand idea about the best suitable schemes to predict thunderstorm over NER.

Thunderstorm life cycle study using DWR polarimetric data

The life of most of the thunderstorm systems can be divided into three main stages, namely cumulus stage,

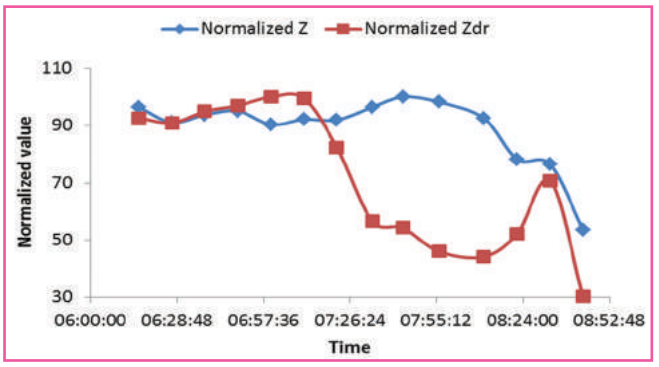


Max reflectivity simulation for selected combination of MP and PBL scheme using WRF model for 8th April, 2017 and actual observed thunderstorm as recorded by DWR at Sohra for the same time.

mature stage, and dissipating stage. In cumulus stage only updraft is present which mainly comprises of warm moist air. In the mature stage the cumulus cloud becomes large enough to start the process of downdraft. The updraft region of a mature system contains lots of super cool water droplets which try to force themselves down to the ground through the updraft region. These super cool water droplets become bigger in size due to mutual impacts which results in a moderate to high differential reflectivity values in that particular region above the freezing level. Once the updraft is finished, the super cool water droplet falls on the ground and high differential reflectivity values disappears from the radar data. Due to the absence of updraft, the system starts to dissipate but still high reflectivity can be observed in DWR data.

A few thunderstorm events have been studied to analyze their life cycle and identify the time when a thunderstorm starts dissipating using the polarimetric data from Sohra DWR. Figure below shows a mature system with observed highest reflectivity value as 53.3 dbz and differential reflectivity value as 3.96 dbz above the freezing level layer and the same system after one hour have shown reflectivity value as 55 dbz and differential reflectivity value as 1.82 dbz. It could be observed that while the reflectivity alone does not give any clear picture of the storm stage, the differential reflectivity data provides a relatively clear indication that at 7:56 UTC, the storm system was only in dissipating stage. This information could be effectively utilized for better thunderstorm nowcasting.

Reflectivity together with differential Reflectivity data can be used to foretell whether a thunderstorm system will grow further or dissipate. Figure below shows the temporal variation of maximum observed values of reflectivity (Z) and differential reflectivity (Zdr) for the same system.



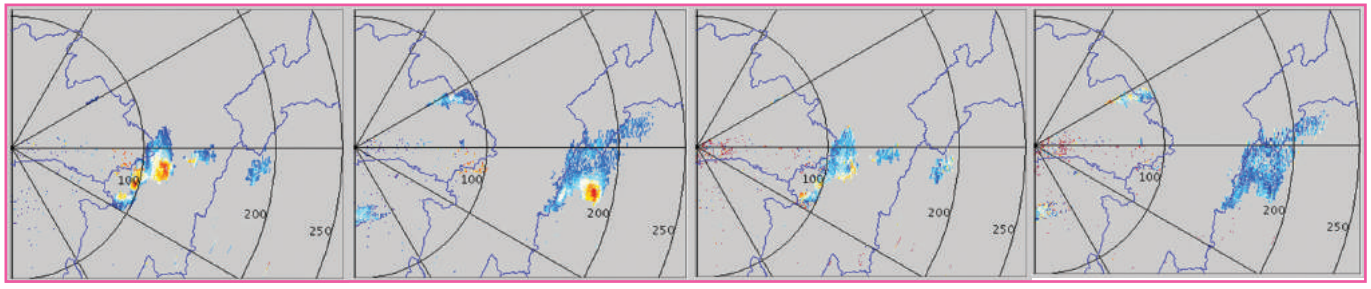
Temporal variation of reflectivity and differential reflectivity over time for a typical thunderstorm

Study of hailstorms using reflectivity data

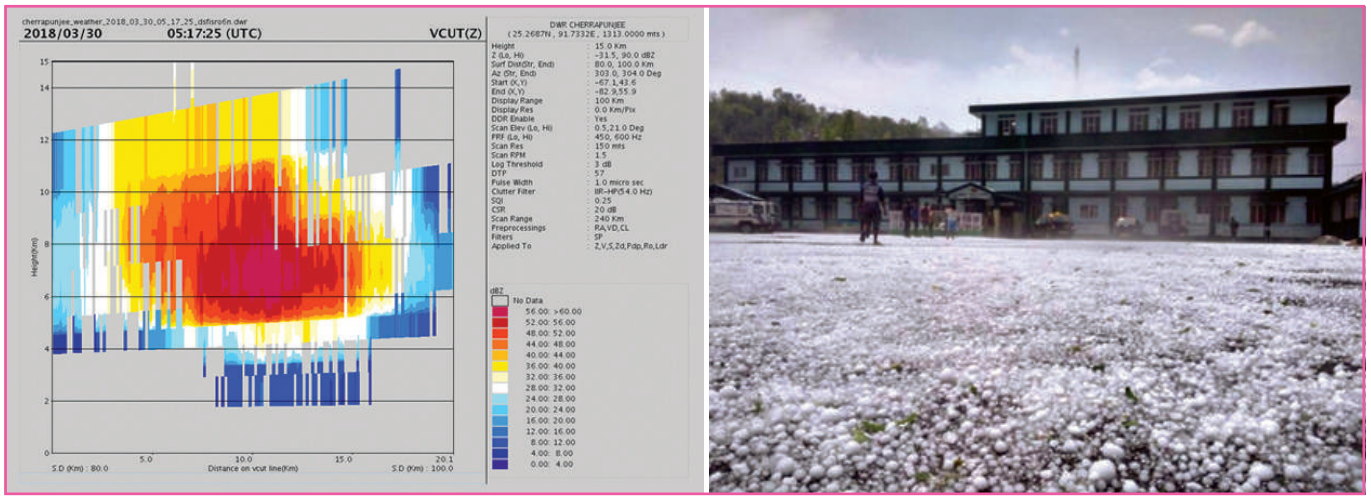
Pre-monsoon severe storms in NER of India are often accompanied by severe hailstorms. This has been one of the major disasters causing severe loss of life and property. Several storms over Meghalaya and surrounding areas have been studied using the DWR, Sohra data to look for signatures of hail. It has been observed that a hailstorm can be predicted if 50 dBz or more reflectivity is observed in the core region of a thunderstorm system that extends beyond 8 km height. A severe thunderstorm system was observed in the Max Z product of DWR, Sohra on 30th March, 2019 that had signatures of hailstorm and a severe hailstorm actually occurred over the place indicated by the DWR data.

Setting up a network of AWS in RHEP, Arunachal Pradesh

A network of 17 numbers of Automatic Weather Stations (AWS) has been set up in the Ranganadi Hydro Electric Project (RHEP) area in Arunachal Pradesh funded by the North Eastern Electric Power Corporation



Plots of reflectivity at 6.49 UTC (left) and at 7.56 UTC (2nd from left), and differential reflectivity at 6.49 UTC (3rd from left) and at 7.56 UTC (right)

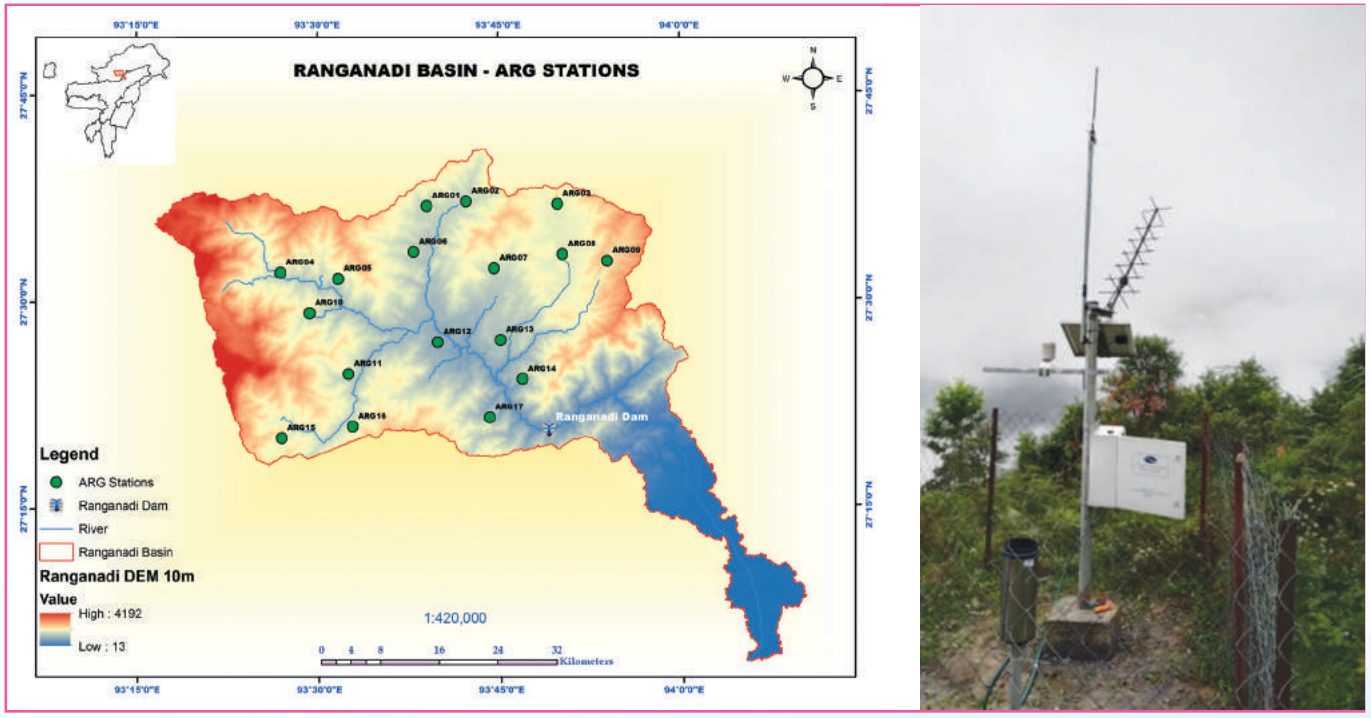


A hailstorm vertical cut as seen using a DWR Max Z product (left) and the actual hail from the same weather system

(NEEPCO) under the project "Implementation of a state of art real time hydro-meteorological monitoring system in catchment areas upstream of RHEP". The major objective for setting up the network has been to forecast Ranganadi river discharge that will help NEEPCO in better management of the dam and in-turn help in flood forecasting over the downstream areas of Ranganadi, particularly for the Lakhimpur district of Assam.

All the AWS has Siphon rain gauge, temperature sensor, and humidity sensor. The AWS has dual communication protocol having both satellite connectivity and mobile communication through GPRS. The hourly data from the AWSs are received at MOSDAC web-portal and the same is immediately fed to NESAC FTP server. Data at every 15 minutes interval are also communicated directly to NESAC FTP server via the GPRS network, however more than half of the stations do not have any mobile connectivity.

NESAC has been receiving the data and efforts are being made to develop software for GIS enabled real time visualization and analysis of the data for faster decision making.



RHEP project area with AWS locations (left) and one of the installed AWS (right)

IMPORTANT EVENTS

Hon'ble Union Minister for Electronics & Information Technology launched GeoPortal on North Eastern District Resources Plan

Shri Ravi Shankar Prasad, Hon'ble Union Minister for Electronics & Information Technology and Law & Justice, Government of India launched the updated and full version of North Eastern District Resources Plan (NEDRP) GeoPortal on 11 August, 2018 in presence of the Hon'ble Chief Ministers and IT Ministers of North Eastern States. The portal was released as a part of the programme on releasing vision document for Digital North East 2022 in Guwahati at the initiative of Ministry of DoNER, Government of India.

State Meet on use of Space Technology for Arunachal Pradesh

State Meet on use of space science & technology for governance for the state of Arunachal Pradesh was conducted jointly by State Remote Sensing Application Centre (SRSAC), Arunachal Pradesh, North Eastern Space Applications Centre (NESAC), Umiam, Shillong and ISRO at the Dorjee Khandu Convention Hall, Itanagar on 7th September, 2018 with the active participation of various stakeholders including officials of the State and Central Government. The main objective of this meet was to promote maximum utilization of space technology to improve the socio-economic conditions of the region as well as sensitize decision makers and ground level functionaries for ensuring the benefits of governance are made available at the grass root level. The program consisted of inaugural session, two technical sessions, lead talks by senior scientists from NRSC followed by the demonstration of ISRO geoportals i.e. Bhuvan and North East District Resource Plan (NEDRP) followed by highlights of NESAC's UAV applications and concluding the session. The event was attended by 129 total participants 85 of which were from 26 User Departments. Across 2 technical sessions, 26 User Departments proposed 77 projects.

Shri Bamang Felix, Hon'ble Minister for RWD, IPR and Parliamentary Affairs Shri Satya Gopal, Chief Secretary, Shri Bamang Mangha Chairman AP State Council for Science and Technology, Er. Gaken Ete, Secretary S&T, Shri H.K. Dutta, Director SRSAC-AP, Shri P.L.N Raju Director NESAC, Shri Santanu Chowdhury, Director NRSC, Dr. P.V.N Rao, Dy Director, RSA, NRSC, and Dr. T. Ravishankar Group director LRLUMG, NRSC attended the meet. As a part of the proceedings, a Compendium on Applications of Space Technology for Governance and Development for Arunachal Pradesh was also released.

Release of Sericulture Phase II project atlas for NER by Hon'ble Sericulture Minister, Assam

A two days workshop on Applications of Geospatial Technology for Sericulture Development was organized jointly by NESAC and Central Silk Board (CSB) at Assam Administrative Staff College, Guwahati during October 22-23, 2018. About 60 Scientists and officials from CSB, State Directorates of Sericulture, State Remote Sensing Application Centres and NESAC participated in the workshop. Inauguration function of the project was started with the welcome address by Shri P.L.N. Raju, Director, NESAC, Shillong followed by opening remarks from Shri R.R. Okhandiar, IFS, Member Secretary, CSB, Bengaluru. Dr. Bijoy K. Handique, Scientist-SF,

NESAC & Project coordinator gave an overview of the programme. Shri HemantaNarzary, IAS, Principal Secretary, Handloom, Textiles & Sericulture, Govt. of Assam was the guest of Honour of the function and he highlighted the various issues and challenges faced by the sericulture industry. He urged upon all the stakeholders to work out towards supporting the sericulture farmers to making it more profitable and attractive for the new generation. Project Atlas for Sericulture Development (Phase II: NE states) and SILKS portal for the selected 20 districts was released by Shri Ranjit Dutta, Hon'ble Minister of Handloom, Textiles & Sericulture, Govt. of Assam. In his address he appreciated the effort of CSB and NESAC in applications of geospatial technology in sericulture development in the country and particularly in NE states. He highlighted the Muga Mission, a flagship programme initiated by Government of Assam for doubling the Muga production in the state. A training on Geotagging of assets created with the financial support of CSB was conducted on Oct 23, 2018 for the officials from various regional centres and units of CSB in NER. For geotagging of assets, a mobile app and a dashboard platform has been developed by NESAC.

Trainings & Workshops

1st Project Monitoring Board Meeting of NeSDR Project

The first Project Monitoring Board Meeting of NeSDR Project was held at NESAC on 8th May, 2018. The meeting was chaired by Shri S. N. Pradhan, Joint Secretary, Ministry of Development of North Eastern Region and was attended by respective heads of State Remote Sensing Applications Centres of NER. Shri PLN Raju, Director, NESAC, while welcoming the participants,

spoke at length about the project and other relevant activities of the centre. The Joint Secretary, MDoNER emphasized upon the importance of space technology with regard to data gathering for solving the problems of the common man and need to fully utilize the RS and GIS technology for the benefit of NER. He appreciated the overall progress of NeSDR project and felt happy to see the infrastructure setup available at different state nodes for the project. State Centres have given presentations on the present setup and details on the spatial database availability for the project. Shri Nilay Nishant, Kum Ritu Anil Kumar, Shri Avinash Chouhan (Scientists from NESAC) gave brief demonstrations on the various g-Governance applications for NeSDR Dashboard. Shri Victor Saikhom, NESAC presented the database related aspects of NeSDR and the need for submitting proper structured database based on NeSDR Metadata standards. Shri P. S. Singh, NESAC gave a presentation cum demonstration on NeSDR SDI Prototype.

Capacity Building under AMRUT Sub-Scheme on plans formulation of GIS based master plan formulation

NESAC in collaboration with Town and Country Planning Organization, Ministry of Housing and Urban

Affairs, Govt. of India, conducted training programs on 'Formulation of GIS based Master Plans' for decision makers during May 29-31, 2018 and for middle level officers during May 14-25, 2018. Altogether 20 officers were trained during the two programs.

A separate training program for senior level officials was also held during the month of August, 2018 (6th-31st August, 2018) where about 20 officers were trained.

One day DGPS Training for officials from Forest Dept., Government of Meghalaya

One day training on 'Differential GPS handling & survey technics' was conducted for the officials of Meghalaya Forest Wildlife Shillong Division, Dept. of Forest, Govt. of Meghalaya at NESAC on 12th June, 2018. The training was conducted by Shri Victor Saikhom, Scientist/ Engineer-SE and Shri Gopal Sharma, Scientist/ Engineer-SC. About 12 officials, which include DFO and MFS had participated in the training programme.

Space Based Information Kiosk for Sikkim, installed and demonstrated

The Space Based Information Kiosk for Sikkim State was installed at the Chief Secretary's Office in Gangtok on 4th July, 2018. The SBIK for Sikkim consisting of 30 layers on different themes was demonstrated to Shri. Alok Kumar Srivasatav, IAS, Chief Secretary, Govt. of Sikkim. In the meeting, Dr. Dibyajyoti Chutia and Shri P.S. Singh, from NESAC briefed the effectiveness and usefulness of SBIK portal in the planning and developmental activities in the state. They also highlighted that, the SBIK portal was earlier launched in 7 NE States, NEC, Ministry of DoNER in Delhi and more than 17 line Departments.

Basic course on 'Remote Sensing and GIS - Technology and Applications'

NESAC conducted Basic course on 'Remote Sensing and Geographical Information System- Technology and Applications' of two weeks duration during July 16-27, 2018 focusing the area of geospatial and earth observation applications. The course was designed so that the participants develop clear understanding of appropriate tools, exposure to new methods and techniques, gaining competence in developing tools for the acquisition, processing, analysis and presentation of spatial data. The course included topics related to Remote Sensing and digital image analysis, Global Navigation Satellite Systems (GNSS), Geographical Information system, open source software and data standards, ground truth and field validation with hands on training on relevant topics. The first week of the training was devoted to topics on basics of RS, GNSS, GIS and image processing, while the advanced topics were covered during the second week. Morning sessions consisted of lectures and demonstrations while hands on training with RS and GIS software were covered during afternoon session. The last two days of the course were dedicated towards formulation of mini-projects by the participants in groups covering various topics of their interest.

Telemedicine Awareness Workshop for North-East

NESAC organized Telemedicine awareness workshop for North-East and 5th Annual Continuing Telemedicine Education program of the Telemedicine Society of India jointly with Regional Resource Centre- NEIGRIHMS, Guwahati Medical College, Ministry of Health and Family Welfare (GOI), TSI and NEC at Guwahati during 24-25 August 2018.

Training on basics of Remote Sensing and GIS for forestry applications

A short course on basics of Remote Sensing and GIS for forestry applications was organized at NESAC for the staff of Arunachal Pradesh Forest Department during 12-16 November 2018. 21 Range Forest Officers, Deputy Rangers, Foresters, Forest Guards deputed by the Additional Principal Chief Conservator of Forests participated in the training programme. The programme was organized as a part of the RS & GIS inputs for preparation of Forest Working Plan, sponsored by the Arunachal Pradesh Forest Department.

Brainstorming Workshop on Space Science & Technology and its Applications at Dibrugarh University

A Brainstorming Workshop on Space Science & Technology and its Applications was organized at Dibrugarh University, Assam on 9th November 2018 at Dibrugarh University. The objective of the workshop

was to create awareness and generate interest among academicians and researchers of the University in the field of Space Technology applications, Space Science and Satellite Communication and finding out the possible areas of collaboration. Hon'ble Vice-Chancellor, Dibrugarh University was the chief guest in the inaugural function. In his inaugural speech, he thanked DOS-ISRO for the initiative and expressed his interest in more collaborative works between DU and ISRO/DOS & NESAC. Approximately 90 participants comprising of Deans, Faculties & Researchers from various departments and centers of the university participated in the workshop. Total seven presentations

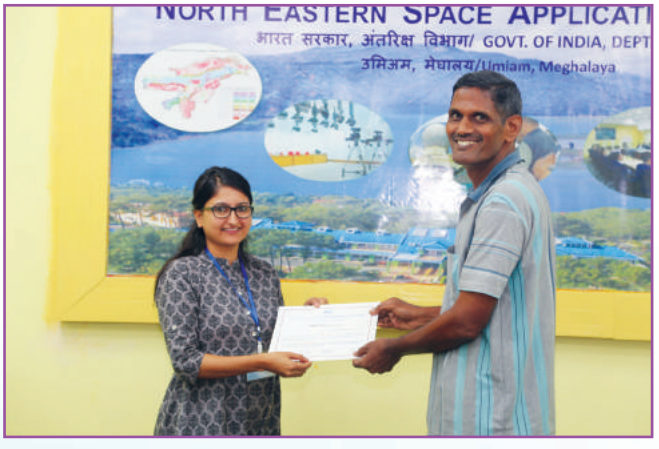
were made from NRSC, Hyderabad, RRSC-East, Kolkata and NESAC, Shillong including a demonstration on UAV-Remote Sensing technology. Two presentations were made by Dean, School of Earth, Atmospheric Science, Environment and Energy, DU and Dean of Research and Development, DU. The role of Space Technology on e-governance, various operational projects (in Agriculture, Sericulture, Disaster, Weather etc.) by ISRO/DOS for national services, the process to take up innovative projects through RESPOND program were discussed. The challenges faced by NER have also been listed out and how ISRO/DOS could contribute towards addressing such challenges was discussed.

NeSDR Bootcamp on WebGIS and Mobile App Development

A 3-day Bootcamp Training on WebGIS and Mobile App Development was organized by NESAC during October 22-24, 2018 under the umbrella of the North Eastern Spatial Data Repository (NeSDR) Programme of the centre. The major aim of the Bootcamp was to train the officials of State Remote Sensing Applications Centres (SRSACs) of NER in order to participate in the Collaborative Development of Governance Applications (CDGA). The training was attended by 17 Officials working in the core areas of IT and GeoInformatics from SRSACs, Meghalaya Basin Development Authority (MBDA) and Meghalaya IT Department. The major focuses were given on hands-on exposure towards development of Mobile Apps and Spatial Dashboard applications using open source software and standards. The programme comprises of practical oriented lectures closely followed by intense hands-on sessions spanning 12 hours each day from 7AM – 7PM. On the day of closing function, 5 mini projects were demonstrated on the following topics – 1) GeoTagging Mobile Apps for asset mapping, 2) Dashboard Application for CrimeGIS, 3) GeoTourism, 4) Secure Mobile Application for Geotagging and 5) Election Dashboard. Director, NESAC with senior scientists from NESAC were also present during the closing function.

NESAC has successfully conducted 3rd Course on UAV Remote Sensing

The 3rd two weeks training course on "UAV Remote Sensing – Technological Advances & Applications" was conducted by North Eastern Space Applications Centre during 04-14 September, 2018. The participants were teachers, students and research scholars from various Colleges, Universities of India. There were also participants from different public/private sectors from various parts of India.



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 e.g. 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 softwares, Pix4D mapper pro and Agisoftphotoscan pro softwares. The course also covered field visit to capture UAV data with GCPs and mini-projects.

NESAC organised a One-Day Workshop on GAGAN Dongles

NESAC organised a one-day workshop on 4th September 2018 for demonstration, training, and distribution of Bluetooth enabled GAGAN Dongles & Smartphones with mobile Apps for field data collection of Planning Department Officials of NER States for various projects under NLCPR Scheme of MDoNER, Govt. of India. Around 50 Officials from various departments of NER states attended the training. Sri Anjan Debnath, Scientist, NESAC & Sri PLN Raju, Director, NESAC gave a theoretical description on the working of the GAGAN Dongles and answered various queries from the participants of the workshop. Sri Avinash Chauhan, Scientist, NESAC gave a demonstration of the mobile app developed for field data collection. Participants tested the mobile app themselves and were happy at its performance. Mr. Yogesh Kumar, Section Officer, Ministry of DoNER, New Delhi represented MDoNER at the workshop. He gave a brief talk addressing vision of the ministry in using state-of-the-art technology in NLCPR and other schemes of the ministry. He also took part in the hands-on demonstration. Later, a demonstration of the UAV facilities at NESAC was given to the participants. The dongles and smartphones were handed over to the Planning Department officials of each state.

Training for Assistant Technology Managers of Meghalaya sponsored by MAMETI

Two days training on "Applications of Remote Sensing & GIS for Agriculture and allied areas" sponsored by Meghalaya Agricultural Management & Extension Training Institute (MAMETI), Govt. of Meghalaya was conducted at NESAC during February 07-08, 2019. Twenty three Assistant Technology Managers posted in various C & RD Blocks of Meghalaya attended the training. A wide range of topics such as Basics of Remote sensing and GIS, Digital Image Processing, GIS, GPS, applications of geospatial technology in Crop acreage and production estimation, soil resource and land capability mapping, site suitability analysis, UAV remote sensing for agricultural applications etc. were covered during the training. Hands on training on digital image processing, image classification and accuracy assessment and handling of GPS etc. were also provided to the participants. At the concluding session of the training, Director, NESAC distributed the certificate of participation to the trainees.

Various Office Events & Celebrations

Celebration of World Environment Day

World Environment Day was celebrated at NESAC on 5th June, 2018. Staff of NESAC led by Director Shri. P L N Raju participated in the Celebration. Saplings were planted at various locations of NESAC office and NESAC residential campus to make the environment cleaner.

Celebration of 4th International Day of Yoga on 21st June, 2018 at NESAC

4th International Day of Yoga was celebrated at NESAC from 19th to 21st June, 2018. Preparatory Yoga sessions were organized for the regular staff, CISF personnel, students & trainees of NESAC as well as their family members on 19th and 20th June, 2018

with 75 participants. On International day of Yoga 21st June, a morning session of Yoga was organized for all staff of NESAC. These Yoga sessions were organized at NESAC Community Hall. The Common Yoga Protocols circulated by Ministry of AYUSH, Government of India were practised by all and the Yoga sessions were conducted by professional Yoga trainers. Reputed international Art of Living teacher, Shri Samir Jolly presented a lecture on use of Yoga for stress relief

at workplace and conducted a Yoga and meditation session for the staff of NESAC from 3 pm to 5 pm on 21st June. He also showed a video on the impact of the teachings of Sri Sri Ravi Shankar and his foundation, Art of Living, a non-government organization involved in humanitarian work throughout the world with a special focus on stress elimination, throughout the world.

Ayurvedic and Homoeopathic Medical Camp at NESAC

NESAC with North Eastern institute of Ayurveda & Homoeopathy (NEIAH), Ministry of Ayush, Shillong jointly organized a free medical checkup

and free medicine distribution camp of Ayurveda & Homoeopathy at NESAC on 25th June, 2018. Eight officials including one Ayurveda Doctor and two Homeopathy doctors from NEIAH conducted the daylong checkup and medicine distribution for NESAC employees and the patients from nearby villages (Umiam, Nogsder, Rongmen) and Institutes.

Yoga, Meditation and knowledge session to children of SOS village

Yoga, meditation and knowledge session was conducted for children of SOS village, G.S Road,

Meghalaya on 1st July 2018. SOS is a self implementing child care NGO, working for the holistic development of parentless children situated at Ri-Bhoi District of Meghalaya. Children were taught about importance of exercise, yoga and meditation. Yoga session was held for one hour, which was followed by a lecture on "Space science and Indian Space Research Organization", followed by question answer sessions. Director, NESAC interacted with children answering their queries on various topics. Refreshment with snacks, fruits and chocolates was provided to all the children and staff. More than 70 children of different age groups participated in the program.

A blood donation camp was organized on 25th July 2018 at NESAC community hall

A blood donation camp was organized on 25th July 2018 at NESAC community hall by Confederation of Ri-Bhoi People (C.O.R.P) & Regional Blood Bank, Pasteur Institute, Shillong in collaboration with NESAC. The blood donation camp was inaugurated by Shri G.B. Lyngdoh, MLA, Umroi Legislative Constituency and Shri P. L. N. Raju, Director, NESAC. Altogether 49 people donated blood during the camp.

NESAC celebrated 72nd Independence Day

72nd Independence Day of the nation was celebrated at NESAC with a day-long colorful programme. 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 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. Prizes were distributed among winners of various sports & recreational events organized as a part of the Independence Day celebration. The programme ended with a movie show arranged at NESAC Auditorium for the staff of NESAC and their family members.

NESAC celebrated Hindi fortnight

Hindi Fortnight was celebrated at NESAC during 14-28 Sept, 2018. The programme was inaugurated on 14.09.2018 by Shri P. L. N. Raju, Director, NESAC.

He administered the pledge to all NESAC employees & also highlighted the importance of Rajbhasha Hindi. A series of programs like, Hindi newspaper reading competition, Hindi speech competition, Hindi debate competition, Hindi handwriting competition & open quiz competition etc. were organized during the Hindi fortnight. As a part of the closing ceremony of Hindi Fortnight Celebration, a lecture was delivered by Shri K. C. Basphor, Manager (OL), SBI, Guwahati.

Release of Election e-ATLAS by Chief Secretary of Mizoram

Shri Arvind Ray, IAS, Chief Secretary to the Government of Mizoram released the Election e-ATLAS portal on 18th October, 2018 for planning and management of upcoming Legislative Assembly Election scheduled on 28th November, 2018. The programme was attended by Shri Krishna Mohan Uppu, Asst. CEO, Dr. R. K. Lallianthanga, Member Secretary, MIRSAC and other Senior Officials from District Administration/Election Department. Shri Nilay Nishant, Scientist from NESAC demonstrated the portal to the gathering.

NESAC celebrated Swachhta Hi Seva Campaign 2018

The Swachhta Hi Seva campaign 2018 was celebrated at NESAC from 14th September 2018 to 2nd October 2018. All the NESAC staff took the "Swacchata Hi Seva" pledge led by theDirector, NESAC. During the campaign, several activities were taken up by NESAC to clean the NESAC office campus, NESAC residential campus, NESAC hostels, Umiam village area and market area etc.

Flagging off Swachhta Rath; creating awareness among the people at different locations such as Umiam market,

GS road junction, NEPA market and ICAR, etc was also organised. A lecture on Waste Management was also conducted. NESAC staff also distributed leaflets to the people with different theme like Recycling of waste, save water, Segregation of waste, Hygiene, WASH capacity building, Ecological sanitation, Food Safety, How to use toilet, etc.

Observance of Vigilance Awareness Week – 2018 on the theme "Eradicate Corruption – Build a new India"

Vigilance Awareness Week-2018 was observed at NESAC on the theme "Eradicate Corruption – Build a new India" from 29th October, 2018 till 2nd November, 2018. A week- long celebration of vigilance was undertaken conducting an array of programs. The programs started on 29th October, Monday with Display of Banners, posters and distribution of handouts etc. followed by Lighting of lamp, taking of Integrity Pledge by all employees at NESAC Auditorium. Employees were encouraged and apprised to take the e-pledge by visiting CVC website. The message from Prime Minister/ Home Minister of India on the occasion was also read to the employees. A lecture was also arranged on the

theme "Eradicate Corruption-Build a New India", by the Chief Guest, Wing Commander (Retd.) Sri Vibhas Singh Gupta, Controller, NRSC, ISRO for the employees. On 30th October, Quiz and Extempore Speech Competition for NESAC Employees were organized. This was followed on 31st October by Quiz and Essay Writing competitions for students from the nearby six Schools and a presentation by Sr. Administrative Officer, on Anti-Corruption Institutions and regimes in India. On 1st November, 2018, a Marathon was organized for Boys and Girls in the morning.

A program for promoting the concept of e-Integrity Pledge by Purchase Section/CMD/PIs to Customers/

Users was held in the afternoon. On 2nd November, after the week long programs, closing ceremony of the Vigilance Awareness Week was held. Soft copy of the article on vigilance to be brought out in the next issue of NESAC Newsletter was released. This was followed by Prize Distribution for all competitions held. The program ended with closing remarks by Director, NESAC.

NESAC celebrated its 18th Foundation Day

18th Foundation Day of NESAC was celebrated with a day-long programme on 5th September, 2018. The program was inaugurated by lighting of lamp by Shri P.L.N. Raju, Director, NESAC and other Senior staff. It was followed by a welcome speech by Director, NESAC and followed by tree plantation program inside NESAC Campus. NESAC Staff participated in various games like Musical Chair, Tug of War, Open Quiz, Antakshari etc. organized by NESAC Recreation Committee on the occasion of the Foundation Day. During the second half, a popular talk was delivered

by Prof. K.G. Bhattacharyya, Chairman, Assam State Environment Impact Assessment Authority on the topic 'Back to Nature'. This was followed by Prize Distribution Ceremony of various sporting and recreational events organized as part of the Foundation Day celebration. The day-long celebration was concluded with a colorful Cultural Program, where staff of NESAC participated with full enthusiasm.

NESAC hosted workshop on "Emerging Technologies, Innovation, Incubation and Entrepreneurship Development"

The Centre for Development of Advanced Computing (C-DAC) organized a five days workshop on "Emerging Technologies, Innovation, Incubation and Entrepreneurship Development" in association with NESAC and Assam Engineering College (AEC) during March 5-9, 2019 at NESAC Outreach Facility. The purpose of this workshop was to strengthen of ICT/Innovation skill development, Entrepreneurial skill development, Raising the awareness of IPR for economic growth and development, Incubation for innovation technologies, Encouragement of entrepreneurial activities in NE region. On the inaugural

day, Mr. Aditya Kumar Sinha, Programme Head, C-DAC, Pune welcomed the participants and delivered a talk on 'Technology Roadmap for Emerging Future'. Prof. Keya Sengupta, Director-in-Charge, IIM Shillong graced the inaugural session as the Chief Guest. Shri PLN Raju, Director, NESAC attended the session as the Guest of Honour and appreciated the efforts of C-DAC and NESAC for conducting the workshop at NESAC. The Workshop was sponsored by the Ministry of Electronics and Information Technology Government of India. More than 42 participants from different parts of India attended workshop. NESAC also conducted two days sessions on the Applications of Machine Learning and Deep Learning followed by hands-on exercises.

World Hindi Day Celebration, 10 January, 2019

World Hindi day was celebrated in the centre on 10th January 2019. The programme was Inaugurated by lighting the lamps by Shri P.L.N. Raju, Director, NESAC & also presented his views on Raajbhasha Hindi. As a part of Vishwa Hindi Diwas Shri Avaneesh Shukla, Sr. Administrative Officer delivered a speech and highlighted the growing influence of Hindi in all over the world. Various other programs like – Poem recitation Competition, Hindi Dictation Competition & Group Discussion 0n 'Hindi as global Language' were conducted on 10th January, 2019 wherein most of the staff members actively participated. Prizes were given to the winners and program concluded with Vote of thanks by Smt. Namita Rani, JHT, NESAC.

NESAC celebrated 70th Republic Day

70th Republic Day of the nation was celebrated at NESAC with a day-long colorful programme. 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. This was followed by refreshment and cultural program organized by Recreation Committee of NESAC. Staff of NESAC and their family members participated in various outdoor games like Tug-of-war (for adults as well as children) as well as indoor events like Quiz, Singing, Dancing, Poem Recitation by kids. Prizes were distributed among winners of various sports & recreational events.

Orientation programme on Sexual Harassment of Women at Workplace

In order to create awareness on the Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013, an orientation programme was organized on 11th February, 2019 at NESAC for all its employees including CISF, Research Scholars, Outsourced workers and Home guard volunteers in collaboration with North East Network (NEN). North East Network (NEN) is a women's rights organisation based at Shillong working on addressing gender issues through dialogue and dissemination. Shri P L N Raju,

Director, NESAC graced the occasion as the Chief Guest. Around 128 participants attended the programme which was conducted in two sessions.

Hindi workshop organized at NESAC

NESAC organized a Hindi Workshop for all permanent Staffs and DEOs on 28th March, 2019. The programme was inaugurated by Dr. K.K. Sarma, Sci/Eng 'SG' by delivering welcome speech presenting his views on Rajbhasha Hindi. Smt. Kamlesh Bajaj, Deputy Director, Central Hindi Training Scheme, Maligaon conducted the programme on Hindi Grammar, Noting & Drafting followed by hands-on exercise.

NESAC also organized one day Session of Personal Contact Programme for Prabodh, Praveen & Pragya candidates on 26th March, 2019. The program was conducted by Smt. Kamlesh Bajaj.

Swachha Bharat Pakhwada during 1st Feb-15th Feb, 2019

The Swachha Bharat Pakhwada for the year 2019 started at NESAC from 1st February, 2019 for a period a two weeks, till 15th Februaury, 2019. The cleanliness drive was planned as per the guidelines from ISRO/ DOS Head Quarters. The Swachhata Pakhwada was inaugurated with the administering of Swachhata Pledge at NESAC Auditorium. This was followed by tree plantation drive coordinated by Smt. Pratibha T. Das & Shri Rocky Pebam, Scientists, NESAC. All staff of NESAC participated in the tree plantation drive.

CEO Manipur officially launched eAtlas for Manipur

The eAtlas for Manipur - a eGovernance dashboard based application was successfully launched today by Chief Electoral Officer, Manipur Shri Prashant Kumar Singh, IAS at his official complex at Imphal, Manipur. The spatial dashboard application was developed by NESAC in close collaborations with Manipur State Remote Sensing Centre. The application will be used by the CEO and respective DEOs during upcoming LS election 2019 for their election management. The event was attended by various officials from all districts of the state. Director of MARSAC, Dr. N. Randhir Singh delivered his formal welcome address and narrated the importance of having such eAtlas Applications in the state. He's accompanied by his official staffs Shri Kuseshwor, Shri Nganba and Shri Gagan to extend

their technical and valuable support for successful launching of the eAtlas application. Shri PS Singh of NESAC gave detail overview on major features of eAtlas dashboard and various modules available within it such as map analytics, live poll process monitoring, ability to print custom maps and mobile app for event and incident monitoring. Shri Avinash Chouhan, NESAC further gave live demonstrations on these modules. The CEO, Manipur has well appreciated and lauded the effort of NESAC for this new space based election planning tool.

NESAC participated in the 2nd Assam State Science Fair

NESAC participated in the 2nd Assam State Science Fair organized by Assam Science Technology & Environment Council (ASTEC) during March 23-25, 2019 at Tezpur University, Tezpur, Assam. The purpose of the Science Fair was to showcase science, technology and innovative activities of various institutions in the state of Assam. The activities of NESAC were showcased to the large number students, researchers and teachers participated in the Science Fair. Demonstration of UAV flying by NESAC team generated lot of interests among school students. NESAC team was comprised of Dr. Bijoy K. Handique, Dr. Arup Borgohain, Shri Himanshujyoti Das, Shri Gautam Bora and Shri Kishore Kumar.

Fire Safety Mock Drill conducted at NESAC

A Fire Safety Mock Drill was organized at NESAC on 08th February, 2019. The Mock Drill was organized jointly by NESAC and Fire & Emergency Services Station, Umiam. Shri Hafizur Rahaman, Senior Officer, Meghalaya Fire & Emergency Services Station, Umiam gave a brief lecture on Fire Safety. Shri Anjan Debnath, Safety Officer, NESAC gave a brief description of the different Fire Safety Equipments available at NESAC. Shri Ramdas, Assistant Commandant, CISF Unit, NESAC presented a General Action Plan during Fire Incidents. After the presentations, demonstrations of the different fire safety equipments available at NESAC were given by the Safety Officer to staff of NESAC. The Smoke Detector & Fire Alarm System, Portable Fire Extinguishers and Fire Hydrant were also demonstrated.

Inauguration of Water Purifier under Corporate Social Responsibility (Antrix Corp.)

Director, NESAC inaugurated Water Purifier at UCC Upper Primary School, Umiam and Ferrando Speech and Hearing Centre, Umsning under CSR of Antrix Corp. and distributed Prizes for Sports on 26th February, 2019.

Students Visit

29 students of M.Sc. Earth Science & Geology from University of Science and Technology, Meghalaya (USTM) and Gauhati University, Guwahati visited NESAC on 3rd May, 2018.

Students from CAU, Kyrdemkulai, who visted NESAC on 12th November, 2018 are enjoying the live demonstration of UAV flight at NESAC.

On October 26, 2018, 29 students of Electrical Engineering background from Girijananda Chowdhury Institute of Management & Technology, Tezpur, Assam visited NESAC.

On October 10, 2018, 38 students of Botany major from Guwahati College, Guwahati, Assam visited NESAC.

60 students of B.Sc Geography from St. Edmunds College, Shillong visited NESAC on 4th September, 2018.

23 students of Electronics & Communication Engineering Dept, National Institute of Technology, Meghalaya visited NESAC on 12th September, 2018.

78 students of B.Sc Geology, Dimoria College, Assam visited NESAC on 27th September, 2018.

68 students from nearby schools (35 from State Govt. run schools, 22 from central govt. run schools and 11 from aided schools) visited NESAC on 28th September, 2018.

Students from Mangaldai College, Darrang Assam, visited NESAC on 07-01-2019.

Students from University of Petroleum and Energy Studies (UPES), Dehradum visited NESAC during 18-19 Feb, 2019.

63 students of Electronics & Telecommunication Engineering and Computer Science Engineering of Assam Engineering College, Guwahati visited NESAC on 18th March 2019.

Visit of Distinguished Guests

Visit of Chairman, Brahmaputra Board to NESAC

Hon'ble Chairman, Brahmaputra Board Sri Rajiv Yadav visited NESAC for a day long appraisal programme on 26th July, 2018 accompanied by Vice Chairman, Brahmaputra Board, Secretary, Brahmaputra Board and other Senior Officials of Brahmaputra Board. Accompanied by Director, NESAC, he visited all the prime facilities of NESAC including IRNSS tracking station, Space and Atmospheric division, SATCOM studio facility, NER-DRR etc. Sri Chirag Gupta of NESAC gave a live demonstration of UAV related activities while Sri Nilay Nishant presented the award winning NEDRP portal. Sri S.S Kundu, Senior Scientist of NESAC briefed hon'ble Chairman about the atmospheric science activities of NESAC while Sri R.K Das, Senior Scientist of NESAC briefed the chairman about SATCOM programmes of NESAC. Later on Hon'ble Chairman also interacted with other employees of NESAC on other

peripheral activities of NESAC before leaving NESAC with very encouraging remarks on NESAC visitor's book.

Dr. S. K. Saha, Distinguished Professor, UPES visited NESAC

Dr. S.K Saha, Distinguished Professor at University of Petroleum and Energy Studies (UPES), Dehradun & Former Dean of Indian Institute of Remote Sensing (IIRS) delivered two talks at the NESAC Outreach Facility on 18th February, 2019. The first talk was on 'Remote Sensing and GIS Inputs for Hydrocarbon Exploration. 'The second talk was on vegetation analysis with hyperspectral remote sensing. His talk covered the

various aspects related to hyperspectral remote sensing for precision agriculture, hyperspectral classification techniques, spectral unmixing and matching, spectral derivative analysis etc. The talks were followed by an interactive session with the scientists, project staff and intern students.

Prof. B.K. Dutta, Hon'ble member, NEC visited NESAC

Prof. Biman Kumar Dutta, Hon'ble Member, North Eastern Council (NEC) and a distinguished academician visited NESAC on 12th March, 2019. During his visit, Director, NESAC presented a brief overview of NESAC activities followed by presentation by individual scientists. Prof, Dutta in his speech appreciated the various activities being carried out at the centre and expressed the need for more exposure of the activities for the benefit of the region.

M. Shahidul Islam, Secretary General of BIMSTEC visited NESAC on 18th March 2019

Mohammad Shahidul Islam, Hon'ble Secretary General of BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation) visited NESAC. He was briefed about the NESAC activities and how NESAC can play a bigger role in meeting some of the objectives of BIMSTEC. Director, NESAC also briefed him about the preparation to start the proposed capacity building initiatives on geospatial technology for the BIMSTEC countries at NESAC as announced by Hon'ble Prime Minister of India. He paid a visit to the NESAC outreach facility and hostels that will be used for the BIMSTEC course. He appreciated the diverse activities carried out by NESAC and also assured full support for an early start of the course and its successful running.

RESEARCH PUBLICATIONS

Publications in journal

1. Barman N, Borgohain A, Kundu S S, Roy R, Saha B, Solanki R, Kiran Kumar NVP, Raju PLN (2019) Daytime temporal variation of surface-layer parameters and turbulence kinetic energy budget in topographically complex terrain around Umiam, India, Springer, Boundary-Layer Meteorology, Doi: 10.1007/s10546-019-00443-6 (IF-3.1)
2. Barman N, Borgohain A, Kundu S S, Roy R, Saha B, Solanki R, Kiran Kumar NVP, Raju PLN (2019) Impact of Atmospheric Conditions In Surface-air Exchange of Energy In A Topographically Complex Terrain Over Umiam, Springer, Meteorology and Atmospheric Physics, Doi: 10.1007/s00703-019-00668-7 (IF-1.65)
3. Barman N, Roy R, Borgohain A, Kundu S S, Saha B, Solanki R, Kiran Kumar NVP, Raju PLN (2019) Investigation of Seasonal Variation of Compensation Parameter and Absorption Ångström Exponent of Aerosol after Loading Correction over a Remote Station in North-East India, Elsevier, Atmospheric Environment. Doi: 10.1016/j.atmosenv.2019.05.036 (IF-4.01)
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1. Applications of Remote Sensing & GIS in Sericulture Development (Phase-II) for NER States. NESAC-SR-190-2018.
2. Site Suitability Analysis for Area Expansion of Turmeric in Jaintia Hills of Meghalaya. NESAC-SR-169-2018.
3. Crop Condition Assessment Under Abiotic Stress of few Selected Major Crops of NER using Remote Sensing Technique. NESAC-SR-177-2018.
4. Land Use Planning towards Sustainable Development of Tirap District, Arunachal Pradesh using GIS and Space Technology. NESAC-SR-178-2018.
5. Cropping Pattern Analysis of Nagaon District of Assam using Geospatial Technique. NESAC-SR-191-2018.
6. Analysis on Sudden Change of Water Quality in Siang River using Remote Sensing and GIS. NESAC-SR-179-2018.
7. Use of Unmanned Aerial Vehicle (UAV) Remote Sensing (UAV-RS) for the States of NE Region (NER). NESAC-SR-180-2018.
8. Compendium on Applications of Space Technology for Governance and Development for Arunachal Pradesh. NESAC-SR-189-2018.
9. Embankment Survey and Monitoring using Unmanned Aerial Vehicle (UAV). NESAC-SR-194-2018.
10. Assessment of Utilization of Irrigation Potential created for Dhansiri, Champamati, Thoubal and Dhalaithabi Irrigation Project of NE India. NESAC-SR-195-2019.

DETAILS OF INTERNSHIP AND PROJECT TRAINEES DURING 2018-19

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. 2018-2019 saw close to 200 applications for internships. Of these, 89 were shortlisted and undertook research internships at NESAC. All the interns were stationed at the Outreach Building where a system with open sourced software and internet connection was provided to all. The projects have been undertaken in across all research domains. M.Sc 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 the IT team to develop unique and innovative solutions to the pressing challenges in the field. We see participation from students from all parts of the country. The detailed list of parent organizations of students undertaking their internship at NESAC is listed below. Statistics of qualification and branch is also attached.

SN	Institute/ University	Course	No of students	Project
1.	North Eastern Hill University	M.Tech ECE	1	• Automated pothole detection using neural networks and object based image analysis
2.	Central University of Karnataka	M.Sc Applied Geography and GIS	4	• Identification of Potential Zones of Development in Indo – Bangladesh Border Area; a Natural Resources Perspective Burnt Area mapping for select regions in Meghalaya • Sub-tasks and ground survey for Master Plan for Shillong Municipal Corporation • Landslide identification and hazard vulnerability assessment
3.	University of Mysore	M.Sc GIS	4	• Landuse Landcover Analysis using LISS4 and Google Earth imagery • Arc-SWAT model for analysis of land atmosphere interactions and impact on hydrological parameters • Solid Waste management Plan for Shillong Municipal Corporation • Identification of environmental damage due to mining in Jaintia Hills
4.	Kumaun University	M.Sc Remote Sensing and GIS	3	• Assessment of Forest Cover Change in Marat Longri Wildlife Sanctuary, Karbi Anglong • Analysis of Forest Cover Change in Sonitpur, Assam • Analysis of the vegetation types of the East and West Kamrup division using geospatial technology

5.	North Orissa University	M.Sc Remote Sensing and GIS	8	• Assesment of bamboo growing areas in umsning block, Ribhoi district, meghalaya, using Geospatial technology. • Bamboo Reserch mapping in Jirang Block-Ribhoi District, Meghalaya • Digital classification of Land Use and Land Cover of South Tripura Districts
6.	DNR College of Engineering and Technology	B.Tech ECE	2	• UAV long range communication design • DC Continuous Power-supplies to increase the UAV flight time
7.	Aligarh Muslim University	M.Sc Remote Sensing and GIS	5	• Urban Heat Island Analysis for Guwhati • Muncipal GIS based property tax assessment for strengthning of Transport Facility • Social Infrastructure Assessment of Shillong Planning Area • 3D modelling • Solid Waste Bin location identification for SMB
8.	Karnataka State Rural Development and Panchayat Raj University, Gadag (Karnataka)	M.Sc Geoinformatics	5	• Mobile application for geotagging of sericulture assets • Maize crop discrimination using advanced classification techniques • Inputs to the Shillong Master Plan • UAV data analysis for crop acreage estimation. • Preparation of village development perspective plan using geospatial technolgy
9.	Amity University	M.Sc Remote Sensing and GIS/ Environmental Sciences	2	• Crop Damage Assessment and prediction using space based inputs • Remote Sensing Indices to study water quality: A case study of the Umiam Lake
10.	Noida International University	M.A Geography	2	• Forest Cover Mapping for a block in Manipur
11.	Bangalore University	M.Sc GIS	4	• Object Based Image Analysis of high resolution imagery to detect mining activity in Jaintia Hills • Earthquake precurser studies using TEC • Site suitability analysis of banana in West Garo Hills • Site suitability Analysis of potato in East khasi Hills
12.	Kazi Nazrul University in Geo-Informatics	M.Sc Geoinformatics	5	• Forest cover analysis using Google Earth Engine • Comparison between terrestrial and Martian glaciers

13.	Maharshi Dayanand Saraswati University	M.Sc Remote Sensing and GIS	2	• Cropping pattern analysis in select districts of Assam • UAV flight planning, data acquisition, processing and object based image analysis for building extraction
14.	Teri School of Advanced Studies	M.Sc Remote Sensing and GIS	1	• Catchment Level Analysis of Urban Flooding in the pockets of Guwahati City
15.	NERIST	B.Tech C.Sc/ECE	20	• Ka band propagation experiment • UAV Flight planning • Mobile App Development
16.	BITS	B.Tech C.Sc and ECE with Masters specialization varied	15	• Identification of open cast mines in Meghalaya using Google Earth Engine • Internet of Thing approach to identification of water level rise
		Total	**89**	

AUDITOR'S REPORT AND STATEMENT OF ACCOUNTS FOR THE FINANCIAL YEAR 2018-19

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

We have audited the attached Balance Sheet as at 31st March 2019 and also the Income and Expenditure Account and Receipts & Payments Account for the year ended on that date of **NORTH EASTERN SPACE APPLICATIONS CENTRE : UMIAM : MEGHALAYA**. These financial statements are the responsibility of the management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with the auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material mis-statement. An audit also includes examining, on a test basis evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

We report that:-

1. Fixed Assets which have been found damaged and obsolete during physically verification have not been written off.
2. Reimbursement by the Centre of amount spent by the employees in obtaining medical treatment for employees or his/her family members has not been taken into account while calculating the Income Tax liability of the concerned employee.

   It may be mentioned as per Section 17(2)(i) & 17(2)(ii) of the Income Tax Act 1961 only the following reimbursement of medical expenses of the employees are not taxable.

   i) The value of any medical treatment provided to an employee or any member of his family in any hospital maintained by the employer

   ii) Any sum paid by the employer is respect of any expenditure actually incurred by the employee on his medical treatment or treatment of any member of his family –

      a. In any hospital maintained by the Government or any local authority or any other hospital approved by the Government for the purposes of medical treatment of its employees.

      b. In respect of the prescribed diseases of ailments, in any hospital approved by the Principal Chief Commissioner or Chief Commissioner having regard to the prescribed guidelines.

   Approval certificates under section 17(ii) (b) from the principal Chief Commissioner of Income Tax were not forthcoming in respect of Centre's approved private hospitals of Shillong.

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 schecule 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, 2019 and

  (b) in case of the Income & Expenditure Account, of the deflict 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: 19054234AAAACP4104

Place: Shillong
Date: 18th September 2019

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-2019

(Amount - ₹)

CAPITAL FUND AND LIABILITIES	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Capital Fund	1	69,73,34,231.46	54,87,71,138.46
Current Liabilities & Provisions	2	31,03,43,444.00	31,31,37,730.00
Pension Fund as per contra*		1,10,18,442.00	91,80,165.00
TOTAL		**1,01,86,96,117.46**	**87,10,89,033.46**
ASSETS			
Fixed Assets	3	62,14,25,640.00	47,78,66,106.00
Current Assets, Loans & Advances etc.	4	38,62,52,035.46	38,40,42,762.46
Pension Fund as per contra*		1,10,18,442.00	91,80,165.00
TOTAL		**1,01,86,96,117.46**	**87,10,89,033.46**
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

Sd/-
(AVANEESH SHUKLA)
Sr Accounts Officer

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

Date: 18.09.2019

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-2019

(Amount - ₹)

INCOME	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Grants	5	19,98,00,000.00	19,50,66,000.00
Other Incomes	6	1,25,73,734.23	30,73,890.18
Incomes from services	7	12,89,738.00	-
TOTAL		**21,36,63,472.23**	**19,81,39,890.18**
EXPENDITURE	**SCHEDULE**	**CURRENT YEAR**	**PREVIOUS YEAR**
Establishment Expenses	8	13,19,70,075.00	11,69,08,155.00
Other Administrative Expenses & etc.	9	4,39,13,433.23	3,84,66,107.18
Depreciation *(Net total at the year-end – corresponding to schedule 3) (Column 7)"		6,35,66,232.00	3,39,96,353.00
TOTAL		**23,94,49,740.23**	**18,93,70,615.18**
BALANCE BEING SURPLUS (+)/ DEFICIT (-)		**(2,57,86,268.00)**	**87,69,275.00**
Less: Prior period expenses - Establishment Expenses		-	7,56,359.00
Less: Prior period expenses - Other Administrative Expenses		2,97,433.00	14,14,064.00
Less: Provision for Pension, Gratuity & Leave Encashment		2,53,53,206.00	4,27,45,379.00
NET SURPLUS (+)/ DEFICIT (-) CARRIED TO CAPITAL FUND		**(5,14,36,907.00)**	**(3,61,46,527.00)**

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

Sd/-
(AVANEESH SHUKLA)
Sr Accounts Officer

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

Date: 18.09.2019

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-2019

Amount in (₹)

	RECEIPTS	CURRENT YEAR	PREVIOUS YEAR		PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I.	**Opening Balances**			**I.**	**Expenses**		
	a) Cash in Hand-Imprest	-	12,000.00		a) Establishment Expenses	11,63,26,594.00	10,44,17,505.00
	b) Bank Balances:				b) Other Administrative Expenses	4,40,52,602.00	3,91,97,013.00
	i) In Current Accounts, SBI Shillong	11,50,55,456.41	9,69,41,485.41	**II**	**Investments and Deposits**		
	ii) In Current Accounts, SBI Umiam	13,94,77,429.05	14,49,83,922.05		a) Deposit with MeSEB/ NRSC/ BSNL	3,97,300.00	-
	iii) In Current Accounts, Canara Bank	11,88,55,868.00	15,07,19,833.00				
		-	-	**III**	**Fixed Assets & Capital Work-In-Progress**		
II	**Grants Received**				a) Purchase of Fixed Assets	20,06,85,427.00	17,74,73,916.00
	From Government of India:			**IV**	**Other Payments**		
	a) Department of Space, Bangalore				a) ISRO Projects	3,50,31,782.00	13,17,54,197.00
	i) For Salaries	8,98,00,000.00	6,90,00,000.00		b) USER Projects	5,73,80,065.00	3,29,58,876.00
	ii) For General	11,00,00,000.00	9,00,00,000.00		c) In-House Projects	9,06,274.00	12,30,975.00
	iii) For Creation of Capital Assets	20,00,00,000.00	16,50,00,000.00		d) Advances to Staffs	49,74,256.00	38,58,159.00
	b) Ministry of DONER, NEC Shillong	-	3,60,66,000.00		e) Advances to Projects	12,03,126.00	6,92,700.00
III	**Interest Received**				f) Training	3,12,253.00	2,20,782.00
	a) On Fixed Deposits & Other Interests	6,60,137.00	-		g) Payment of Recoveries	1,93,24,244.00	2,00,85,171.00
IV	**Other Incomes**				h) Prior Period Expenses	2,39,402.00	21,64,440.00
	a) Others	12,98,128.23	8,48,841.18		i) Security Deposits	1,31,17,778.00	82,53,927.00
					j) ISTRAC Expenses	24,94,339.00	22,40,385.00
					k) DWR Cheerapunji	59,12,199.00	-
V	**Other Receipts**				l) Assam ISRO Centre	12,79,171.00	-
	a) Miscelleneous Recoveries	22,55,819.77	27,51,573.00	**V**	**Closing Balances**	-	-
	b) Recovery of Advances and Deposits from:				a) Cash in Hand (Imprest)	15,000.00	-
	i) Staffs (Cont., Imprest, TA/ DA & LTC Advances)	4,27,629.00	7,98,979.82		b) Bank Balances:		
	ii) Others Receipts from ISTRAC/ NRSC/ DWR	49,00,000.00	1,47,63,658.00		i) In Current Accounts, SBI Shillong	10,44,52,852.41	11,50,55,456.41
	c) Receipts on ISRO Projects	4,24,96,687.00	5,75,99,559.00		ii) In Current Accounts, SBI Umiam	12,87,37,589.05	13,94,77,429.05
	d) Receipts on USER Projects	3,76,76,882.00	5,98,67,149.00		iii) In Current Accounts, Canara Bank	50,83,093.00	11,88,55,868.00
	e) Security Deposits	88,67,500.00	85,83,799.00		iv) MOD with Canara Bank	12,98,46,190.00	-
	TOTAL	**87,17,71,536.46**	**89,79,36,799.46**		**TOTAL**	**87,17,71,536.46**	**89,79,36,799.46**

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

for **R PAL & Co**
Chartered Accountants

Sd/-
(RANADHIR PAL)
Proprietor

Date: 18.09.2019

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(AVANEESH SHUKLA)
Sr Accounts Officer

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उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2019

(Amount - ₹)

SCHEDULE 1 - CAPITAL FUND	CURRENT YEAR		PREVIOUS YEAR	
Balance as at the beginning of the year	54,87,71,138.46		41,99,17,665.46	
Add: Balance of Surplus (+)/ Deficit (-) transferred from the "Income & Expenditure Account"	(5,14,36,907.00)		(3,61,46,527.00)	
Add: Grant-In-Aid for Creation for Capital Assets	20,00,00,000.00	69,73,34,231.46	16,50,00,000.00	54,87,71,138.46
BALANCE AS AT THE YEAR END		**69,73,34,231.46**		**54,87,71,138.46**
SCHEDULE 2 – CURRENT LIABILITIES AND PROVISIONS	**CURRENT YEAR**		**PREVIOUS YEAR**	
CURRENT LIABILITIES:				
1 Other Current Liabilities				
a) Establishment Expenses	1,20,20,242.00		1,15,82,846.00	
b) Other Administrative Expenses	15,39,564.00		36,41,535.00	
c) Others	88,82,065.00		1,45,24,377.00	
d) Audit Fee	70,200.00	2,25,12,071.00	46,600.00	2,97,95,358.00
2 Deposit from Contractors	38,62,663.00	38,62,663.00	78,99,810.00	78,99,810.00
3 Project Accounts: USER Project				
Balance as at the begining of the year	10,30,94,704.00		7,88,03,261.00	
Add: Received during the year	4,27,62,496.00		6,07,14,649.00	
Less: Utilised during the year	6,68,94,262.00	7,89,62,938.00	3,64,23,206.00	10,30,94,704.00
4 Project Accounts: ISRO Project				
Balance as at the begining of the year	4,71,29,906.00		12,20,83,526.00	
Add: Received during the year	4,32,14,887.00		5,75,99,559.00	
Less: Utilised during the year	3,59,10,179.00	5,44,34,614.00	13,25,53,179.00	4,71,29,906.00
5 PROVISIONS:				
Pension, Gratuity & Leave Encashment	15,05,71,158.00	15,05,71,158.00	12,52,17,952.00	12,52,17,952.00
TOTAL		**31,03,43,444.00**		**31,31,37,730.00**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
Proprietor

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(AVANEESH SHUKLA)
Sr Accounts Officer

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(P. L. N. RAJU)
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Date: 18.09.2019

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उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2019

SCHEDULE 3 – FIXED ASSETS

(Amount- ₹)

DESCRIPTION		GROSS BLOCK					DEPRECIATION				NET BLOCK	
Sl. No	Particular	Cost/ Valuation as at the beginning of the year	Additions during the year	Sale/ Disposal	Cost/ Valuation as at the end of the year	Rate (%)	As at the beginning of the year	During the year	On deduction during the year	Total up to the year-end	As at the Current year-end	As at the previous year-end
		1	2	3	4=(1+2-3)	5	6	7	8	9=(6 +7- 8)	10=(4-9)	11
1	Land & Land Devolopment	1,77,53,045.00	-	-	1,77,53,045.00	0%	-	-	-	-	1,77,53,045.00	1,77,53,045.00
2	Boundry of New Land	36,43,529.00	-	-	36,43,529.00	10%	5,17,068.00	3,12,646.00	-	8,29,714.00	28,13,815.00	31,26,461.00
3	Renovation of lease Buildings	52,40,087.00	-	-	52,40,087.00	10%	40,78,254.00	1,16,183.00	-	41,94,437.00	10,45,650.00	11,61,833.00
4	Machinery & Equipment	95,40,622.00	-	-	95,40,622.00	15%	79,33,981.00	2,40,996.00	-	81,74,977.00	13,65,645.00	16,06,641.00
5	Furniture & Fixtures	1,93,12,920.76	94,18,850.00	-	2,87,31,770.76	10%	82,53,134.76	15,78,108.00	-	98,31,242.76	1,89,00,528.00	1,10,59,786.00
6	Office Equipments	68,11,237.00	7,32,613.00	-	75,43,850.00	15%	35,92,865.00	5,99,714.00	-	41,92,579.00	33,51,271.00	32,18,372.00
7	Computer & Pheripherals	6,44,35,666.60	16,40,327.00	-	6,60,75,993.60	40%	5,96,89,532.60	22,26,519.00	-	6,19,16,051.60	41,59,942.00	47,46,134.00
8	Library Books	5,07,44,691.93	26,87,008.00	-	5,34,31,699.93	40%	4,12,90,084.93	43,19,245.00	-	4,56,09,329.93	78,22,370.00	94,54,607.00
9	Telephones Installation	19,02,230.00	-	-	19,02,230.00	15%	7,83,448.00	1,67,817.00	-	9,51,265.00	9,50,965.00	11,18,782.00
10	Other Equipments	6,44,19,434.00	1,78,74,068.00	-	8,22,93,502.00	15%	2,44,90,175.00	81,57,316.00	-	3,26,47,491.00	4,96,46,011.00	3,99,29,259.00
11	NE-SAC Complex	17,33,09,856.00	20,98,026.00	-	17,54,07,882.00	10%	7,57,34,717.00	99,67,317.00	-	8,57,02,034.00	8,97,05,848.00	9,75,75,139.00
12	Vehicles	22,55,829.00	21,35,387.00	-	43,91,216.00	15%	11,55,188.00	4,35,416.00	-	15,90,604.00	28,00,612.00	11,00,641.00
13	Air Conditioner (Heating & Cooling)	27,28,835.00	-	-	27,28,835.00	15%	4,81,953.00	3,37,032.00	-	8,18,985.00	19,09,850.00	22,46,882.00
14	Apple I-Pad	71,250.00	-	-	71,250.00	15%	42,007.00	4,386.00	-	46,393.00	24,857.00	29,243.00
15	Aquarium	35,630.00	-	-	35,630.00	15%	21,006.00	2,194.00	-	23,200.00	12,430.00	14,624.00
16	CISF Barrack	27,08,604.00	-	-	27,08,604.00	5%	5,09,768.00	2,19,884.00	-	7,29,652.00	19,78,952.00	21,98,836.00
17	Mobile Set	48,100.00	-	-	48,100.00	15%	22,650.00	3,196.00	-	25,846.00	22,254.00	25,450.00
18	Motorised Treadmill	1,26,000.00	-	-	1,26,000.00	15%	74,286.00	7,757.00	-	82,043.00	43,957.00	51,714.00
19	SMF Batteries	6,35,400.00	-	-	6,35,400.00	15%	3,93,125.00	36,341.00	-	4,29,466.00	2,05,934.00	2,42,275.00
20	Vending Machine	20,500.00	-	-	20,500.00	15%	12,768.00	1,160.00	-	13,928.00	6,572.00	7,732.00

21	Water Dispenser	21,200.00	-	-	21,200.00	15%	13,205.00	1,199.00	-	14,404.00	6,796.00	7,995.00
22	Wifi Connectivity	-	14,45,666.00	-	14,45,666.00	15%	-	2,16,743.00	-	2,16,743.00	12,28,923.00	-
23	Residential complex	15,79,78,105.00	17,70,904.00	-	15,97,49,009.00	10%	78,37,728.00	1,51,83,660.00	-	2,30,21,388.00	13,67,27,621.00	15,01,40,377.00
24	Outreach Facilities	11,51,95,856.00	11,43,52,649.00	-	22,95,48,505.00	10%	-	1,89,20,544.00	-	1,89,20,544.00	21,06,27,961.00	11,51,95,856.00
Capital Work In Progress:												
24	CISF Quarter/Barrack	1,54,20,878.00	4,54,66,831.00	-	6,08,87,709.00	0%	-	-	-	-	6,08,87,709.00	1,54,20,878.00
25	Residential Complex Phase II	-	50,02,272.00	-	50,02,272.00	0%	-	-	-	-	50,02,272.00	-
Intangible Assets:												
26	Software	31,47,676.00	25,01,165.00	-	56,48,841.00	25%	27,14,132.00	5,10,859.00	-	32,24,991.00	24,23,850.00	4,33,544.00
	TOTAL FOR CURRENT YEAR	**71,75,07,182.29**	**20,71,25,766**	**-**	**92,46,32,948.29**		**23,96,41,076.29**	**6,35,66,232**	**-**	**30,32,07,308.29**	**62,14,25,640.00**	**47,78,66,106**
	TOTAL FOR PREVIOUS YEAR	**52,84,64,678.29**	**18,90,42,504**	**-**	**71,75,07,182.29**	**-**	**20,56,44,723.29**	**3,39,96,353**	**-**	**23,96,41,076.29**	**47,78,66,106.00**	**32,28,19,955.00**

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

for **R PAL & Co**
Chartered Accountants

Sd/-
(RANADHIR PAL)
Proprietor

Date: 18.09.2019

for and on behalf of
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SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31-MARCH-2019

(Amount- ₹)

SCHEDULE 4 – CURRENT ASSETS, LOANS & ADVANCES etc.	CURRENT YEAR		PREVIOUS YEAR	
A. CURRENT ASSETS:				
1) Cash balances in hand	15,000.00	-	-	-
2) Bank balances with scheduled banks				
a) On Current Accounts	23,82,73,534.46		37,33,88,753.46	37,33,88,753.46
b) MOD with Canara Bank	12,98,46,190.00	36,81,34,724.46		
B. LOANS, ADVANCES AND OTHER ASSETS:				
1) Advances to:				
a) Staffs:				
TA/ DA	2,49,887.00		2,40,690.00	
Contingencies	80,276.00		33,040.00	
Others	60,000.00	3,90,163.00	4,43,228.00	7,16,958.00
b) Projects: (User & Isro)	-	3,21,500.00	-	3,16,600.00
c) Others	-	13,52,452.00	-	9,54,902.00
2) Claims Receivable/ Recoverable	32,22,451.00	32,22,451.00	40,04,453.00	40,04,453.00
3) TDS receivable	1,95,138.00	1,95,138.00		
4) Interest receivable	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		11,70,080.00	
c) Satellite Data's with NRSC	32,25,654.00	49,08,692.00		
6) Closing Stock of Cartridges	11,84,006.00	11,84,006.00	33,75,358.00	46,61,096.00
TOTAL		**38,62,52,035.46**		**38,40,42,762.46**

for **R PAL & Co**
Chartered Accountants

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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2019

(Amount - ₹)

SCHEDULE 5 - GRANTS	Current Year	Previous Year
Central Government:		
a) Department of Space, Bangalore	19,98,00,000.00	15,90,00,000.00
b) North Eastern Council, Shillong	-	3,60,66,000.00
TOTAL	**19,98,00,000.00**	**19,50,66,000.00**
SCHEDULE 6 - OTHER INCOMES	**Current Year**	**Previous Year**
Miscellaneous	41,33,152.23	27,09,546.18
Maintenance Charges	2,55,612.00	99,740.00
Guest House Rent	7,86,786.00	2,64,604.00
Interest from Bank	73,98,184.00	-
TOTAL	**1,25,73,734.23**	**30,73,890.18**
SCHEDULE 7 - INCOME FROM SERVICES	**Current Year**	**Previous Year**
Service of Scientists	4,00,738.00	-
Infrastructure Usage	8,89,000.00	-
TOTAL	**12,89,738.00**	**-**

for **R PAL & Co**
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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2019

(Amount - ₹)

SCHEDULE 8 - ESTABLISHMENT EXPENSES		Current Year		Previous Year	
a)	Salary & Allowances	7,26,33,473.00		6,25,33,544.00	
b)	Honorarium	2,67,945.00		2,43,710.00	
c)	Employer Contributions towards NPS	32,35,095.00		21,22,734.00	
d)	Wages	34,78,908.00		24,75,264.00	
e)	LTC	21,50,090.00		12,69,415.00	
f)	Leave Encashment Expenses	2,32,571.00		1,92,093.00	
g)	Children Education Allowance	7,35,000.00		6,77,596.00	
h)	Outsourced DEO	30,89,122.00		26,92,926.00	
i)	Outsourced Electrician	16,90,683.00		14,32,006.00	
j)	Outsourced Worker for Various Services	1,10,20,061.00		73,05,086.00	
k)	NER-DRR (Salary)	46,27,699.00		60,57,027.00	
l)	CISF Salary	2,76,98,318.00		2,93,35,898.00	
m)	Retirement Pension	11,11,110.00	13,19,70,075.00	5,70,856.00	11,69,08,155.00
	TOTAL		**13,19,70,075.00**		**11,69,08,155.00**

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SCHEDULE FORMING PART OF INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31-MARCH-2019

(Amount - ₹)

SCHEDULE 9 - OTHER ADMINISTRATIVE EXPENSES & etc.		Current Year		Previous Year	
1	Postage, Courier & Telephone Charges	8,13,339.00		10,44,984.00	
2	Bank Charges	3,330.00		8,710.00	
3	Electricity & Power Charges	44,59,171.00		38,82,768.00	
4	Maintenance of Garden	1,59,795.00		-	
5	Printing & Stationery	25,64,036.00		13,17,454.18	
6	Advertisement & Publicity	12,85,966.00		17,99,549.00	
7	Hiring of Vehicles	25,71,104.00		30,11,626.00	
8	Travelling & Conveyance	42,73,644.23		47,27,414.00	
9	Professional Charges	9,67,572.00		10,56,743.00	
10	Project Expenses [In-house]	9,70,125.00		16,77,218.00	
11	Rent	4,09,500.00		6,36,435.00	
12	Repair & Maintenance	1,41,23,322.00		91,87,240.00	
13	Books & Periodicals	40,084.00		46,487.00	
14	Trainings/ Seminars & Workshops	5,94,800.00		7,08,340.00	
15	Medical Expenses	9,56,610.00		7,98,032.00	
16	Parliamentary Standing Committee (PSC)	-		6,500.00	
17	Other Charges	26,79,517.00		14,50,886.00	
18	POL	6,33,199.00		4,41,514.00	
19	Sanitary Items	5,71,916.00		2,29,991.00	
20	Hindi Week Celeberations	7,010.00		62,701.00	
21	Annual Maintenance Contracts	10,35,159.00		21,56,248.00	
22	Fooding & Lodging	44,299.00		2,19,702.00	
23	Miscellaneous Expenses	16,42,750.00		7,68,644.00	
24	Repair & Maintenance of Vehicles	1,62,696.00		1,85,074.00	
25	Operational Charges & Maintenance of Canteen	9,46,287.00		12,03,165.00	
26	ICRB Examination	6,79,020.00		6,34,593.00	
27	NER-DRR Expenses	5,49,955.00		6,51,401.00	
28	CISF Expenses	7,51,177.00		5,39,788.00	
29	Supply of Water for Hostels	18,050.00	4,39,13,433.23	12,900.00	3,84,66,107.18
	TOTAL		**4,39,13,433.23**		**3,84,66,107.18**

for **R PAL & Co**
Chartered Accountants

for and on behalf of
NORTH EASTERN SPACE APPLICATIONS CENTRE

Sd/-
(RANADHIR PAL)
Proprietor

Sd/-
(AVANEESH SHUKLA)
Sr Accounts Officer

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

Date: 18.09.2019

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

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

उमियम / UMIAM - 793103, मेघालय / MEGHALAYA

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH 2019

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 30.09.18 – 100% as per the applicable rate.
   - Assets acquired after 30.09.18 – 50% as per the applicable rate.

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

4. **Retirement Benefits:**- Pension, Gratuity and Leave Encashment liability is provided on the basis of Actuarial Valuation as t 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
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SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31-MARCH-2019

SCHEDULE 11 – NOTES ON THE ACCOUNTS & CONTINGENT LIABILITIES

NOTES ON THE ACCOUNTS

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

b) Pension, gratuity and leave encashment liability has been provided till 31.03.2019.

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

d) Schedules 1 to 11 are annexed to and form an integral part of the Balance Sheet as at 31-March-2019 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/-
(RANADHIR PAL)
Proprietor

Sd/-
(AVANEESH SHUKLA)
Sr Accounts Officer

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

Date 18.09.2019

ACRONYMS

3DVAR	:	Three-Dimensional Variational
AAU	:	Assam Agricultural University
ADC	:	Autonomous District Council
ADP	:	Automated Data Processing
AIRS	:	Atmospheric Infrared Sounder
ALG	:	Advanced Landing Ground
AMRUT	:	Atal Mission for Urban Rejuvenation & Transformation
MSL	:	Mean Sea Level
ANOVA	:	Analysis of Variance
AOD	:	Aerosol Optical Depth
ARFI	:	Aerosol Radiative Forcing over India
ASDMA	:	Assam State Disaster Management Authority
ASI	:	Astronautical Society of India
ASP	:	Atmospheric Science Program
ATM	:	Automated Teller Machine
AVHRR	:	Advanced Very High Resolution Radiometer
AWiFS	:	Advanced Wide Field Sensor
AWS	:	Automatic Weather Stations
BC	:	Black Carbon
BEL	:	Bharat Electronics Limited
BLL	:	Boundary Layer Lidar
BRO	:	Border Road Organization
BSNL	:	Bharat Sanchar Nigam Limited
CAMC	:	Comprehensive Annual Maintenance Contract
CARTOSAT	:	Cartographic Satellite
CCCI	:	Canopy Chlorophyll Content Index
CEC	:	Cation Exchange Capacity
CHAMAN	:	Coordinated program on Horticulture Assessment and Management
CISF	:	Central Industrial Security Force
CMD	:	Construction and Maintenance Division
COTS	:	Commercial Of-The-Shelf
COPLOT	:	Committee on Paper Laid on the Table
CSB	:	Central Silk Board
CSDM	:	Communication support in Disaster
CSR	:	Corporate Social Responsibility
CSRTI	:	Central Sericultural Research & Training Institute
CSS	:	Cascaded Style Sheet
CTGT	:	Carbondioxide Temperature Gradient Tunnel
CWC	:	Central Water Commission
DAC&FW	:	Department of Agriculture, Cooperation & Farmers' Welfare
DAR&PG	:	Department for Administrative Reforms & Public Grievance
DDMA	:	District Disaster Management Authority
DEM	:	Digital Elevation Model
DERT	:	Directorate of Educational Research & Training
DGPS	:	Differential Global Positioning System
DIET	:	Directorate of Education & Training
DIG	:	Deputy Inspector General
DMS	:	Disaster Management Support
DNS	:	Domain Name Servers
DONER	:	Development of North Eastern Region
DoA	:	Directorate of Agriculture
DOS	:	Department of Space
DoT	:	Department of Telecom
DPR	:	Detailed Project Report
DSM	:	Digital Surface Model
DTM	:	Digital Terrain Model
DWR	:	Doppler Weather Radar
EAC	:	Eastern Air Command
e-cognition	:	Electronic Cognition
ELPI	:	Electric Low Pressure Impactor
EOAM	:	Earth Observations Applications Mission
EOS	:	Earth Observation Satellite
EPRIS	:	Empowering Panchayati Raj Institutions Spatially
EQC	:	External Quality Check
ESRI	:	Environmental Systems Research Institute
FAO	:	Food and Agriculture Organization
FCC	:	False Colour Composite
FLEWS	:	Flood Early Warning System
FSI	:	Forest Survey of India
FTP	:	File Transfer Protocal
FWP	:	Forest Working Plan
GAGAN	:	GPS Aided Geo Augmented Navigation
GBH	:	Girth at Breast Height
Gbps	:	Giga bits per second
GC	:	Governing Council
GCP	:	Ground Control Point
GFS	:	Global Forecast System
GHADC	:	Garo Hills Autonomous District Council
GHG	:	Green House Gases
GHZ	:	Giga Hertz
GIS	:	Geographical Information System
GNDVI	:	Green Normalized Difference Vegetation Index

GNSS	:	Global Navigation Satellite System
GPF	:	General Planar Fit
GPM	:	Global Precipitation Measurement
GPS	:	Global Positioning System
GRACE	:	Gravity Recovery And Climate Experiment
GSAT	:	Geo-StationarySatellites
GSI	:	Geological Survey of India
HEC-HMS	:	Hydrology Engineering College Hydrologic Modeling System
HPC	:	High Performance Computing
HYSPLIT	:	Hybrid single particle Lagrangian Integrated Trajectory
IARI	:	Indian Agricultural Research Institute
ICAR	:	Indian Council of Agricultural Research
ICMR	:	Indian council for medical research
ICT	:	Information & Communication Technologies
IDSP	:	Integrated Disease surveillance program
IEEE	:	Institute of Electrical and Electronics Engineers
IITM	:	Indian Institute of Technology Madras
IGBP	:	ISRO Geosphere Biosphere Program
INSAT	:	Indian National Satellite
IQC	:	Intermediate Quality Check
IRS	:	Indian Remote Sensing (Satellite)
ISAC	:	ISRO Satellite Centre
ISPRS	:	International Society of Photogrammetry and Remote Sensing
ISTRAC	:	ISRO Telemetry Tracking and Command Centre
IWMP	:	Integrated Watershed Management Program
JEWS	:	Japanese Encephalitis Early Warning System
JHADC	:	Jaintia Hills Autonomous District Council
KHADC	:	Khasi Hills Autonomous District Council
KLNP	:	KeibulLamjao National Park
LAN	:	Local Area Network
LB	:	Load Balancing
LISS	:	Linear Imaging Self Scanning
LiDAR	:	Light Detection & Ranging
LULC	:	Land Use Land Cover
MA&FW	:	Ministry of Agriculture & farmers' Welfare
MARSAC	:	Manipur Remote Sensing Application Centre
MBLM	:	Mini Boundary Layer Mast
Mbps	:	Mega Bits Per Second
MCS	:	Mesoscale Convective System
MERRA	:	Modern-Era Retrospective analysis for Research and Application
MGNREGA	:	Mahatma Gandhi National Rural Employment Guarantee Act
MHRD	:	Ministry of Human Resource Development
MIS	:	Management Information System
MIDH	:	Mission for Integrated Development of Horticulture
MNCFC	:	Mahalanobis National Crop Forecast Centre
MODIS	:	Moderate-resolution Imaging Spectroradiometer
MoEFCC	:	Ministry of Environment, Forests and Climate Change
MOSDAC	:	Meteorological and Oceanographic Satellite Data Archival Centre
MoU	:	Memorandum of Understanding
MRR	:	Micro Rain Radar
MSI	:	Media Sustainability Index
MSS	:	Mobile Satellite Service
MSW	:	Municipal Solid Waste
MWR	:	Multi Wavelength Radiometer
NAS	:	Network Attached Storage
NASA	:	National Aeronautics and Space Administration
NAVIC	:	Navigation with Indian Constellation
NCEP	:	National Centers for Environmental Prediction
NCP	:	National Carbon Project
NDEM	:	National Database for Emergency Management
NDRE	:	Normalized Difference Red Edge
NDRF	:	National Disaster Response Force
NDNI	:	Normalized Difference Nitrogen Index
NDVI	:	Normalized Difference Vegetation Index
NDWI	:	Normalized difference water index
NEC	:	North Eastern Council
NEDRP	:	North Eastern District Resources Plan
NEIST	:	North East Institute of Science & Technology
NEHR	:	North Eastern Hill Region
NEIGRIMHS	:	North East Indira Gandhi Regional Institute of Medical & Health Sciences
NEPA	:	North East Police Academy
NER-DRR	:	North Eastern Regional node for Disaster Risk Reduction
NERTPS	:	North Eastern Region Textile Promotion Scheme
NESDR	:	North East Spatial Data Repository
NHAI	:	National Highways Authority of India

NIRD&PR	:	National Institute of Rural Development & Panchayati Raj
NKN	:	National Knowledge Network
NNRMS	:	National Natural Resources Management System
NOBLE	:	Network Of Boundary Layer Experiments
NWIA	:	National Wetland Inventory and Assessment
NWP	:	Numerical Weather Prediction
NUIS	:	National Urban Information System
OFC	:	Optical Fiber Communication
OLI	:	Official Language Implementation
OMI	:	Ozone Monitoring Instrument
ONERA	:	Office National d'Etudes et de Recherches Aérospatiales
PAC	:	Precipitation Accumulation
PCA	:	Principal Component Analysis
PDA	:	Personal Digital Assistant
PM	:	Particulate Matter
PRI	:	Panchayati Raj Institutions
PSSRa	:	Pigment Specific Simple Ratio for chlorophyll a
PWD	:	Public Welfare Department
PMGSY	:	Pradhan Mantri Gram SadakYojna
RAM	:	Random Access Memory
REG GCM	:	Regional Global Climate Model
REP	:	Red Edge Position
RGB	:	Red Green Blue
RHI	:	Range Height Indicator
RKVY	:	Rashtriya Krishi Vikas Yojana
RMC	:	Regional Meteorological Center
RMSD	:	Root Mean Square Deviation
RMSE	:	Root Mean Square Error
RRTM	:	Rapid Radiative Transfer Model
RS	:	Remote Sensing
RSAA	:	Remote Sensing Application Area
SAC	:	Space Applications Centre
SAN	:	Storage Area Network
SAR	:	Synthetic Aperture Radar
S&T	:	Science and Technology
SATCOM	:	Satellite Communications
SBIK	:	Space Based Information KIOSK
SCERT	:	State Council of Educational Research & Training
SCNP	:	Satellite Communications & Navigation Program
SDI	:	Spatial Data Infrastructures
SDR	:	Spatial Data Repository
SDSC SHAR	:	Satish Dhawan Space Centre Sriharikota Range
SDSS	:	Spatial Decision Support System
SILKS	:	Sericulture Information Linkages & Knowledge System
SIRD	:	State Institute of Rural Development
SIS-DP	:	Space Based Information Support for Decentralized Planning
SIT	:	Satellite Interactive Terminal
SLIM	:	Seasonal Landslide Inventory Mapping
SLNA	:	State Level Nodal Agency
SMR	:	Satellite Mobile Radio
SMS	:	Short Message Service
SNR	:	Signal to Noise Ratio
SODAR	:	Sound Detection And Ranging
SOI	:	Survey Of India
SPL	:	Space Physics Laboratory
SPS	:	Standard Positioning Services
SRA	:	Synoptic Rainfall Advisory
SRI	:	Surface Rainfall Intensity
SRSAC	:	State Remote Sensing Applications Centre
SRTM	:	Shuttle Radar Topography Mission
SSA	:	Sarva Siksha Abhiyan
SWJ	:	Subtropical Westerly Jetstream
TB	:	Tera Byte
TCARI	:	Transformed Chlorophyll Absorption Reflectance Index
TCN	:	Tropospheric Columnar NO_2
TDP	:	Technology Demonstration Project
TEC	:	Total Electron Content
TIBL	:	Thermal Internal Boundary Layers
TKE	:	Tau Kappa Epsilon
ToR	:	Terms of Reference
TRGA	:	Total Rice Growing Area
UAV	:	Unmanned Aerial Vehicle
ULB	:	Urban Level Block
UNAVCO	:	University NAVSTAR Consortium
USA	:	United States of America
USGS	:	United States Geological Survey
UTC	:	Universal Coordinated Time
VCP	:	Vegetation Carbon Pool
VIS	:	Village Information System
VPN	:	Virtual Private Network
VSSC	:	Vikram Sarabhai Space Center
VSAT	:	Very Small Aperture Terminal
WEKA	:	Waikato Environment for Knowledge Analysis
WiFi	:	Wireless Fidelity
WLL	:	Wireless in Local Loop
WRF	:	Weather Research And Forecasting

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